The morbidity profiles and lifetime health of Australian centenarians.

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STRUCTURED ABSTRACT

OBJECTIVES: To examine the lifetime prevalence and initial onset of diseases among centenarians.

METHOD: In this descriptive study, we administered structured questionnaires by interview to 188 centenarians and asked about the presence and timing of 14 common age-related diseases.

RESULTS: The most common conditions were ocular disease (70%), arthritis (58%) and hypertension (40%). Average age at disease onset was 80, and average number of comorbidities was 3, and participants were characterised into three morbidity profiles - survivors (46%), delayers (34%) and escapers (19%). No participants had a diagnosis of dementia or osteoporosis before age 80.

CONCLUSION: Relative to the general population, a select sample of Australian centenarians reported lower rates of chronic conditions, with many escaping osteoporosis, dementia, cardiovascular disease, respiratory illnesses, cancers, anxiety and depression. Increasing age is correlated with increasing morbidity but a few centenarians reached 100 years of age without disease.

INTRODUCTION

Centenarians, defined as people who have reached 100 years of age or more, represent one of the fastest growing age groups within industrialised nations (1). In Australia, the number of centenarians has increased from 131 in 1971 to 3,154 in 2006, and continue to grow rapidly at approximately 8.5% per year (1, 2). The fascination with centenarians lies not just in their demographic growth, but in their characteristic patterns of health, which is consistent with James Fries' compression of morbidity hypothesis (3). That is, the lifetime burden of illness could be compressed into a shorter period before the time of death if the onset of chronic illness could be postponed, and with this postponement in chronic disease onset is increased life expectancy (3-4). Indeed, centenarians appear to compress the onset and duration of many illnesses and age-related disability towards the end of their lives, and evade early-onset cardiovascular disease, cancer and dementia, which are significant causes of premature death in Australia (5, 6). As centenarians demonstrate resistance to age-related diseases and disabilities, this group demands closer examination to identify and predict those factors that will keep people healthy as they age.

In terms of health, there is some heterogeneity seen among individuals who reach 100 years of age (7, 8). Within the New England Centenarian Study (NECS), some centenarians had escaped or delayed the onset of age-related diseases, while others were able to achieve longevity despite multiple comorbidities. Evert et al. suggests there are multiple routes to achieving exceptional longevity, and categorised centenarians into three morbidity profiles (7). The term "Survivor" (38%) was used to describe centenarians who were diagnosed with at least one of the common age-related diseases before the age of 80. "Delayers" (43%) were centenarians who were diagnosed with at least one disease at or after the age of 80. "Escapers" (19%) reached 100 years of age without the diagnosis of any of the common age-related diseases. The presence or absence of the following age-associated conditions were used to determine morbidity profiles in the NECS: hypertension, heart

disease, diabetes, stroke, non-skin cancer, skin cancer, osteoporosis, thyroid condition, Parkinson's disease, and chronic obstructive pulmonary disease (7). Although a different set of diseases were examined, a similar proportion of Hungarian centenarians were escapers (20%) - that is, they had not experienced any major diseases during their lifetime (8).

Overall, very little work has described the multiple ways in which centenarians attain 100 years of age. Doing so will provide the basis for understanding the complexities of attaining exceptional longevity. People age with varying degrees of success (9) and the multiple pathways to ageing need to be better understood (10). This is the first study to assess the lifetime health histories of centenarians in Australia and to investigate whether the morbidity profiles described by Evert et al. demonstrate a similar distribution among Australian centenarians. The purpose of this study was to understand the health histories of centenarians, and to investigate their patterns of survival into extreme old age.

METHODS

Study Population

A total of 188 centenarians living in New South Wales, Queensland, Victoria, Australian Capital Territory, and South Australia participated in this descriptive study between 2007 and 2009. A convenience sampling approach, including telephoning all residential aged care facilities in Sydney, Brisbane, Melbourne and Gold Coast listed in the Aged Care Directory Online; identifying centenarians in local and national news items; liaising with general practitioners; and engaging aged care support groups, was used to identify participants. All participants who responded to our recruitment strategies above were included in the study. Details of the study design, recruitment and baseline characteristics of centenarians have been described elsewhere (11, 12). In short, the sample comprised 37 males (20%) and reported a mean age of 101 years (SD 1.71) at interview. The majority of the sample (n=113, 61%) were born in Australia or England (n=28, 15%), and were currently living in a Nursing Home (n=89, 52%) or low-care hostel setting (n=41, 22%). Some centenarians were still living in the general community, in a retirement village (n=15, 9%) or in their own homes (n=17, 10%). Eighty two percent of the sample had children (average of 2 children, range 0-7). The sample reported generally positive feelings about living to 100, with 79% rating living to 100 as “good”, “very good” or “excellent”. This study was approved by the University of New South Wales Human Research Ethics Committee (HREC 07144).

Age Validation

Most individuals who turn 100 in Australia receive congratulatory cards and letters from Queen Elizabeth II of England; the Governor-General of Australia; and the Prime Minister of Australia.

All centenarians in our sample received these congratulatory notifications and these documents were sighted to validate that centenarians were indeed 100.

Data Collection

After recruiting centenarians by telephone and mail, researchers visited the participants individually at their place of residence to conduct the health questionnaires by interview. Almost all carers were present at the interviews to assist with answering and to validate centenarians' responses except in circumstances where centenarians did not qualify for caregivers (i.e. sufficient in all Activities of Daily Living, or did not have a surviving next-of-kin). Input from support people was only sought for objective measures, e.g. medical conditions, medications, functionality and only in cases where this could not be determined directly from the centenarian participant. Participants (and their carers) reported to-date diagnoses of 14 common age-related illnesses and reported the approximate age at diagnosis for the following diseases: heart disease, cerebrovascular disease, hypertension, skin cancer, non-skin cancer, diabetes, respiratory illnesses, thyroid conditions, ocular disease, osteoporosis, arthritis, dementia, depression and anxiety. The presence of a specific disease was based on having a medical diagnosis made by a physician at some stage in their lives. Medical records at aged care facilities were also examined for any medical conditions or diagnoses that may have been omitted. In virtually all cases, diagnoses were not missed in self-reports by centenarians and their caregivers.

Several of the diagnoses required clarification. The presence of osteoporosis was defined by a physician's diagnosis of osteoporosis. Heart disease was defined by a positive diagnosis of: angina, heart attack, cardiac arrhythmia, or congestive heart failure. Cerebrovascular disease encompassed strokes as well as transient ischaemic attacks. The insidious onset of dementia prevented us from accurately assessing the age at onset of cognitive impairment, but the current cognitive status of

centenarians was also assessed using the Mini-Mental State Examination (MMSE, 13), with scores below 21 on the MMSE indicative of cognitive impairment for this age group (23). Likewise, the age at onset and diagnosis for anxiety was unable to be determined. Respiratory conditions encompassed asthma, pneumonia, COPD and other single-occurrence severe chest infections.

Statistical analyses

The statistical analysis was performed using Statistical Package for the Social Sciences Version 17 for Windows. Descriptive statistical analyses were used, and chi-square tests were conducted on selected measures.

Morbidity profiles

The NECS found that their centenarians fell into three age-defined categories of when medical conditions first became clinically evident (7). Participants who had an age of onset of less than 80 years for at least one of the diseases were termed “Survivors”. Those classified as “Delayers” had an age of onset of disease between 80 and 100 years of age. Those categorised as “Escapers” had no diseases prior to age 100. We similarly categorised our participants into one of the three groups. Although the NECS only categorised participants according to the age of onset for three conditions (heart disease, stroke and non-skin cancer), we also grouped participants into these morbidity profiles for each medical condition individually, and then for all conditions.

RESULTS

Of the 188 participants, there were 151 females (80%) and 37 males (20%) and the mean age was 101 years old. The mean age of female participants (n=151) was 101.2 ± 1.7 years old, and the mean age of male participants (n=37) was 100.9 ± 1.65 years old. The participants were all caucasians. The mean Mini-Mental State Examination score was 21.5 (SD 7.38).

The lifetime prevalence and mean ages of onset for the 14 medical conditions are shown in Table 1. The most prevalent conditions were ocular disease (mainly cataracts) (71%), followed by arthritis (58%) and hypertension (40%). Other than ocular disease and arthritis, the most common diseases were hypertension among women (43%) and skin cancer among men (51.5%). In terms of gender differences, the prevalence of skin cancer was significantly greater in male centenarians (51.5% vs 22%) (χ=11.9, p=0.001). The mean age of diagnosis was significantly lower in women than in men for depression (51 vs 98 years old, p=0.034). No other significant gender effects were found.

Table 1. Prevalence of diseases and age at diagnosis

Disease	**Men**			**Women**			**Total**		
	Prevalence[1] (%)	Diagnosis Age Range (y)	Diagnosis Mean Age (y)	Prevalence[1] (%)	Diagnosis Age Range (y)	Diagnosis Mean Age (y)	Prevalence[1] (%)	Diagnosis Age Range (y)	Diagnosis Mean Age (y ± SD)
Heart disease	31.3	65-97	83.2	30.3	55-103	87.8	30.5	55-103	86.8 ± 12.1
Cerebrovascular disease (including TIA)	31.0	90-99	94.0	21.8	66-103	91.8	23.5	66-103	92.4 ± 7.9
Hypertension	28.1	25-90	72.3	42.9	37-98	79.0	40.1	25-98	77.9 ± 19.4
Non-skin cancer	18.2	50-101	79.5	13.1	47-99	83.3	14.0	47-101	82.3 ± 18.8
Skin cancer	51.5	55-90	78.0	21.9	30-102	80.0	27.4	30-102	79.3 ± 20.5

Diabetes mellitus	12.5	85	85.0	9.7	70-100	88.33	10.2	70-100	87.5 ± 13.2
Respiratory condition	16.1	**	**	25.4	2-103	**	23.5	**	64.1 ± 39.1
Thyroid disorder	9.4	**	**	8.7	20-97	**	8.8	**	56.2 ± 30.5
Ocular disease	64.5	20-100	79.1	71.9	0-103	82.4	70.6	0-103	81.8 ± 22.9
Osteoporosis	16.7	98-99	98.5	30.7	80-99	91.2	28.1	80-99	92.0 ± 5.5
Arthritis	58.3	80-102	80.0	58.0	55-102	82.2	58.1	55-102	82.1 ± 15.2
Depression	18.2	97-100	98.3	18.3	13-99	50.6	18.3	13-100	66.5 ± 38.3
Anxiety	0.0	**	**	4.1	**	**	3.3	**	**
Dementia	15.6	98	98.0	21.2	88-98	95.2	20.1	88-98	95.7 ± 3.9

** Difficult to ascertain time at diagnosis and/or missing information

[1] Please note that the sample could have been diagnosed with more than one disease at the time of survey. Hence, percentages do not add to 100%.

The average age of onset of initial disease was 80 years old (95% CI 77.3, 84.4). Participants had an average of 3 comorbidities (95% CI 2.8, 3.3), and men and women did not differ significantly in terms of their number of comorbidities.

We then categorised participants as survivors, delayers or escapers. When considering all conditions, 46% of participants were survivors (at least one disease with age of onset < 80 years old), 34% were delayers (at least one disease with onset between 80-99 years old) and 19% were escapers (no diseases prior to age 100). Overall, there was no difference in the likelihood of men or women being survivors, escapers or delayers. When considering only the three conditions - heart disease, stroke, and non-skin cancer - there were 6% survivors, 20% delayers and 74% escapers. Table 2 indicates the frequency with which centenarians fall into each of these categories when the 14 conditions are considered individually. No participants had a diagnosis of dementia or osteoporosis before age 80. There were no differences between men and women in terms of being

an escaper, delayer or survivor for any condition with the exception that females were more likely to be survivors of depression than males (χ=6.7, p=0.036).

Table 2. Survivors, delayers and escapers according to specific medical conditions

Disease	**Survivors (%)**	**Delayers (%)**	**Escapers (%)**
Heart disease	2.7	12.4	84.9
Cerebrovascular disease	0.6	15.5	83.9
Hypertension	2.8	9.4	87.8
Non-skin cancer	2.7	5.4	91.9
Skin cancer	5.9	9.7	84.4
Diabetes mellitus	0.6	1.6	97.8
Respiratory condition	0.5	5.4	94.1
Thyroid disorder	2.7	1.6	95.7
Ocular disease	6.5	29.7	63.8
Osteoporosis	0.0	9.7	90.3
Arthritis	5.0	13.8	81.2
Depression	2.2	3.8	94.0
Dementia	0.0	3.2	96.8
Heart disease, stroke and non-skin cancer only	6.4	19.7	73.9
All conditions	46	35	19

DISCUSSION

The most common condition among centenarians in this study was ocular disease (mainly cataracts) (71%) as well as in the NECS (82% had cataracts) (7). In addition, 49% of Hungarian centenarians would be considered legally blind (8). The most frequent conditions in the Hungarian study were cardiac decompensation (26%), dyspnoea (24%), kyphosis, kyphoscoliosis or scoliosis (39%) and emphysema (21%) based on medical examinations by doctors (8). Based on structured questionnaires, we found that apart from ocular disease, arthritis (mainly osteoarthritis) (58%), hypertension (40%), and heart disease (30.5%) were most common. Similarly, heart disease (40% in women, 42% in men) and hypertension (35% in women, 19% in men) were most common among centenarians in the NECS (7). In support of the NECS, we found a higher prevalence of hypertension among women, although this result was not statistically significant in our study. On the other hand, we found that skin cancer (almost all were basal cell carcinomas and squamous cell carcinomas) was the second most prevalent condition among men, and was significantly more prevalent among men than women. This is comparable to national statistics in which the incidence of non-melanoma skin cancer was estimated to be 53% higher in Australian males than females in 2002 (14).

Evert et al. proposed that the emergence of the morbidity profile suggests that there are numerous routes to attaining extreme longevity (7). The data shows that although a proportion of centenarians are able to escape or delay the onset of diseases associated with ageing, others are simply able to live with diseases that would otherwise cause mortality at younger ages. When considering only the three major lethal illnesses (heart disease, stroke, and non-skin cancer), we had more escapers in our study compared to the NECS: 74% vs 19% (7). Heart disease, stroke and non-skin cancer are the leading causes of premature death in Australia (6), and our results suggest that the ability to evade these conditions maximises one’s chance of attaining exceptional longevity. When

considering all conditions, we had 19% escapers, which was close to the proportion of escapers (20%) in the Hungarian centenarian study (8). But in most cases, survivors and delayers predominated. Evert et al. suggests that medical advancement and better preventive measures have contributed to survival into older ages (7). Therefore more people will be able to live longer with disease and perhaps achieving centenarian status is not only reserved for those who escape lethal diseases.

However, unlike the present study and the NECS in which 19% of centenarians were disease free at age 100 (7), the Danish centenarian study reported that only one of the 207 centenarians was free from disease (15). Prevalences of certain diseases also varied widely between studies of centenarians, with higher cardiovascular disease (72% in the Danish, 40% in the NECS and 30% in the current study) and higher dementia rates (52% in the Danish, ~79% in the NECS and 19% in this study) reported in the other two studies compared to the current one. The variation between studies most likely relates to the different disease definitions as well as the fact that investigations (e.g. ECGs to detect myocardial infarction and blood tests to detect undiagnosed diabetes mellitus) used in the Danish centenarian study was a more sensitive measure than questionnaire-based methods used in the current study and in the NECS. Further, the Danish Centenarian Study included all 100-years-olds in Denmark identified through a central register between 1995-1996 whereas our study may be biased by the practical selection of relatively healthy survivors (limited to those who were healthy enough to be interviewed). Despite the differences in prevalence, all 3 studies concluded that although it is a rare occurrence, a very small proportion of centenarians were cognitively intact and disease-free in their centenary years (~20%) (7, 8, 15).

The majority of centenarians reached 100 years of age without heart disease, stroke and non-skin cancer, osteoporosis and dementia, which are common causes of mortality in the elderly. In fact, very few centenarians experienced these conditions before age 80 which suggests that it is difficult

to survive > 20 years with these diseases which are otherwise associated with significant mortality on the population level. It also suggests that the absence of these diseases is a significant predictor of one's ability to attain exceptional longevity. Even at 100 years of age, the prevalence of cardiovascular disease was relatively low. Cardiovascular disease (including heart disease and stroke) is Australia's second leading cause of disease burden and the largest single cause of mortality in Australia, and the prevalence increases with age (16). In 2004-05, cardiovascular disease was reported in 13% of people aged 35-44, 23% of people aged 45-54 and 63% of those aged 75 years and over (17). Cardiovascular disease was reported in only 53% of centenarians in our sample, which may be an over-estimate as we included transient ischaemic attacks in the analysis.

Regarding specific conditions, only 10% had a lifetime history of diabetes which is almost identical to rates reported in the Danish (10%) (15) and Swedish studies (9%) (18). Although age is a major risk factor for diabetes (6), the prevalence of diabetes among centenarians in our study was less than that among Australians aged 65-74 years (14%) (19). Cancer is a frequent disease among older persons, and by age 75 years, 1 in 3 Australian males and 1 in 4 Australian females will have been diagnosed with cancer in their lifetime (excluding squamous cell carcinoma and basal cell carcinoma); and this risk increases to 1 in 2 males and 1 in 3 females by age 85 (6). Surprisingly, only 14% of centenarians (1 in 9 centenarians) in our study had a lifetime history of non-skin cancer, which is exceptionally low compared to national statistics. The prevalence of cancer was also low in the NECS (20% prevalence of non-skin cancer) (7) and in the Swedish Centenarian Study (6% in men and 16% in women) (18). Smith (1998) reported that although cancer deaths accounted for ~40% of deaths in adults aged 50-69 years old, cancer comprised only 4% of total deaths among centenarians (20). The above findings collectively suggest that perhaps centenarians share some resistance to malignancy, either through environmental or genetic mechanisms, which deserves further investigation.

Although the NECS found that female centenarians were more likely to be survivors of diseases, and that male centenarians had fewer comorbidities than their female counterparts, our study did not detect major gender differences in terms of the morbidity profiles (7). Our study is limited by the smaller number of male participants, which reflects the ratio of female:male centenarians in Australia (4:1), but means our results need to be interpreted with caution.

Limitations

There were several limitations in this study. First, self-report of disease prevalence has limitations. However, centenarians in this study were represented by carers in almost all cases, most often their child. The carer's validated centenarian responses and were able to report any missed diagnoses or inaccuracies. Further, nursing home records were reviewed to detect omitted diagnoses. Studies have also shown that self-recall of diagnosis for major chronic conditions is accurate and the accuracy is not majorly affected by education, sex nor race of participants (7, 21). Nevertheless, these results should be viewed within the practical limitations of data collection. We also had a small number of male participants, and our sampling techniques may have imparted bias on our results, as discussed above.

Conclusion

In this select sample of centenarians, there was a lower prevalence of chronic medical conditions among centenarians compared to the general Australian population; and the age of onset of these conditions, if they occurred, was considerably delayed, especially for osteoporosis and dementia. A further discussion on the cognitive status of centenarian sample is described elsewhere (22), however the MMSE results confirm that the majority of our sample (n=110, 66%) was cognitively

intact. Although cardiovascular diseases, cancers and respiratory diseases remain the leading cause of overall death in Australia, the prevalences of these conditions were significantly lower among centenarians in our sample (6). This was also true for anxiety and depression, which are major contributors to the burden of disease in Australia (6)**.** The emergence of morbidity profiles suggest that centenarians are fairly heterogeneous compared to one another, and a combination of particular genetic and environmental factors – which enable one to delay the onset of chronic disease and then to cope with illness for a very long time – is a common route to longevity. This is supported by our study findings that the majority of centenarians were "survivors" rather than "escapers". Finally, the overall finding is that increasing age *is* correlated with increasing morbidity. However the majority of our sample reported a high quality of life despite the presence of illness, objective deterioration in functional status, and a high dependence on others for everyday tasks (22). Potentially, this is suggestive of a unique ability within the sample to adapt to ageing and its limitations. Further, although the majority of centenarians had multiple comorbidities, a minor proportion were relatively disease-free, indicating that it is possible for some to achieve extreme old age and still be functioning relatively well.

Conflict of interest: Nil

There are no conflicts of interest related to the material in the manuscript. I certify that all conflict of interest with the subject matter or materials discussed in the manuscript are completely disclosed (e.g., employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, royalties).

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