Use of Western Australian linked hospital morbidity and mortality data to explore theories of compression, expansion and dynamic equilibrium

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Abstract

Three hypotheses have been advanced to predict changes in population health in countries experiencing low birth and death rates, and increasing expectation of life. Determining which of these best accounts for changing patterns of illness and death is an important step in understanding both the public health and economic impacts of health interventions in an ageing population. The aim of this study was to use the WA Data Linkage System to evaluate the compression, expansion and dynamic equilibrium theories in Western Australia. Changes in life expectancy, average age at first-time hospitalisation and time spent in chronic disabling or activity limiting states were used to evaluate the competing hypotheses.

Life expectancy increased by 4.0 and 2.6 years over the 24-year study period in males and females, respectively. However, average time spent with a diagnosed chronic disabling condition increased by 9.2 and 9.4 years in males and females, respectively. These results suggest that an increase in the "medicalisation of more serious morbidity" may be in operation in Australia.

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What is known about the topic?

Three hypotheses have been advanced to predict changes in population health in countries experiencing low birth and death rates, and increasing expectation of life: namely, the compression of morbidity, expansion of morbidity, and dynamic equilibrium theories. However, a quarter of a century of research has failed to answer definitively the fundamental question: Are we trading off quality of life for a greater quantity of life?

What does this paper add?

This paper evaluated the compression, expansion and dynamic equilibrium hypotheses using population-based data on first-time hospital admissions and deaths linked at the individual level. The study found evidence in support of an expansion of morbidity and evidence against the dynamic equilibrium theory. Specifically, the results suggest that an increase in the medicalisation of more serious morbidity may be in operation in Australia. This finding may have profound implications for both health costs and the future capacity to provide health care services.

What are the implications for practitioners?

Knowledge regarding population health changes can assist in preparation for the challenges of future health care delivery. Determining which theory best accounts for changing patterns of illness and death is an important step in understanding both the public health and economic impacts of health intervention for an ageing population.

OVER THE LAST 30 YEARS, the age composition of the population in most developed countries has changed significantly. The relative number of old persons (those aged 80 years and over) has steadily increased, and this is expected to continue in the future. The main contributors to population ageing are decreased fertility and increased life expectancy made possible by improved living standards, prevention programs and innovations in medicine.[1]

Recognising the significance of an ageing population, the Australian Federal Government devel-

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oped a national strategy to devise short, medium and longer term policy responses to population ageing.[2] While many of the problems associated with the economic effects of ageing are concerned with the size of the workforce (working age depopulation), wealth creation (ratio of producers to consumers) and the impact of increasing welfare costs (relative rise in the public resources required for age pensions), the cost of health care is also a major concern. Policy responses that do not adequately account for changes in population health occurring within ageing populations are unlikely to prepare adequately for the challenges posed by the future delivery of health care.

Three major hypotheses have been advanced to explain changes in population health in countries experiencing low birth and death rates, and increasing expectation of life.[3] These are the compression of morbidity,[4] expansion of morbidity,[5] and dynamic equilibrium[6] theories. The first theory proposes improving health status, the second declining health status and the third a net status quo.[7]

Knowledge regarding which theory most accurately accounts for health status within ageing populations is important for public health policy makers and economists. However, the literature is not decisive on which theory best explains observed trends in morbidity and mortality. Nevertheless, a number of common themes emerge from the literature.[8,9] Firstly, the lack of consistent definitions of morbidity and disability may have contributed to mixed findings.[8] Secondly, despite the helpful contribution of health expectancies to the knowledge base, the disadvantages of subjective self-report data have precluded a reliable comparison of morbidity trends across time, people and places. Finally, the issue of population ageing has been examined from different vantage points, and while each study design has added useful methods and findings to the literature, the different methods have made an integrative synthesis of all the findings difficult. In summary, a quarter of a century of research has failed to answer definitively the fundamental question: Are we trading off quality of life for a greater quantity of life?

The aim of this study was to evaluate the compression, expansion and dynamic equilibrium theories by examining the relationship between onset of disability requiring hospitalisation and mortality in Western Australia using data from the Western Australian Data Linkage System (WADLS).

Methods

This study used life table methods to construct a simulated longitudinal cohort modelling hospital morbidity and mortality rates observed cross-sectionally in the dynamic population of WA. Ethical approval for this study was obtained from the University of Western Australia's Human Research Ethics Committee.

The WADLS[10] was used to extract all hospital morbidity (HM) and death records pertaining to individuals aged 15 years and older living in WA between 1970 and 2003. The data comprised encrypted patient identification and episode numbers, gender, age in years at time of record, dates of admission and separation from hospital, principal diagnosis on hospital separation, and date, age and cause of death.

Determination of morbid (chronic disabling and activity limiting) events

We adopted an operational definition of morbidity, termed "chronic disabling" conditions derived from a large study commissioned by the US Department of Health and Human Services.[11] We also adopted a classification of less severe chronic disabling conditions termed "activity limiting" as defined by LaPlante.[12] Version-specific International classification of diseases (ICD) codes, for chronic disabling and activity limiting conditions as described above, were used to identify target condition. Once this was identified, the individual's sex, age and date of admission were recorded and categorised as follows:

- First-time hospitalisation for any condition classified as either chronic disabling or activity limiting;
- First-time hospitalisation for any condition classified as chronic disabling;

- First-time hospitalisation for any condition classified as activity limiting.

To limit potential underestimation of the incidence of morbid events (chronic disabling or activity limiting) in the population, the date and age of death was used as a proxy for the onset of morbidity requiring hospitalisation in individuals who died of a condition classified as chronic disabling or activity limiting, but who had no record of hospitalisation for that condition.

Taking the first-time hospital record for each individual in the study population would have resulted in an overestimation of morbid events during the initial years of the study, as some patients may have been admitted before the observation period, thereby causing a "prevalent pool effect".[13] To minimise the effect of prevalence pooling, a 10-year lead-in period was used before counting any hospitalisation as a first-time admission in any category.

Construction of life tables

The study period was divided into three equal time periods (1980–1987, 1988–1995 and 1996–2003). Standard life tables were constructed for each time period to determine changes in life expectancy in WA between 1980 and 2003. The annual number of deaths in relation to 5-year age group and sex were determined from the data. Australian Bureau of Statistics resident population data[14] encompassing 30 June census and intercensal estimates by sex and age-group were used to estimate the person-years at risk (of dying) by age and gender in each time period.

In this study, multiple decrement life tables[15] were used to account for the competing risks posed by: (1) the chance of a first-time hospitalisation for a target condition; and (2) the chance of dying from an unrelated event before a first-time hospitalisation for a target condition. Empirical estimates of the age, sex and time-specific prevalence of having experienced a first-time hospitalisation for a target condition were used to adjust the census-derived denominators. In addition, deaths occurring after first-time hospitalisation for a target condition were not counted as competing events.

Analysis of survival curves

The areas under each of the hospital morbidity and mortality survival curves were calculated as follows, where n refers to the nth age group:

Σ_{n1-ni} (Cumulative incidence of survival × no of years in age-group interval).

Subsequently the area between these two curves was determined and used to estimate the average number of years spent in each type of disabled state in each time period. Changes in this estimate were used to evaluate the three competing theories.

Results

The dataset contained 228 368 deaths from all causes in individuals aged 15 or more years between 1980 and 2003. Box 1 shows the number of first-time chronic disabling and activity limiting hospitalisations by major diagnostic classification in the three time periods. We identified 195 746 first-time hospital admissions categorised as chronic disabling, 207 719 categorised as activity limiting and 322 745 categorised using the either classification. With respect to first-time hospitalisations for chronic disabling conditions, in the first two time periods the top three diagnostic classifications were cardiovascular disease, neoplasm, and asthma or chronic obstructive pulmonary disease (COPD), while in the third time period a substantial increase in the frequency of mental and behavioural disorders was observed. In contrast, for activity limiting conditions cardiovascular disease accounted for over 75% of first-time hospitalisations in all three time periods. The general trends apparent from Box 1 were similarly evident in separate analyses of males and females.

Changes in life expectancy

Life expectancies, conditional upon survival to age 15 years, of males and females obtained from cross-sectional rates in the three time periods are summarised in Box 2. Life expectancy in females was higher than in males across all three time periods; eg, 80.8 years compared with 75.6 years in the most recent period. Between 1980 and

1 First-time hospitalisations for conditions identified as either chronic disabling or activity limiting in Western Australia, 1980–2003, by major diagnostic classification

	Time period of admission (first-time hospitalisation) (no [%])			
Major diagnostic classification*	**1980–1987**	**1988–1995**	**1996–2003**	**Total 1980–2003**
Chronic disabling				
Neoplasm	10007 (21.7)	14128 (23.7)	15420 (17.1)	39555 (20.2)
Mental and behavioural disorders	3405 (7.4)	5608 (9.4)	21253 (23.6)	30266 (15.5)
Diseases of the nervous system	5124 (11.1)	5162 (8.7)	5686 (6.3)	15972 (8.2)
Cardiovascular disease	11201 (24.3)	11075 (18.6)	9229 (10.2)	31505 (16.1)
Diseases of the respiratory system†	401 (0.9)	690 (1.2)	1696 (1.9)	2787 (1.4)
Injury	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Diabetes	29 (0.1)	1308 (2.2)	2380 (2.6)	3717 (1.9)
Asthma and COPD	9149 (19.9)	11628 (19.5)	13530 (15.0)	34307 (17.5)
Other‡	6717 (14.6)	9988 (16.8)	20932 (23.2)	37637 (19.2)
Total	46033 (23.5)	59587 (30.4)	90126 (46.0)	195746 (100.0)
Activity limiting				
Neoplasm	4777 (8.0)	8171 (11.2)	8361 (11.1)	21309 (10.3)
Mental and behavioural disorders	73 (0.1)	162 (0.2)	288 (0.4)	523 (0.3)
Diseases of the nervous system	5004 (8.4)	3995 (5.5)	3342 (4.4)	12341 (5.9)
Cardiovascular disease	46963 (79.1)	57419 (78.9)	61272 (81.0)	165654 (79.7)
Diseases of the respiratory system†	873 (1.5)	1383 (1.9)	954 (1.3)	3210 (1.5)
Injury	61 (0.1)	38 (0.1)	219 (0.3)	318 (0.2)
Diabetes	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Asthma and COPD	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Other‡	1605 (2.7)	1572 (2.2)	1187 (1.6)	4364 (2.1)
Total	59356 (28.6)	72740 (35.0)	75623 (36.4)	207719 (100.0)
Either category§				
Neoplasm	12948 (15.3)	18982 (18.0)	20073 (15.1)	52003 (16.1)
Mental and behavioural disorders	3106 (3.7)	4807 (4.6)	19321 (14.6)	27234 (8.4)
Diseases of the nervous system	8155 (9.6)	7158 (6.8)	6612 (5.0)	21925 (6.8)
Cardiovascular disease	43971 (52.0)	52434 (49.7)	53646 (40.4)	150051 (46.5)
Diseases of the respiratory system†	798 (0.9)	1176 (1.1)	1711 (1.3)	3685 (1.1)
Injury	58 (0.1)	38 (0.0)	195 (0.1)	291 (0.1)
Diabetes	27 (0.0)	978 (0.9)	1573 (1.2)	2578 (0.8)
Asthma and COPD	8087 (9.6)	9876 (9.4)	10395 (7.8)	28358 (8.8)
Other‡	7398 (8.8)	10089 (9.6)	19133 (14.4)	36620 (11.3)
Total	84548 (26.2)	105538 (32.7)	132659 (41.1)	322745 (100.0)

COPD = chronic obstructive pulmonary disease. * Based on major groups of diseases identified and mapped to International classification of diseases version 9 CM (clinical modification). † Excluding asthma and COPD. ‡ Includes endocrine, congenital, digestive, musculoskeletal and other condition not elsewhere classified. § First-time hospitalisation for any disease specified in the chronic disabling or activity limiting categories.

2 Life expectancy for males and females, 1980–2003*

	Males			Females		
	Life expectancy			Life expectancy		
	From age 15 years	From birth†	Difference between periods	From age 15 years	From birth†	Difference between periods
Period 1 1980–1987	56.6	71.6		63.2	78.2	
			1.9			1.1
Period 2 1988–1995	58.5	73.5		64.3	79.3	
			2.1			1.5
Period 3 1996–2003	60.6	75.6		65.8	80.8	
Increase in life expectancy (period 1 to period 3)			4.0			2.6

*All values are number of years. †These figures were derived from adding 15 years to the life expectancy from age 15 years.

2003, life expectancy in males increased by 4.0 years, whereas in females an increase of only 2.6 years over the same period was observed.

Changes in average age of first-time hospitalisations

The multiple decrement life table results on changes across the three time periods in the average age of first-time hospitalisations for a chronic disabling, activity limiting, or any of the conditions listed are shown in Box 3. Similarly to life expectancy, the expected age at first-time hospitalisation for a chronic disabling condition was higher in females than males across all time periods, although the difference reduced to about 1 year in the second and third time periods.

In both males and females, first-time hospitalisations for chronic disabling conditions occurred at progressively earlier ages over the study period. When life expectancy was taken into consideration, the time from the first available evidence of a chronically disabled state requiring hospitalisation until death increased by 9.2 and 9.4 years in males and females, respectively.

In males, the average age of a first-time hospitalisation for an activity limiting condition increased from 56.6 years to 58.2 years, while in females it increased from 64.2 years to 65.7 years. However, when average life expectancy was taken into account over the study period, on average, both males and females spent a slightly increased amount of time in an activity limiting state.

When the average ages of first-time hospitalisations for either a chronic disabling or an activity limiting condition (whichever condition came first) were analysed, a similar pattern to that for first-time hospitalisations due to a chronic disabling condition was observed.

Time spent in chronic disabled and activity limiting states

Box 4 and Box 5 show the survival curves for first-time hospitalisation due to "chronic disabling", "activity limiting" and "either classification" of condition compared with all cause mortality in males and females respectively over the study period. The curves showed an increase (expansion) in the area between the chronic disabling and the all cause mortality curves in males between the ages of 30 and 79 years (Box 4). A similar finding was observed when the survival curves for either type of condition were evaluated. The expansion is due to increased longevity of males aged between 59 and 84 years, coupled with marked reduced time to first hospitalisation for a chronic disabling condition in males aged between 30 and 79 years of age. Box 4 also shows that in the third time period there was a marked expansion of the area between the chronic disabling and activity limiting curves. This is especially marked in males aged over 64

3 Life expectancy pre and post first-time hospitalisation for chronic disabling, activity limiting and either classification of condition in males and females in Western Australia, 1980–2003

	Life expectancy* (years)					
	First-time hospitalisation for a chronic disabling condition		First-time hospitalisation for an activity limiting condition		First-time hospitalisation for either a chronic disabling OR an activity limiting condition	
	Pre	Post	Pre	Post	Pre	Post
Males						
1980–1987	56.3	15.3	56.6	15.0	52.3	19.3
1988–1995	56.2	17.3	57.5	16.0	52.1	21.4
1996–2003	51.1	24.5	58.2	17.4	48.4	27.1
Change in life expectancy post 1st hospitalisation (1980–2003)		+9.2		+2.4		+7.9
Females						
1980–1987	58.6	19.5	64.2	14.0	55.6	22.5
1988–1995	57.2	22.1	65.0	14.3	54.6	24.8
1996–2003	51.9	28.9	65.7	15.1	50.3	30.5
Change in life expectancy post 1st hospitalisation (1980–2003)		+9.4		+1.1		+8.0

* Calculated from birth.

years where, in the first two time periods, first-time hospitalisation for activity limiting conditions occurred at an earlier age than for chronic disabling conditions. However, in the third time period the reverse was observed, except in males over the age of 84 years.

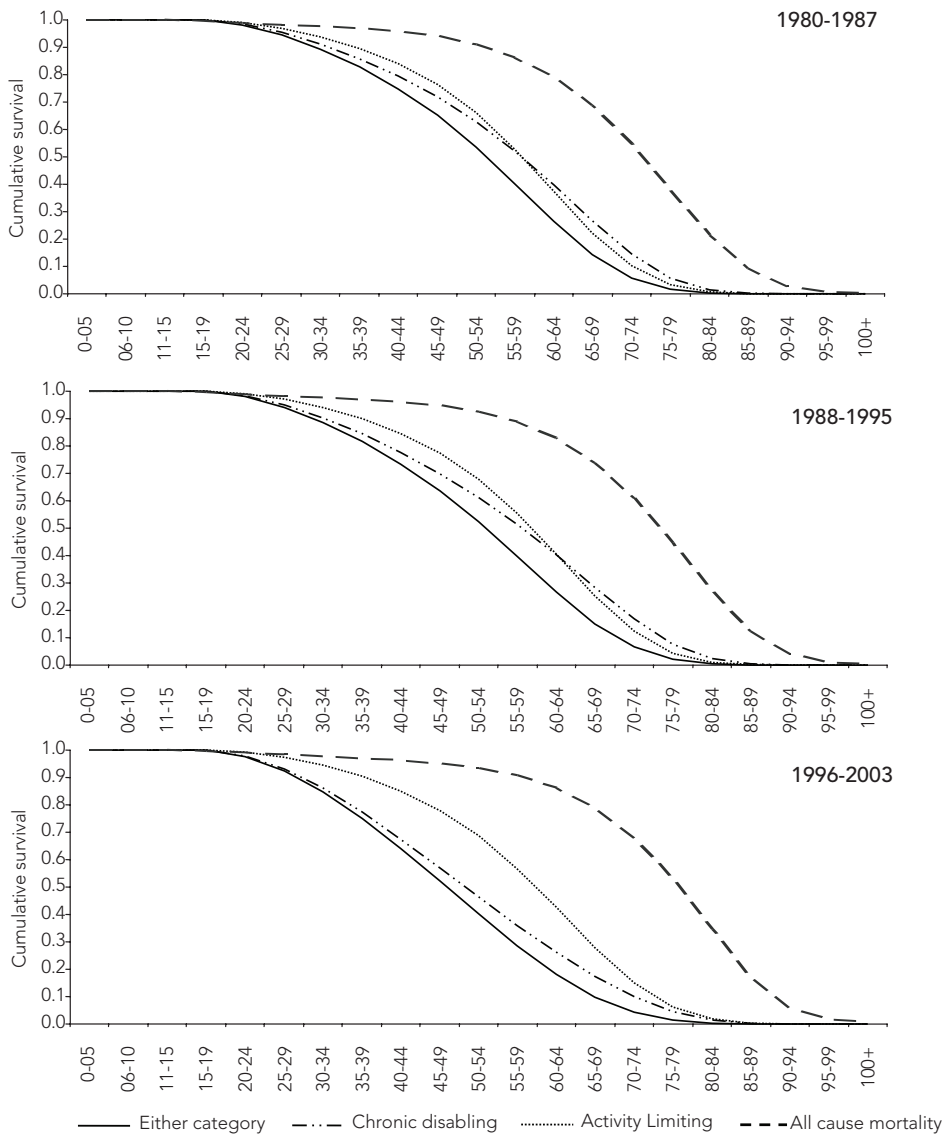
A similar pattern was observed in females (Box 5), except that, in contrast to males, in females aged less than 85 years first-time hospitalisation for a chronic disabling condition occurred at an earlier average age than for an activity limiting condition across all time periods.

Discussion

The findings of the study support the expansion of morbidity hypothesis. We found that the average time between the first available evidence of a chronic disabled state and death had increased by 9.2 years in males and 9.4 years in females over the three study periods. This result does not support the compression of morbidity hypothesis, which would have required no change or a reduction in the average time spent with evidence of chronic disability. The third theory, dynamic equilibrium, is also not supported by our results because we observed only a relatively small change in the time spent in an activity limiting state over the study period (+2.4 years in males and +1.1 years in females). Thus, we have not observed a large enough decrease in severity levels of disability to offset the observed increase in overall expectation of chronic disability in the population.

Our results are consistent with those of Davis et al,[16] who found that expansion of morbidity occurred in Australia between 1981 and 1998. Australian Health Survey and death data used by Davis et al[16] to calculate health expectancies indicated an expansion of morbidity across all severity levels of disability. In our study we sought to evaluate the dynamic equilibrium

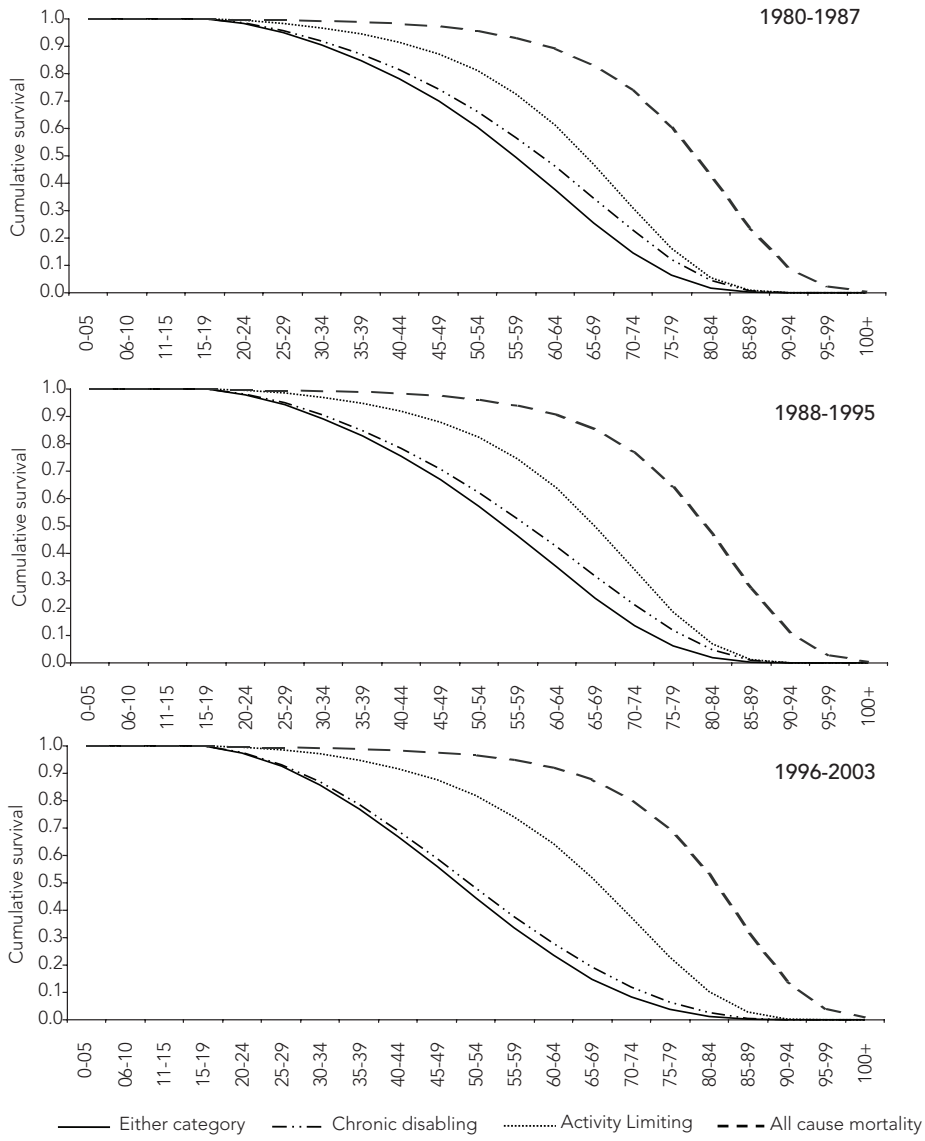
4 Survival to first-time hospitalisation for activity limiting and chronic disabling events compared with all cause mortality in males between 1980–1987 and 1996–2003



hypothesis, thus we distinguished between severe ("chronic disabling") and moderate ("activity limiting") disability. However, despite the overall finding being consistent with Davis et al,[16] our examination of disability severity found some evidence that the expansion of morbidity may be due to an increase in the prevalence of more severe disability. Therefore, our study has confirmed the expansion hypothesis and provided some evidence against the dynamic equilibrium hypothesis.

Available literature suggests that recent US data support the compression of morbidity hypothesis whereas, in concordance with our

5 Survival to first-time hospitalisation for activity limiting and chronic disabling events compared with all cause mortality in females between 1980–1987 and 1996–2003



results, data from New Zealand suggest an expansion of morbidity.[17] In terms of disability trends among older people, Australian results appear particularly at odds with results from many other countries, which either show declines or static trends.[18] International evidence suggests that self-reported disability prevalence has increased since the 1970s; however, it has been suggested that this expansion is confined to the less severe end of the disability spectrum.[7] A major reason cited for the expansion of morbidity at less severe levels of disability relates to changes in thresholds at which individuals self-report their disability levels over time.[17]

Although we found that overall disability prevalence increased, the expansion of morbidity was apparently due to an increasing prevalence of severe, rather than moderate, disability. Since our study did not involve self-reported data, but rather used first-time hospitalisation as a proxy for disability prevalence, this may explain the discordance of our findings compared with those reported in the literature. Further, the discordant results observed across countries may be "artefactual" due to data inadequacies and inconsistent definitions of morbidity and different methods of analysis, or may represent differences in cultural attitudes to disability, ageing and medicalisation.[9] Disability is a social construct because it refers to an individual's capacity to function or carry out a role in a given social and environmental context.[19] Therefore, studies attempting to measure disability per se are limited by both contextual and attitudinal elements intrinsic in the measurement. In our study we used first-time hospitalisation of a validated list containing over 300 conditions as the measure of disability. Thus, our study measured real changes over time in the occurrence of first-time hospitalisation for disabling conditions, a measure useful for comparing the burden of disability on the health system across different time periods.

The observed expansion of morbidity may reflect an "expansion of medicalisation" rather than an expansion of morbidity per se. Medicalisation can be defined as the adoption of a medical framework to understand a problem or the use of a medical intervention to treat the problem.[20,21] A combination of earlier detection and diagnosis as well as an increasing propensity to "medicalise" disease and disability may have implications for health care costs in addition to psychosocial ramifications for the patient. There are opposing arguments relating to this issue. If a patient assumes a "sick role" this may legitimise their subsequent withdrawal from normal responsibilities.[20] For an individual, knowing the extent of their disability does not necessarily translate into improved quality of life. In fact, it could potentially lead to anxiety or poorer health. On the other hand, early diagnosis of disability may provide a better prognosis or even a sense of relief for the patient as their problem has been labelled or identified.

Changing expectations associated with ageing are important when considering whether an expansion of medicalisation could account for the study findings. Whereas in the past individuals may have expected to be in a poorer state of health at older ages, it is now assumed that old age is associated with good health. As a result, changing expectations over time in addition to medical advances may have contributed to the increase in first-time hospitalisations observed over the study period.

Strengths and limitations of this study

These results must be interpreted within the context of the limitations and strengths associated with this study. The greatest limitation involved the definition of morbidity. While every effort was made to ensure a suitable operational definition, there is no "gold standard" for measuring disability.[22] Thus the results obtained relate to states of disability covered by the definitions used and are not generalisable beyond the boundaries of those definitions. Furthermore, our operational construct of the definition of morbidity assumed that disability commenced on the date of a first-time hospital admission with a specified pre-defined diagnosis. Therefore, it was impossible to adjust for stage of disease, recovery, remission or the effects of comorbidity. In addition, Creasey[23] has noted that many individuals struggle with disability long before being classified as disabled. Hence, the use of first-time hospital admission dates do not accurately measure the incidence of disability per se, but rather measure the incidence of first hospitalisation for disability.

There is also the possibility that changes over time in hospital admission policies may obscure underlying trends in disability incidence. This limitation may be likened to changes over time in reporting thresholds in disability surveys. Nevertheless, hospital admission data have the distinct advantages of objectivity and avoidance of recall bias. The implication of this is that rather than measuring the prevalence of morbidity per se, this

study measured the occurrence of morbidity involving at least one hospitalisation, that is, the "medicalisation of morbidity", a phenomenon inviting investigation in its own right.

Despite the limitations of the construct of morbidity, the working definition of morbidity was a strength. Creation of comprehensive lists of chronic disabling and activity limiting conditions was beyond the scope of our study, and therefore those conditions defined and validated by Ozminkowski et al[11] and LaPlante[12] were used. Ozminkowski et al[11] operationalised morbidity by identifying chronic disabling conditions on the basis of ICD diagnosis codes, which made them fully compatible with hospital morbidity data available in our study. In addition, a distinction was made between severe disability and more moderate disability as represented by the "chronic disabling" and "activity limiting" classifications. This allowed us to determine whether severe or moderate disability was a major driver of the overall expansion of morbidity. This was important since many chronic conditions are not necessarily associated with severe disability.

A major advantage of this study was the use of linked health data[24] which contained detailed information regarding almost 2 million individuals. This reduced selection bias and sampling error and increased power due to the extensive population coverage.

Conclusion

This study has evaluated the compression, expansion and dynamic equilibrium hypotheses from a unique vantage point using population-based data on first-time hospital admissions and deaths linked at the individual level. This study found evidence in support of an expansion of morbidity and evidence against the dynamic equilibrium theory. Although life expectancy was observed to increase over time, the observed increase in the prevalence of severe disability provided evidence for an expansion of morbidity. Due to the operational construct used in this study to measure disability this may reflect an increase in the "medicalisation of morbidity". This finding may have implications for both health costs and the future capacity to provide health care services.

Competing interests

The authors declare they have no competing interests

References

1 Zweifel P, Ferrari M. Is there a Sisyphus syndrome in health care? In: Health economics worldwide. Zweifel P, Frech H III, editors. Dordrecht, NL: Kluwer, 1992.

2 Access Economics. Population ageing and the economy. Canberra: Commonwealth Department of Health and Aged Care, 2001.

3 Mathers C. International trends in health expectancies: do they provide evidence for expansion or compression of morbidity? Compression of morbidity workshop papers. Commonwealth Government Occasional Papers Series No 4. Canberra: Department of Health and Aged Care, 1999.

4 Fries J. Aging, natural death and the compression of morbidity. *N Engl J Med* 1980; 303: 130-5.

5 Gruenberg E. The failures of success. *Milbank Mem Fund Q Health Soc* 1977; 55: 3-24.

6 Manton K. Changing concepts of morbidity and mortality in the elderly population. *Milbank Mem Fund Q Health Soc* 1982; 60: 183-244.

7 Mathers C, Robine J. International trends in health expectancies: a review. *Australas J Ageing* 1997; 17(1): 51-5.

8 Crimmins E, Saito Y, Ingegneri D. Trends in disability-free life expectancy in the United States. *Popul Dev Rev* 1997; 23: 555-72.

9 Productivity Commission. Economic implications of an ageing Australia. Research Report. Canberra: Productivity Commission, Australian Government, 2005.

10 Holman C, Bass A, Rouse I, Hobbs M. Population-based linkage of health records in Western Australia: Development of a health services research linked database. *Aust N Z J Public Health* 1999; 23 (5): 453-9.

11 Ozminkowski R, Smith M, Coffey R, et al. Private payers serving individuals with disabilities and chronic conditions. Washington: US Department of Health and Human Services, 2000.

12 LaPlante MP. Disability risks of chronic illnesses and impairments: disability statistics report 2. Washington, DC: National Institute on Disability and Rehabilitation Research, US Department of Education, 1991.

13 Brameld K, Holman C, Lawrence D, Hobbs M. Improved methods for estimating incidence from

linked hospital morbidity data. *Int J Epidemiol* 2003; 32: 617-24.

14 Australian Bureau of Statistics. 3201.0 — Population by Age and Sex, Australian States and Territories June 2005. Table 5 Estimated resident population by single year of age Western Australia. Canberra: ABS. http://abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3201.0Jun%202005?OpenDocument (accessed Sep 2005).

15 Lai D, Tsai S, Hardy R. Impact of HIV/AIDS on life expectancy in the United States. *AIDS* 1997; 11(2): 203-7.

16 Davis P, Mathers C, Graham P. Health expectancy in Australia and New Zealand. In: Determining health expectancies [e-book]. Robine J, Jagger C, Mathers C, et al, editors. Chichester: John Wiley, 2003.

17 Graham P, Blakely T, Davis P, et al. Compression, expansion, or dynamic equilibrium? The evolution of health expectancy in New Zealand. *J Epidemiol Community Health* 2004; 58(8): 659-66.

18 Organisation for Economic Cooperation and Development. Health Data 2004 [web page]. Available at: http://www.oecd.org/searchResult/0,3400,en_2649_201185_1_1_1_1_1,00.html (accessed Sep 2005).

19 Howse K. Increasing life expectancy and the compression of morbidity: a critical review of the debate. Working paper number 206. Oxford: Oxford Institute of Ageing, 2006.

20 Broom D, Woodward R. Medicalisation reconsidered: toward a collaborative approach to care. *Sociol Health Illn* 1996; 18(3): 357-78.

21 Conrad P. The shifting engines of medicalization. *J Health Soc Behav* 2005; 46(1): 3-14.

22 Dorevitch M, Cossar R, Bailey F, et al. The accuracy of self and informant ratings of physical functional capacity in the elderly. *J Clin Epidemiol* 1992; 45(7): 791-8.

23 Creasey H. Compression of morbidity: evidence in relation to the age of onset of neurological disorders. Compression of morbidity workshop papers. Commonwealth Government Occasional Papers Series No 4. Canberra: Department of Health and Aged Care, 1999.

24 Leibson C, Ballard D, Whisnant J, Melton L. The compression of morbidity hypothesis: promise and pitfalls of using record-linked data bases to assess secular trends in morbidity and mortality. *Milbank Q* 1992; 70(1): 127-40.

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