Is mortality from heart failure increasing in Australia? An analysis of official data on mortality for 1997–2003

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Objective To assess whether trends in mortality from heart failure (HF) in Australia are due to a change in awareness of the condition or real changes in its epidemiology.
Methods We carried out a retrospective analysis of official data on national mortality data between 1997 and 2003. A death was attributed to HF if the death certificate mentioned HF as either the underlying cause of death (UCD) or among the contributory factors.
Findings From a total of 907 242 deaths, heart failure was coded as the UCD for 29 341 (3.2%) and was mentioned anywhere on the death certificate in 135 268 (14.9%). Between 1997 and 2003, there were decreases in the absolute numbers of deaths and in the age-specific and age-standardized mortality rates for HF either as UCD or mentioned anywhere for both sexes. HF was mentioned for 24.6% and 17.8% of deaths attributed to ischaemic heart disease and circulatory disease, respectively, and these proportions remained unchanged over the period of study. In addition, HF as UCD accounted for 8.3% of deaths attributed to circulatory disease and this did not change materially from 1997 to 2003.
Conclusion The decline in mortality from HF measured as either number of deaths or rate probably reflects a real change in the epidemiology of HF. Population-based studies are required to determine accurately the contributions of changes in incidence, survival and demographic factors to the evolving epidemiology of HF.

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Introduction

Heart failure (HF) is a disabling chronic disease and a major cause of morbidity and mortality among older adults.[1] Despite its being a significant burden on health-care systems, especially with recent improvements in survival of patients with HF,[2–4] the epidemiology of HF is incompletely understood. There are numbers of reports referring to an "epidemic" of HF in developed countries.[5–8] However, recent declines in incidence, case fatality and mortality from major antecedents of HF, ischaemic heart disease (IHD) and hypertensive heart disease, suggest that the incidence and mortality of HF might also be changing.[3,9–11] Untangling this conundrum requires careful investigation of the relevant epidemiological indices of HF.

In countries with complete vital registration, mortality data can provide valuable information on the epidemiology of HF. While many studies have used data on the single underlying cause of death (UCD) given in official statistics to estimate the mortality from particular diseases,[12–15] this strategy can underestimate mortality associated with some conditions such as HF that are regarded as a "mode of death" rather than an underlying "cause of death".[16] For example, in Australia in 2002, HF was the official cause of only 2% (2729) of all deaths,[17] which appears to be inconsistent with first-year case fatality for HF of 24–28% and an estimated incidence of 30 000 cases per year.[3,17]

There are additional problems related to use of mortality statistics for conditions whose incidence rises sharply with increasing age. The presence of several chronic conditions in many elderly individuals makes it difficult to identify the exact single UCD. Thus, even where medical certification of cause of death is universal, three factors complicate the use of official mortality statistics to study trends in HF. These are: lack of precision in the diagnosis, certification rules about not ascribing fatalities to a "mode of death", and the presence of multiple co-morbidities.

The study of trends in mortality is potentially complicated by the change from the 9th to the 10th revision of the *International classification of diseases* (ICD) in the late 1990s, and perhaps also by the adoption of new diagnostic criteria for acute myocardial infarction, which could influence clinical perceptions as to which individuals are at special risk of developing HF.

Complete death registration and certification of all deaths by a medical practitioner facilitate the study of mortality as one of the main epidemiological features of HF in Australia. Furthermore, recording and coding, within official mortality data, of multiple conditions contributing to death provides an important opportunity to examine not only trends in HF as the UCD, but also in the proportion of all deaths to which HF is believed to have contributed and in other conditions that might "compete" with HF for identification as the UCD. This paper presents a detailed examination of HF as the single cause of death and as a contributor to all deaths in Australia in 1997–2003, when all deaths were coded using ICD-10, to determine whether

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recent changes in antecedent factors in Australia are reflected in changes in mortality from HF.

Methods

Data sources

We obtained computerized records for calendar years 1997–2003 from the Australian Institute of Health and Welfare (AIHW), which collates information on all deaths occurring in Australia. Mortality data in Australia are coded using ICD-10 rules, meaning that ill-defined conditions such as HF are less likely to be accepted as the UCD even if they had been certified as the UCD. We selected all death certificates on which HF was mentioned as the underlying cause or another contributory factor in the death. Data on the Australian population for each year of the study, disaggregated by sex and age, were obtained from the Australia Bureau of Statistics.[18]

Measurement of HF-related mortality and other associated causes

Australia has used ICD-10 to classify mortality data since 1997. In the present study a death was defined as involving HF if at least one of the causes of death was coded to any of the following ten rubrics: hypertensive heart disease with congestive heart failure (I11.0), hypertensive heart and renal disease with congestive heart failure (I13.0), hypertensive heart and renal disease with heart failure and renal failure (I13.2), ischaemic cardiomyopathy (I25.5), chronic constrictive pericarditis (I31.1), dilated cardiomyopathy (I42.0), alcoholic cardiomyopathy (I42.6), congestive heart failure (I50.0), left ventricular heart failure (I50.1), or heart failure, unspecified (I50.9). In addition, to find other conditions associated with HF either as the UCD or as a contributory factor, we identified all mortality records mentioning IHD and circulatory disease as defined by the relevant chapter of ICD-10.

Statistical analysis

The data were analysed using Stata version 8.[19] We calculated age- and sex-specific mortality rates for HF for each year by dividing the number of deaths attributed to HF by the relevant population during that year. Mortality rates were standardized using the "European" population,[20] treating people aged less than 60 years and 85 years and older as single groups, and employing 5-year age groups to age 85 years. We calculated the mortality rate for HF as the UCD or where HF was mentioned anywhere on the death certificate separately for each year. We estimated trends for both mortality rates and crude total numbers of deaths associated with HF and calculated changes relative to levels in the first year of study.

In order to investigate the extent to which changes in certification or coding practice may have contributed to changes in mortality from HF, we examined trends in other diagnoses associated with HF in two ways. First, we examined the proportion of deaths ascribed to IHD and other circulatory disease in which there was mention of HF. Second, among deaths assigned to HF as UCD, we examined the proportion with mentions of IHD or other circulatory disease. We also examined the trend in the proportion of all deaths from circulatory disease and of all deaths that had mention of HF on the death certificate.

Results

In 1997, the total numbers of deaths attributed to HF as UCD or mentioned anywhere on the death certificate were 4667 and 20 614, respectively (Table 1). From 1997 to 2003 the annual numbers of deaths with HF as UCD or mentioned anywhere on the death certificate fell to 3661 and 18 491, decreases of 21.6% and 10.3%, respectively. In each year the number of deaths in women exceeded those in men; over the 7 years, women accounted for 53.9% of deaths for which HF was mentioned anywhere on the death certificate.

Mortality rates

The overall age-standardized mortality rates for HF as UCD or mentioned anywhere were 17.1 and 78.8 per 100 000 person-years, respectively. Mortality rates for HF rose sharply with age (Table 2), but decreased in all age groups and both sexes over the study period, such that age-standardized rates for HF as UCD fell by 38% and 39% in men and women, respectively (Table 1). The decreases were inversely related to age and were least in men and women aged 85 and older (1.3% and 5.7%, respectively).

The age-standardized mortality rate was higher in men than in women. This was true for HF either as the UCD or

Table 1. **Number of deaths involving heart failure and mortality rates, Australia, 1997–2003**

Year	No. of deaths						Age-standardized mortality rate[a]					
	Heart failure as UCD[b]			Heart failure mentioned anywhere on death certificate			Heart failure as UCD			Heart failure mentioned anywhere on death certificate		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
1997	2057	2610	4667	9503	11 111	20 614	25.0	18.5	21.5	113.7	79.8	94.5
1998	1892	2447	4339	9166	10 423	19 589	22.2	16.7	19.2	105.5	72.5	86.8
1999	1923	2493	4416	9127	10 480	19 607	21.7	16.0	19.0	101.3	69.6	83.7
2000	1855	2357	4212	8780	10 388	19 168	20.2	14.7	17.3	94.1	66.4	78.4
2001	1721	2194	3915	8475	10 070	18 545	18.0	13.3	15.4	87.2	61.7	72.8
2002	1797	2334	4131	8769	10 485	19 254	18.0	13.3	15.6	86.3	61.3	72.2
2003	1616	2045	3661	8490	10 001	18 491	15.4	11.3	13.3	80.4	56.7	67.0

[a] Mortality rates per 100 000 person-years standardized using the "European" population as the external reference.
[b] UCD = Underlying cause of death.

Table 2. **Age-specific and age-standardized mortality rates[a] for heart failure, Australia, 1997–2003**

Age groups	Heart failure as the underlying cause			Heart failure mentioned anywhere on the death certificate		
	Male	Female	Male:female ratio	Male	Female	Male:female ratio
<60	1.9	0.6	3.2	7.0	3.1	2.3
60–64	20.7	7.5	2.7	88.4	42.6	2.1
65–69	35.7	16.6	2.2	175.8	87.8	2.0
70–74	69.5	32.9	2.1	375.2	200.0	1.9
75–79	133.1	82.2	1.6	726.5	442.7	1.6
80–84	283.6	211.2	1.3	1506.0	1053.1	1.4
⩾ 85	819.8	839.4	0.98	3672.1	3282.4	1.2
Age-standardized[b]	19.8	14.7	1.4	94.8	66.4	1.4

[a] Other than the sex ratios, all figures in the table are rates per 100 000 person-years.
[b] Standardized using the strata indicated and the "European" population as the external reference.

when it was mentioned anywhere on the certificate, but the excess in males decreased with increasing age such that, among people aged 85 years and older, mortality from HF as UCD was higher in women than in men (Table 2).

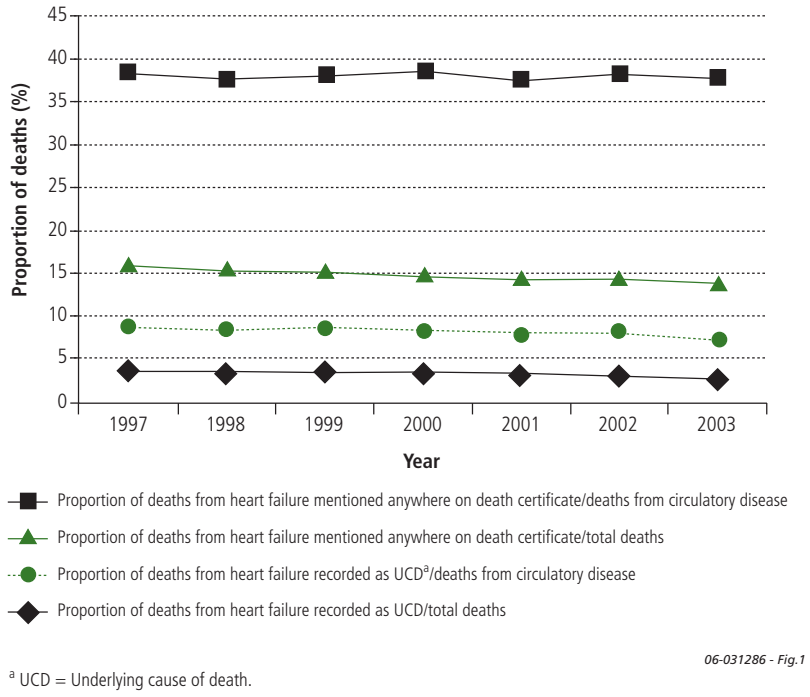
Deaths from HF as a proportion of all deaths and deaths due to circulatory disease

HF as UCD accounted for 3.2% of all deaths and 8.3% of deaths due to circulatory disease. Both of these proportions fell slightly during 1997–2003 (Fig. 1). Deaths with any mention of HF made up 14.9% of all deaths, with a small decrease over the period. Among deaths ascribed to circulatory disease, 38.1% had any mention of HF and this proportion did not change over time.

Relationship between deaths from HF, IHD and circulatory disease

In 1997, 24.8% and 18.3% of all deaths attributed to IHD and circulatory disease mentioned HF as a contributory factor (Fig. 2). These proportions remained stable over the period of study, and were 24.1% and 17.3%, respectively, in 2003.

Fig. 1. **Trends in the proportions of deaths involving heart failure, Australia, 1997–2003**



[a] UCD = Underlying cause of death.

IHD was mentioned on only 2.8% of certificates nominating HF as the UCD. The corresponding proportion for other circulatory disease was 36.3%. Neither of these proportions changed markedly over the period of study.

Discussion

This study shows a large decline in the mortality rate for HF in Australia since 1997. Several factors suggest that this decline is real and not an artefact arising from changes in writing or coding death certificates. These include the magnitude of the change (38% in 7 years), the unchanging contribution of HF to total cardiovascular mortality, the unchanging proportions of deaths from IHD and circulatory disease with mention of HF, and the very small decreases in HF relative to total mortality.

Rule 3 of ICD-10 specifies that HF should not be recorded as the UCD. Thus, at least some of the deaths ascribed by the certifying doctors to HF will be officially allocated to other conditions such as IHD by the specialist nosologist coding death certificates. However, our data showing no changes in the proportions of deaths from IHD and circulatory disease with mention of HF as a contributory cause suggest that the extent of reassignment of deaths initially ascribed to HF has not changed over the study period. Thus, change in coding practice is very unlikely to have made a major contribution to the decline in mortality from HF that we observed. The unchanged relationship of HF to total mortality from circulatory disease adds further support to this conclusion.

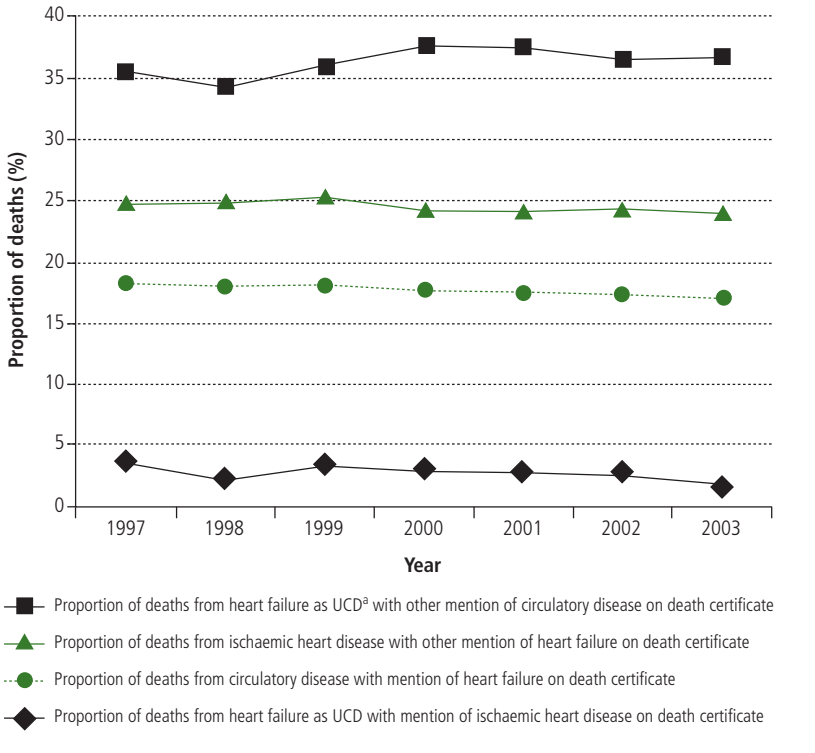
The decrease in mortality from HF in Australia appears to be at odds with

recent reports from several comparable countries of an "epidemic" of HF.[5–8] However, imprecise use of epidemiological terms is contributing to the confusion about the speed and direction of changes in HF. For example, there is a need to distinguish between "incidence", meaning new cases of HF in a specific period, and "case-load", meaning the count of prevalent cases. The case-load partly reflects the size of the population at risk, which is increasing as the population ages. Therefore the case-load can increase while incidence is stable or even falling. HF may have become relatively more prominent in cardiologists' work because of increased diagnostic activity due to changes in techniques of investigation, or the advent of more effective therapies that extend survival of patients with HF, or because other conditions are becoming less common. Claims that we are in the midst of an "epidemic of heart failure"[5] therefore need to be examined critically.

Apart from changes in the preparation and classification of death certificates (discussed above and seen to be unlikely as a cause of the observed decrease), several other factors affect deaths from HF. As mortality from HF is strongly related to age, the increase in the Australian population aged 75 years and older from 5.1% in 1997 to 6.0% in 2003 might have been expected to precipitate an increase in absolute numbers of deaths from HF, but in fact these decreased over the study period. At the same time, the continuing decline in incidence of IHD[21] and better care for this condition might have resulted in a decrease in incident cases of HF.[22,23] Thus, a decline in the incidence and even the population-wide prevalence of HF is one possible explanation for the observed decline in mortality from HF.

Another possible explanation for observed trends is better care for HF patients.[24] Despite continuing underutilization of effective treatment in patients suffering from HF (such as angiotensin-converting enzyme inhibitors, beta-blockers, warfarin and angiotensin-II antagonists),[25] earlier diagnosis of HF (as a result of increased use of diagnostic procedures) and increasing use of proven treatments[26,27] should have lengthened survival of affected patients. This would increase the period in which competing causes of death could exact their toll. However, without detailed information on the magnitude of each of these effects, it is difficult to quantify the contribution of such factors to the observed decline in mortality from HF in Australia.

Fig. 2. **Trends in mortality involving heart failure, expressed as proportion of deaths attributable to ischaemic heart disease and circulatory disease, Australia, 1997-2003**



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[a] UCD = Underlying cause of death.

The results of this study are consistent with previous reports on mortality from HF in Australia that indicate a downward trend from 1981, although these studies were based on analysis of UCD alone.[17,28] While studies in Canada and the USA did not show consistent results,[13,15] mortality from HF has been falling in England, Scotland and Spain.[12,29,30] These trends are based on age-standardized mortality rates and therefore will not be distorted by changes in the age structure of the relevant populations.

Except for the studies in Scotland and England that identified HF mentioned anywhere on the death certificates, all previous reports have been based on HF as UCD. Consequently, in addition to underestimating the real contribution of HF to mortality, variation in selection and recording of HF as the UCD in different countries and periods might produce some systematic errors.[31] Furthermore, all of those studies were conducted before 1997 and employed ICD-9. The increasing use of echocardiography for diagnosis of HF since 1997 potentially affords greater diagnostic precision, but may have increased the case-load of diagnosed cases, while possibly also decreasing their average severity. On the other hand, many international studies in the 1990s reported considerable underutilization of angiotensin-converting enzyme inhibitors, beta-blockers, and warfarin, which would have contributed to an avoidably high case fatality in HF.[32–34]

Study limitations

Official mortality statistics are open to artefacts related to changes in diagnostic practice and technology concerning particular conditions, customs for the completion of death certificates, and use of new systems and rules for selecting and recording the single UCD. In addition, diagnoses of HF might vary systematically between different populations, doctors and sets of diagnostic criteria, which may preclude generalization of our estimated rates to other countries.[35,36] However, these potential

difficulties probably do not affect the trends we observed during the period studied. As Australia has complete death registration with certification by medical practitioners or coroners, official data on Australian mortality are regarded as being of high quality.[37] Our data allow us to rule out a shift away from HF to other cardiovascular conditions in the recording and coding of deaths as the explanation for the decrease in mortality from HF that we have documented. They also relate to a period in which a single system of classification was used to identify and code the UCD.

Conclusion

We have demonstrated a major decline in mortality from HF in Australia over recent years. Rather than being an artefact related to changes in certification of death or coding the death certificates, this decline is likely to reflect a real change in the epidemiology of HF. A prospective population-based cohort study would help to determine whether this trend reflects primarily a decline in the incidence of HF, reflecting a decrease in the incidence of IHD, or improved care of patients with IHD, or better management of established HF and reduced case-fatality in this condition. ■

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Résumé

Evolution de la mortalité par insuffisance cardiaque en Australie. Une analyse des données officielles de mortalité de 1997 à 2003

Objectif Déterminer si les tendances de la mortalité par insuffisance cardiaque en Australie résultent d'une amélioration du diagnostic et de la prise en charge de cette affection ou d'une véritable évolution épidémiologique.

Méthodes Une analyse rétrospective a été effectuée sur les données nationales officielles de mortalité pour la période 1997-2003, un décès étant attribué à une insuffisance cardiaque si le certificat de décès mentionnait celle-ci comme cause primaire (initiale) de décès ou comme un des facteurs contributifs.

Résultats Sur 907 242 décès, l'insuffisance cardiaque a été indiquée comme cause primaire dans 29 341 cas (3,2 %) et mentionnée par ailleurs sur le certificat de décès dans 135 268 cas (14,9 %). Entre 1997 et 2003, on a constaté concernant l'insuffisance cardiaque une diminution en valeur absolue de la mortalité par âge et des taux de mortalité standardisés selon l'âge pour les deux sexes, que cette pathologie soit indiquée comme cause primaire ou autre du décès. L'insuffisance cardiaque a été mentionnée respectivement dans 24,6 % et 17,8 % des décès imputés à une cardiopathie ischémique et à une affection circulatoire, les proportions n'ayant pas varié au cours de la période étudiée. En outre, l'insuffisance cardiaque comme cause primaire de décès a représenté 8,3 % des décès attribués à une affection circulatoire et cette proportion n'a pas sensiblement évolué entre 1997 et 2003.

Conclusion La diminution de la mortalité par insuffisance cardiaque mesurée au moyen du nombre de décès ou du taux de mortalité traduit probablement une vraie évolution de l'épidémiologie de cette affection. Des études en population s'imposent pour déterminer exactement les contributions des variations de l'incidence, du taux de survie et des facteurs démographiques dans cette évolution épidémiologique.

Resumen

¿Está aumentando la mortalidad por insuficiencia cardiaca en Australia? Análisis de los datos oficiales sobre la mortalidad en 1997–2003

Objetivo Determinar si las tendencias de la mortalidad por insuficiencia cardiaca (IC) en Australia se deben a diferencias de la sensibilización sobre esa enfermedad o a cambios reales de la epidemiología de la dolencia.

Métodos Llevamos a cabo un análisis retrospectivo de los datos oficiales sobre la mortalidad a nivel nacional entre 1997 y 2003. Se consideró que una defunción era atribuible a IC cuando el certificado de defunción mencionaba ese factor como causa de la muerte o como uno de los factores contribuyentes.

Resultados De un total de 907 242 defunciones, la insuficiencia cardiaca aparecía codificada como causa de defunción en 29 341 casos (3,2%), y se mencionaba en algún lugar en otros 135 268 casos (14,9%). Entre 1997 y 2003 se registraron disminuciones del número absoluto de defunciones y de las tasas de mortalidad por edad y normalizada por edad para la IC tanto cuando ésta era la causa de defunción como cuando simplemente se mencionaba, y ello en los dos sexos. La IC se mencionaba en el 24,6% y el 17,8% de las defunciones atribuidas a cardiopatía isquémica y a enfermedades del aparato circulatorio, respectivamente, y esos porcentajes se mantuvieron prácticamente estables entre 1997 y 2003.

Conclusiones La disminución de la mortalidad por IC medida ya sea como número de defunciones o como tasa refleja probablemente un cambio real de la epidemiología de esa dolencia. Es preciso llevar a cabo estudios poblacionales para determinar con precisión la contribución de las variaciones de la incidencia, la supervivencia y los factores demográficos a los cambios de la epidemiología de la IC.

ملخص

هل تتزايد معدلات الوفيات بالفشل القلبي في أستراليا؟ تحليل للمعطيات الرسمية حول معدلات الوفيات بين عامي 1997 و2003

الهدف: تقييم فيما إذا كانت اتجاهات معدلات الوفيات الناجمة عن الفشل القلبي في أستراليا ناجمة عن تغيُّر في إدراك الحالة أو عن تغيير حقيقي في وبائيات الحالة.

الطريقة: نفذنا تحليلاً استعادياً للمعطيات الرسمية من بين المعطيات الوطنية لمعدلات الوفيات بين عامي 1997 و2003. وقد كان الموت يعزى للفشل القلبي إذا ذكر الفشل القلبي في شهادة الوفاة كسبب دفين للموت أو من بين العوامل المساهمة بحدوثه.

الموجودات: من بين 242 907 وفاة، سجَّل الفشل القلبي كسبب دفين للموت في 341 29 وفاة (3.2%)، فيما ذكر في مكان ما من شهادات الوفاة لدى 268 135 وفاة (14.9%). وفي الفترة بين عامي 1997 و2003، لوحظ نقص في العدد المطلق للوفيات وفي معدلات الوفيات لخاصة بعمر معين أو المقيَّسة للعمر والتي كان الفشل القلبي قد ذكر فيها كسبب دفين للموت أو ذكر في مكان ما في شهادة الوفاة لدى الذكور والإناث. لقد ذكر الفشل القلبي لـدى 24.6% من الوفيات التي عُزِيَتْ إلى مرض القلب الإقفاري، و17.8% من الوفيات التي عُزِيَتْ إلى مرض دوراني، وقد بقيت هذه المعدلات ثابتة دون تغيير طيلة فترة الدراسة. وبالإضافة إلى ذلك فإن الفشل القلبي يعد سبباً لـ 8.3% من الوفيات التي عُزِيَتْ إلى مرض دوراني وكان الفشل القلبي هو السبب الدفين للموت فيها، ولم تتغير هذه المعدلات تغيراً واضحاً في الفترة من 1997 و2003.

الاستنتاج: قد يعكس التناقص في معدل الوفيات الناجم عن الفشل القلبي الذي يقاس بعدد أو بمعدل الوفيات تغيراً حقيقياً في وبائيات الفشل القلبي، وتمس الحاجة إلى دراسات مرتكزة على السكان لمعرفة مدى مساهمة التغيرات في معدلات الوقوع والبقيا والعوامل الديموغرافية في التحولات الوبائية للفشل القلبي، وبشكل دقيق.

References

1. Hoes A, Mosterd A, Grobbee D. An epidemic of heart failure? Recent evidence from Europe. *Eur Heart J* 1998;19 Suppl L:L2-9.
2. Stewart S, Jenkins A, Buchan S, McGuire A, Capewell S, McMurray JJ. The current cost of heart failure to the National Health Service in the UK. *Eur J Heart Fail* 2002;4:361-71.
3. Levy D, Kenchaiah S, Larson M. Long-term trends in the incidence of and survival with heart failure. *N Eng J Med* 2002;347:1397-402.
4. Torp-Pedersen C, Hildebrandt P, Kober L, Nielsen FE, Jensen G, Melchior T, et al. Improving long-term survival of patients with acute myocardial infarction from 1977-1988 in a region of Denmark. *Eur Heart J* 1995;16:14-21.
5. Braunwald E. Shattuck Lecture. Cardiovascular medicine at the turn of the millennium: triumphs, concerns, and opportunities. *N Eng J Med* 1997; 337:1360-9.
6. Redfield M. Heart failure — an epidemic of uncertain proportion. *N Eng J Med* 2002;347:1442-4.
7. Cleland J, Khand A, Clark A. The heart failure epidemic: exactly how big is it? *Eur Heart J* 2001;22:623-6.
8. Young J. The global epidemiology of heart failure. *Med Clin North Am* 2004; 88:1135-43.
9. Burt V, Cutler J, Higgins M, Horan MJ, Labarthe D, Whelton P, et al. Trends in the prevalence, awareness, treatment, and control of hypertension in the adult US population: data from the health examination surveys, 1960 to 1991. *Hypertension* 1995;26:60-9.
10. Mosterd A, D'Agostino R, Silbershatz H, Sytkowski PA, Kannel WB, Grobbee DE, et al. Trends in the prevalence of hypertension, antihypertensive therapy, and left ventricular hypertrophy from 1950 to 1989. *N Eng J Med* 1999; 340:1221-7.
11. Tunstall-Pedoe H, Kuulasmaa K, Mahonen M, Tolonen H, Ruokokoski E, Amouyel P. Contribution of trends in survival and coronary-event rates to changes in coronary heart disease mortality: 10-year results from 37 WHO MONICA project populations: monitoring trends and determinants in cardiovascular disease. *Lancet* 1999;353:1547-57.
12. Rodrigues-Artalejo F, Guallar-Castillon P, Banegas Banegas J, del rey Calero J. Trends in hospitalization and mortality for heart failure in Spain, 1980-1993. *Eur Heart J* 1997;18:1771-9.
13. Feldman D, Thivierge C, Guerard L, Dery V, Kapetanakis C, Lavoie G, et al. Changing trends in mortality and admissions to hospital for elderly patents with congestive heart failure in Montreal. *CMAJ* 2001;165:1033-6.
14. Gillum R. Epidemiology of heart failure in the United States. *Am Heart J* 1993; 126:1042-7.
15. Centers for Disease Control. Changes in mortality from heart failure — United States. *MMWR Morb Mortal Wkly Rep* 1988;47:633-7.
16. Goldacre MJ, Duncan ME, Cook-Mozaffari P, Griffith M. Trends in mortality rates comparing underlying-cause and multiple-cause coding in an English population 1979-1998. *J Public Health Med* 2003;25:249-53.
17. Australian Institute of Health and Welfare (AIHW). *Heart, stroke and vascular diseases — Australian facts.* Canberra: AIHW and National Heart Foundation of Australia; 2004.
18. Australian Bureau of Statistics. Population by age and sex, Australian States and Territories. Canberra: Australian Bureau of Statistics; 2003.
19. *Stata 8 Statistics/data analysis special edition.* College Station (TX): Stata Corporation; 2003.
20. Breslow N, Day N. Statistical methods in cancer research. Volume II — The design and analysis of cohort studies. Oxford: Oxford University Press; 1987.
21. Tunstall-Pedoe H, editor. *MONICA monograph and multimedia sourcebook, world's largest study of heart disease, stroke, risk factors, and population trends 1979–2002.* Geneva: World Health Organization; 2003.
22. Hellerman J, Goraya T, Jacobsen S, Weston SA, Reeder GS, Gersh BJ, et al. Incidence of heart failure after myocardial infarction: is it changing over time? *Am J Epidemiol* 2003;157:1101-7.
23. Spencer F, Meyer T, Goldberg R, Yarzebski J, Hatton M, Lessard D, et al. Twenty-year trends (1975–1995) in the incidence, in-hospital and long-term death rate associated with heart failure complicating acute myocardial infarction, a community-wide perspective. *J Am Coll Cardiol* 1999;34: 1378-87.
24. Scott I, Denaro C, Flores J, Bennett CJ, Hickey AC, Mudge AM, et al. Quality of care of patients hospitalized with congestive heart failure. *Intern Med J* 2003;33:140-51.
25. Komajda M, Follath F, Swedberg K, Cleland J, Aguilar JC, Cohen-Solal A, et al. The EuroHeart Failure Survey programme — a survey on the quality of care among patients with heart failure in Europe. Part 2: treatment. *Eur Heart J* 2003;24:467-74.
26. Mosterd A, Reitsma J, Grobbee D. Angiotensin converting enzyme inhibition and hospitalisation rates for heart failure in the Netherlands, 1980 to 1999: the end of an epidemic? *Heart* 2002;87:75-6.
27. Polanczyk CA, Rohde LE, Dec GW, DiSalvo T. Ten-year trends in hospital care for congestive heart failure: improved outcomes and increased use of resources. *Arch Intern Med* 2000;160:325-32.
28. Roughead L, Gilbert A. Australian trends in hospitalization and mortality associated with chronic heart failure. *Med J Aust* 1998;168:256.
29. Murdoch D, Love M, Robb S, McDonagh TA, Davie AP, Ford I, et al. Importance of heart failure as a cause of death. Changing contribution to overall mortality and coronary heart disease mortality in Scotland 1979–1992. *Eur Heart J* 1998;19:1829-35.
30. Goldacre M, Mant D, Duncan M, Griffith M. Mortality from heart failure in an English population, 1979-2003: study of death certification. *J Epidemiol Community Health* 2005;59:782-4.
31. Kannel W, Vasan R. Epidemiology of heart failure. In: Mann D, editor. *Heart failure: a companion to Braunwald's* heart disease. Philadelphia: Saunders; 2004. p. 341.

32. Nohria A, Chen Y, Morton D, Walsh R, Vlasses PH, Krumholz HM. Quality of care for patients hospitalized with heart failure at academic medical centers. *Am Heart J* 1999;137:1028-34.
33. Krumholz H, Wang Y, Parent E, Mockalis J, Petrillo M, Radford MJ. Quality of care for elderly patients hospitalised with heart failure. *Arch Intern Med* 1997;157:2242-7.
34. Stafford R, Saglam D, Blumenthal D. National pattern of angiotensin-converting enzyme inhibitor use in heart failure. *Arch Intern Med* 1997; 157:2460-4.
35. Remes J, Miettinen H, Reunanen A, Pyorala K. Validity of clinical diagnosis of heart failure in primary health care. *Eur Heart J* 1991;12:315-21.
36. Di Bari M, Pozzi C, Cavallini MC, Innocenti F, Baldereschi G, De Alfieri W, et al. The diagnosis of heart failure in the community. Comparative validation of four sets of criteria in unselected older adults: the ICARe Dicomano Study. *J Am Coll Cardiol* 2004;44:1601-8.
37. Mathers C, Fat D, Inoue M, Rao C, Lopez AD. Counting the dead and what they died from: an assessment of the global status of cause of death data. *Bull World Health Organ* 2005;83:171-7.