Mortality Trends Among People With Type 1 and Type 2 Diabetes in Australia: 1997–2010

Jessica L. Harding,[1,2] Jonathan E. Shaw,[1,2] Anna Peeters,[1,2] Tenniel Guiver,[3] Susan Davidson,[4] and Dianna J. Magliano[1,2]

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OBJECTIVE

With improvements in cardiovascular disease (CVD) rates among people with diabetes, mortality rates may also be changing. However, these trends may be influenced by coding practices of CVD-related deaths on death certificates. We analyzed trends of mortality over 13 years in people with diabetes and quantified the potential misclassification of CVD mortality according to current coding methods.

RESEARCH DESIGN AND METHODS

A total of 1,136,617 Australians with diabetes registered on the National Diabetes Services Scheme between 1997 and 2010 were linked to the National Death Index. Excess mortality relative to the Australian population was reported as standardized mortality ratios (SMRs). Potential misclassification of CVD mortality was determined by coding CVD according to underlying cause of death (COD) and then after consideration of both the underlying *and* other causes listed in part I of the death certificate.

RESULTS

For type 1 diabetes, the SMR decreased in males from 4.20 in 1997 to 3.08 in 2010 ($P_{trend} < 0.001$) and from 3.92 to 3.46 in females ($P_{trend} < 0.01$). For type 2 diabetes, the SMR decreased in males from 1.40 to 1.21 ($P_{trend} < 0.001$) and from 1.56 to 1.22 in females ($P_{trend} < 0.001$). CVD deaths decreased from 35.6 to 31.2% and from 31.5 to 27.2% in males and females with type 1 diabetes, respectively ($P_{trend} < 0.001$ for both sexes). For type 2 diabetes, CVD decreased from 44.5 to 29.2% in males and from 45.5 to 31.6% in females ($P_{trend} < 0.001$ for both sexes). Using traditional coding methods, ~38 and 26% of CVD deaths are underestimated in type 1 diabetes and type 2 diabetes, respectively.

CONCLUSIONS

All-cause and CVD mortality has decreased in diabetes. However, the total CVD mortality burden is underestimated when only underlying COD is considered. This has important ramifications for understanding mortality patterns in diabetes.

Diabetes increases mortality, with this excess mainly being attributable to cardiovascular disease (CVD) (1). However, patterns of mortality may be changing (2,3). Marked declines in mortality among the general population, primarily from CVD, have been noted in the past 4 decades (4), with some evidence that mortality in type 2 diabetes may be approaching that of the general population, particularly at older ages (2,3,5). Studies of type 1 diabetes are, however, inconsistent, with some reporting a decrease in all-cause mortality over time (6–8), while others report no

[1]*Department of Clinical Diabetes and Epidemiology, Baker IDI Heart and Diabetes Institute, Melbourne, Australia*
[2]*Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, Australia*
[3]*Data Integration Services Centre, Australian Institute of Health and Welfare, Canberra, Australia*
[4]*Diabetes Australia, Canberra, Australia*

Corresponding author: Jessica L. Harding, jessica.harding@bakeridi.edu.au.

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change (9–11). Furthermore, little is known about the extent to which mortality from different causes of death (CODs) in people with diabetes has changed over time. Evidence suggests a reduction in mortality from complications of diabetes (6,12,13), an increase in cancer mortality (3), and no change in mortality from acute complications of diabetes (3,14). However most of these studies are based on small sample sizes and do not distinguish between type 1 and type 2 diabetes.

Although examining cause-specific mortality is of significant value, limitations in using death certificate data are well recognized (15–17). Most of the attention in this area has focused on whether or not death certificates in people with diabetes refer to diabetes at all (17–19). It is also possible that due to an increasing recognition of the role of diabetes, the underlying COD may be given as diabetes when the death was primarily caused by CVD. This may lead to misclassification, whereby deaths due to CVD in people with diabetes are not classified as CVD deaths, but as diabetes deaths, leading to an underestimate of the impact of CVD.

The aims of the current study, using a cohort of Australians registered on the National Diabetes Services Scheme (NDSS) followed from 1997–2010, are to

i. examine secular trends in excess all-cause mortality in type 1 and type 2 diabetes compared with the general population,
ii. examine secular trends in proportions of cause-specific deaths in type 1 and type 2 diabetes, and
iii. explore the potential underestimation of CVD deaths in people with diabetes.

RESEARCH DESIGN AND METHODS

The NDSS was set up in 1987 to deliver diabetes-related products at subsidized prices and provide information to people with diabetes. Registration of patients is free and is completed by a medical practitioner or credentialed diabetes nurse educator. The NDSS captures 80–90% of all Australians with known diabetes (20).

We included all people with type 1 or type 2 diabetes who were on the NDSS between 1997 and 2010. 1997 was chosen as the start date, as this time period followed a unification of state-based registries as well as an improvement in data quality. After excluding 944 registrants, because registration date and date of death were the same, the sample size for these analyses was 1,136,617. Diabetes type is classified by the health practitioner completing registration. However, for the current study, type 1 diabetes status was assigned to registrants who were classified as type 1 on the NDSS and were diagnosed before the age of 30 years, and the time between diagnosis date and date of first insulin use was less than 1 year. For those missing data on date of diagnosis or insulin initiation date (many of whom registered in the early years of the operation of the NDSS and had had diabetes for a number of years), we classified people as type 1 diabetes if they were recorded as type 1 on the registry, were taking insulin, and were registered at $\leq$45 years of age. We chose 45 years as the cutoff to minimize the number of people with type 1 diabetes that we would miss, without misclassifying significant numbers of people with type 2 as type 1 (21). All others were classified as type 2 diabetes.

The NDSS was linked to the National Death Index (NDI) using data up to and including 31 December 2010, and the general framework of Fellegi and Sunter (22) was used. First name, second name, third name, sex, and date of birth were used to conduct the linkage. The record linkage methodology assigns each compared pair of records a record pair comparison weight. Based on clerical review of a sample of these links, it is expected that links with a weighting of low, medium, and high correspond to a link accuracy (positive predictive value) of 96.75, 98.97, and 99.90%, respectively (23). For this study, we chose a medium cutoff point with a predictive value of 98.97%. Sensitivity analyses were also conducted using the high and low cutoffs.

Statistical Analysis

Individuals were followed from 1 January 1997, or registration date if thereafter, to 31 December 2010 or date of death, whichever occurred first. Annual mortality rates were calculated by direct standardization. In brief, 5-year age-specific mortality rates of those with diabetes were applied to the equivalent age strata from the Australian population of 2001, obtained from the Australian Institute of Health and Welfare. For type 1 diabetes, this was 0–75 years of age, and for type 2, it was all ages. Among the general population, mortality rates were also age-standardized to the 2001 Australian population.

All-cause mortality by year, 5-year age group (0–85+ years), and sex was calculated among people with diabetes. Year-, age-, and sex-specific mortality rates from the general Australian population, obtained from the Australian Institute of Health and Welfare, were applied to the diabetes population. The number of people in each age group of the diabetes population was multiplied by the age (in 5-year age groups), sex, and year-specific mortality rates in the general population to obtain the expected number of deaths and then summed to give a total expected number of deaths. Standardized mortality ratios (SMRs) were calculated by comparing the observed and expected mortality. An SMR of 1 indicates equivalent mortality risk to the age-matched general population, and 95% CIs were calculated using limits for a Poisson distributed variable.

For the assessment of changes in all-cause mortality over time, annual SMRs were fitted separately for each type of diabetes using a Poisson regression model using age as the time scale and including sex and calendar year as covariates, with P_{trends} reported. To examine changes in all-cause mortality over time by age group, we grouped data from the calendar years 1997–2003 and 2004–2010 together.

COD was classified according to underlying COD codes as follows: CVD I10-I25, I60-I69; diabetes E10-E14; cancer C00-C97; respiratory J00-J99; infections A00-B99; renal diseases N00-N21, N25-N26; and all remaining "other" codes. In a second analysis, deaths with an underlying COD corresponding to "uncomplicated diabetes" (E10.9, E11.9, E12.9, E13.9, E14.9) or "diabetes with circulatory complications" (E105, E11.5, E12.5, E13.5, E14.5) where a CVD code *also* appeared in the first part of the death certificate were reclassified to CVD. These recoded deaths are thought to be reflective of *real* CVD

deaths, as it is unlikely that people die of "uncomplicated diabetes" or "diabetes with circulatory complications," but rather, the CVD death, as described in part I of the death certificate, is a consequence of diabetes.

Binary outcomes were created for each cause-specific death, categorized into, for example, CVD or "other death" and individual logistic regression analyses (crude and age-adjusted) were performed to observe trends in the proportion of deaths attributed to each category, with P_{trends} reported. Trends in the proportions of underestimated CVD deaths over time were also reported using logistic regression with the binary outcome "misclassified" or "not misclassified." Statistical significance was established at $P < 0.05$. All analysis used STATA version 12.1 (StataCorp, College Station, TX). This study was approved by the Alfred Health Human Ethics Committee and the Australian Institute of Health and Welfare Ethics Committee.

RESULTS

This study included 1,136,617 (7.6% type 1) individuals with type 1 or type 2 diabetes who were registered on the NDSS between 1997 and 2010. In brief, there were a greater proportion of males with type 1 and type 2 diabetes compared with females, 52.4 and 53.8%, respectively; median age at diagnosis was 21.1 and 60.0 years for type 1 and type 2 diabetes, respectively; average follow-up time was 10.5 and 6.9 years for type 1 and type 2 diabetes, respectively; and 21.7% of people with type 2 diabetes were on insulin.

Among 86,250 people with type 1 diabetes, a total of 6,134 deaths occurred during 908,730 person-years (PY) of follow-up between 1997 and 2010; crude mortality rate was 6.8 per 1,000 PY. Age-standardized (0–75 years) mortality rates decreased among the type 1 diabetes population from 9.5 per 1,000 to 6.3 per 1,000 PY over the follow-up period, and from 3.3 per 1,000 to 2.3 per 1,000 among the general population for the same age group. The SMR for males decreased from 4.20 (95% CI 3.66–4.82) in 1997 to 3.08 (95% CI 2.77–3.42) in 2010 ($P_{trend} < 0.001$) and for females from 3.92 (95% CI 3.19–4.82) to 3.46 (95% CI 3.01–3.97; $P_{trend} < 0.01$) (Fig. 1).

Among 1,060,367 people with type 2 diabetes, a total of 211,082 deaths occurred during 7,263,618 PY of follow-up for the same time period; crude mortality rate was 29 per 1,000 PY. Age-standardized (0–75 years) mortality rates decreased among the type 2 diabetes population from 9.4 per 1,000 to 5.5 per 1,000 PY over the follow-up period. The SMR for males decreased from 1.40 (95% CI 1.36–1.44) in 1997 to 1.21 (95% CI 1.19–1.23) in 2010 ($P_{trend} < 0.001$) and for females from 1.56 (95% CI 1.51–1.61) to 1.22 (95% CI 1.19–1.24; $P_{trend} < 0.001$) (Fig. 2).

Age-specific SMRs in 1997–2003 and 2004–2010 are presented in Table 1. In general, SMRs for type 1 diabetes were

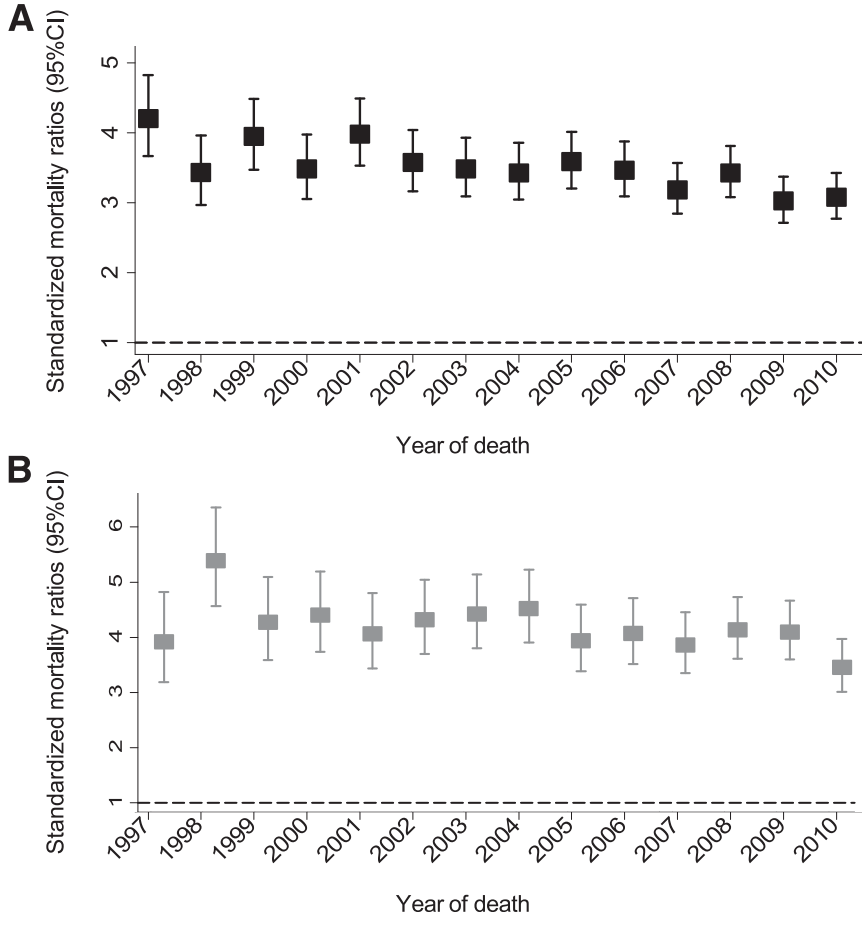

Figure 1—All-cause SMRs in males (*A*) and females (*B*) with type 1 diabetes compared with the general population between 1997 and 2010.

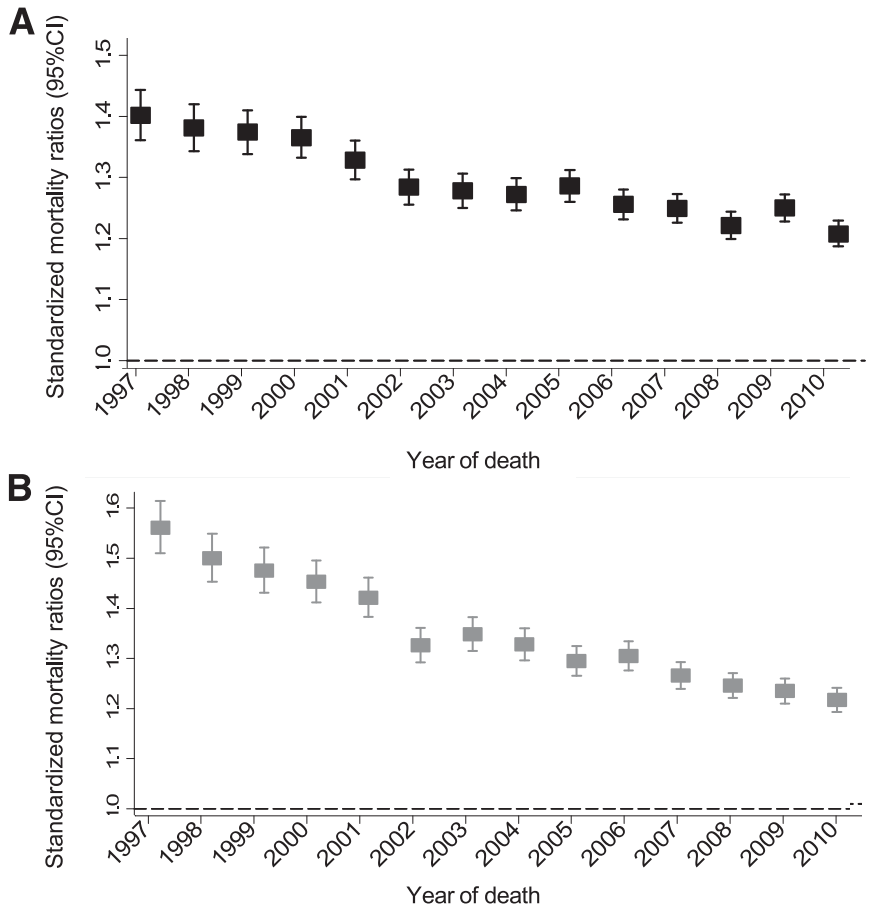

Figure 2—All-cause SMRs in males (*A*) and females (*B*) with type 2 diabetes compared with the general population between 1997 and 2010.

almost double across all age groups compared with those for type 2 diabetes in 1997–2003 and 2004–2010. Females generally had higher SMRs compared with males, and SMRs generally decreased from 1997–2003 to 2004–2010 for males and females with type 2, but not type 1, diabetes.

COD data were available for 85.8% (n = 5,261) of all deaths among type 1 diabetes and for 95.3% (n = 201,156) among type 2 diabetes. Using the standard underlying COD data, Fig. 3 shows that in type 1 diabetes, the percentage of crude deaths due to CVD fell between 1997 and 2010 (significant only for females), while the percentage due to cancer increased. Age-adjustment resulted in the CVD decline between 1997 and 2010 becoming significant in males also. Figure 3 also shows that there were similar findings for type 2 diabetes, both crude and age-adjusted (significant in males and females).

After recoding relevant "uncomplicated diabetes" deaths and "diabetes with circulatory complications" deaths to CVD, the proportion of deaths for the total time period among those with type 1 diabetes attributed to CVD increased from 22.3 to 35.7% in males and from 18.9 to 31.6% in females (Table 2). For both males and females, the amount of underestimation increased over time ($P_{trend} < 0.05$), and subsequently, decreases in the proportion of deaths attributed to CVD over time were overestimated. Similar findings were seen for type 2 diabetes.

Separate sensitivity analyses using NDI cutoffs with linkage rates of 99.9 and 96.75% and using a cutoff date of age <40 at registration for classification as type 1 diabetes among those missing data on age at diagnosis did not change the overall pattern of results (data not shown).

CONCLUSIONS

Our findings of an analysis of mortality trends among Australians with diabetes are threefold. First, we observed a significant decline in excess all-cause mortality among both males and females for type 1 and type 2 diabetes between 1997 and 2010. This decrease in excess risk over time was underpinned by decreases in mortality for both the diabetes and general population groups, though decreases in mortality were greater among the diabetes population, making the relative difference between the two groups smaller over time. However, people with type 1 and type 2 diabetes still experience a 3 and 1.2 times increased risk of excess all-cause mortality, respectively, compared with the general population. Second, we observed a decline in the proportion of deaths attributed to CVD among type 1 diabetes and type 2 diabetes and for both males and females. Finally, we observed that a large proportion of deaths from CVD are potentially underestimated using standard underlying COD coding methods, and this proportion has increased over time.

Table 1—Age group– and sex-specific SMRs (95% CI) from 1997–2003 and 2004–2010 in type 1 and type 2 diabetes

Age group, years	1997–2003						2004–2010					
	Male			Female			Male			Female		
	Deaths (*n*)	SMR	95% CI	Deaths (*n*)	SMR	95% CI	Deaths (*n*)	SMR	95% CI	Deaths (*n*)	SMR	95% CI
Type 1 diabetes												
0–9	2	0.75	0.19–2.99	1	0.56	0.08–4.00	3	1.21	0.39–3.74	3	1.73	0.56–5.36
10–19	37	3.26	2.36–4.49	41	7.77	5.72–10.56	32	3.06	2.16–4.32	20	3.98	2.57–6.17
20–29	101	2.56	2.11–3.11	80	5.91	4.75–7.36	95	2.95	2.41–3.61	81	6.91	5.56–8.59
30–39	258	4.09	3.62–4.62	159	4.57	3.92–5.34	236	4.08	3.59–4.653	137	4.95	4.19–5.85
40–49	582	4.69	4.33–5.09	315	4.72	4.23–5.27	505	4.39	4.02–4.79	313	4.22	3.77–4.71
50–59	533	3.75	3.45–4.08	284	4.36	3.88–4.89	780	3.37	3.14–3.61	467	4.02	3.67–4.40
60–69	55	2.01	1.54–2.62	30	2.52	1.76–3.60	402	2.60	2.36–2.87	237	3.40	3.00–3.87
70–79	47	2.10	1.58–2.41	28	2.81	1.99–3.95	80	2.25	1.81–2.80	64	3.12	2.44–3.98
80–89	23	2.42	1.61–3.64	18	2.25	1.42–3.57	46	2.13	1.59–2.84	34	2.53	1.81–3.54
Type 2 diabetes												
0–9	—	—	—	—	—	—	—	—	—	—	—	—
10–19	4	14.26	5.35–38.0	2	7.75	1.94–31.0	2	3.57	0.89–14.28	1	2.40	0.34–17.02
20–29	10	2.06	1.11–3.84	15	1.82	1.10–3.02	23	4.00	2.66–6.02	21	4.59	3.00–7.04
30–39	134	3.16	2.67–3.74	99	1.60	1.32–1.95	192	3.02	2.62–3.48	164	2.93	2.52–3.42
40–49	650	2.26	2.09–2.44	407	2.43	2.20–2.67	1,250	2.65	2.51–2.80	793	2.63	2.45–2.82
50–59	3,491	2.14	2.07–2.21	1787	2.51	2.40–2.63	4,890	1.97	1.91–2.02	2,527	2.23	2.14–2.32
60–69	9,504	1.69	1.66–1.73	5224	2.07	2.02–2.13	13,724	1.63	1.60–1.65	7,122	1.90	1.86–1.95
70–79	17,441	1.40	1.38–1.42	11,726	1.70	1.67–1.73	25,562	1.36	1.34–1.37	16,361	1.56	1.54–1.59
80–89	12,501	0.98	0.96–1.00	13,694	1.08	1.05–1.09	29,917	0.99	0.98–1.00	31,844	1.03	1.02–1.04

The dash indicates that there were no deaths among people with diabetes for this age group.

Comparison With the Literature

Our results for the risk of excess all-cause mortality are consistent with other studies. Lind et al. (2) show that in a large diabetes population in Ontario, Canada, the mortality rate ratios decreased from 1.90 in 1996 to 1.51 in 2009 compared with people without diabetes and from 2.14 to 1.65 in a diabetes population from the U.K. for the same time period. However, this study did not distinguish diabetes type and may explain why the rate ratios lie somewhere between our estimates for type 1 and type 2 diabetes. Gregg et al. (13) showed that between 1997 and 2006, all-cause and CVD death rates declined by 23 and 40%, respectively, in a population of U.S. adults with diabetes, and there were no differences between males and females. This study also did not discriminate between type 1 diabetes and type 2 diabetes. Allemann et al. (6) examined type 1 and type 2 diabetes separately and showed that SMRs for all-cause and CVD mortality decreased significantly over 30 years of follow-up in Switzerland. In that study, SMRs for type 1 and type 2 diabetes from 1974 to 2005 were 4.5 and 3.5, respectively, and were higher for females than males. These SMRs are much higher than those reported here, most likely due to the fact that the Swiss study began in the 1970s when mortality from diabetes

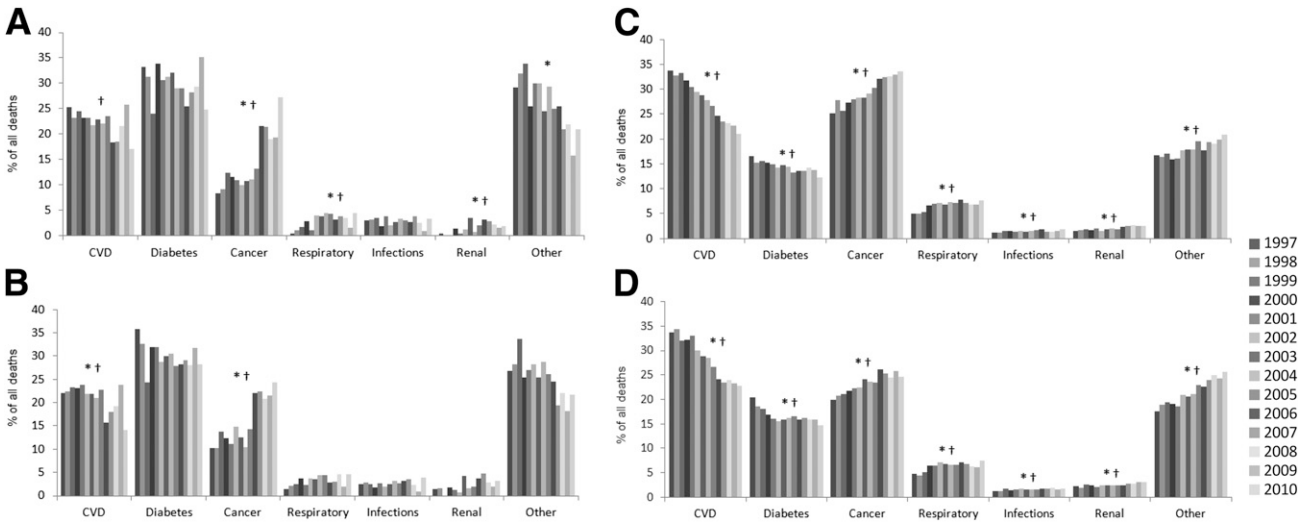

Figure 3—Cause-specific mortality in males (*A*) and females (*B*) with type 1 diabetes and males (*C*) and females (*D*) with type 2 diabetes using traditional coding between 1997 and 2010. *crude $P_{trend} < 0.001$; †age-adjusted $P_{trend} < 0.001$.

Table 2—Proportion of CVD deaths misclassified using traditional coding in males and females with type 1 and type 2 diabetes

	Men			Women		
Year of death	% of CVD deaths[a]	% of CVD deaths after recoding[b]	% of CVD deaths underestimated	% of CVD deaths[a]	% of CVD deaths after recoding[b]	% of CVD deaths underestimated
Type 1 diabetes						
1997	25.3	34.7	27.1	14.6	28.1	48
1998	23.2	34.1	31.7	21.4	32.1	33.3
1999	24.5	33.9	27.8	21.0	33.1	36.6
2000	23.2	38.0	39.0	23.2	34.1	31.9
2001	23.2	36.3	36.1	24.8	39.4	54.0
2002	21.7	33.6	35.3	21.9	29.0	24.4
2003	22.9	35.5	35.5	20.2	28.6	29.2
2004	22.1	35.3	37.5	19.4	32.8	40.7
2005	23.6	37.4	36.9	21.7	32.9	34.0
2006	18.4	30.8	40.4	12.2	24.5	50.0
2007	18.5	34.6	46.5	16.6	33.1	50.0
2008	21.6	35.8	39.8	15.7	26.4	40.5
2009	25.7	41.6	38.1	20.6	31.5	34.6
2010	17.1	31.2	45.3	9.9	26.5	62.5
Total	22.3	35.3	36.8[c]	18.9[d]	30.9	38.7[c]
Type 2 diabetes						
1997	33.8	43.8	22.7	33.7	44.6	24.3
1998	32.7	42.2	22.5	34.3	44.8	23.3
1999	33.3	42.7	22.0	32.0	42.1	23.9
2000	31.7	40.8	22.2	32.2	40.9	21.3
2001	30.5	39.4	22.6	33.1	42.3	21.7
2002	29.4	37.6	21.7	30.0	38.7	22.5
2003	28.8	37.8	23.9	28.9	38.4	24.6
2004	27.7	36.6	24.3	28.5	37.8	24.5
2005	26.6	35.8	25.6	26.6	37.0	28.1
2006	24.6	32.8	24.8	24.1	33.0	27.1
2007	23.5	31.5	25.3	23.5	32.2	27.1
2008	23.2	31.6	26.7	23.9	32.3	25.9
2009	22.6	30.5	25.7	23.3	32.0	27.3
2010	21.1	28.2	25.2	22.8	30.9	26.1
Total	26.7	35.3[d]	24.1[c]	27.2[d]	36.3[d]	25.1[c]

[a]Proportion of deaths using traditional ICD coding using underlying COD only. [b]Proportion of deaths after recoding diabetes to CVD where it was suspected CVD was the true underlying COD. [c]Significant increase between 1997 and 2010 ($P_{trend} < 0.05$). [d]Significant decrease between 1997 and 2010 ($P_{trend} < 0.05$).

was much higher compared with the general population.

In our study, we show that the second largest contributor to mortality among people with diabetes is now cancer, which increased substantially between 1997 and 2010. While there is now a plethora of epidemiological evidence supporting a strong association between diabetes and many types of cancer (24), only one other study that we are aware of has shown increasing trends of mortality from cancer over time in people with diabetes. In this study, the proportion of deaths attributed to cancer increased from ~23% in 1970 to 27% in 1990 (3). This is similar to our results where we show that the proportion of deaths attributed to cancer among type 1 diabetes is now 27%, but we show a higher proportion among people with type 2 diabetes, with 33% of all deaths in people with diabetes attributed to cancer in 2010. This is of significant importance in light of the increasing prevalence of diabetes, coinciding with an ageing population, an inherent risk factor for both diabetes and cancer.

Mortality ICD codes are widely used in epidemiological research to assess the health of populations, direct the allocation of funds, and inform appropriate health care policy. But as we, and others, have shown, misclassification of COD can have major implications for the conclusions drawn from epidemiological research (25). In this study, we show that the proportion of CVD deaths potentially underestimated by using underlying COD was ~39 and 26% for type 1 and type 2 diabetes, respectively. We also show that the proportion has increased over time. It is most likely that this reflects an increasing awareness among doctors that diabetes is a key etiological factor in the development of CVD. Our findings are supported by a study by Harriss et al. (26), which adjudicated 750 deaths from an Australian longitudinal cohort and found that of 54 deaths with an underlying ICD code listed as "diabetes," almost 60% were primarily due to CVD. Our somewhat lower estimates are most likely explained by our conservative approach, whereby only those diabetes cases that were "diabetes with circulatory complication" or "uncomplicated diabetes" were recoded. Additionally, our study distinguished between diabetes types and had a different age distribution. Our data show that when death from CVD is attributed to diabetes (often correctly) on the death certificate, it can significantly

obscure patterns of CVD mortality if only underlying COD is used to attribute COD. Similar issues may also apply to other chronic diseases and their complications. We suggest that when considering mortality data, particularly for diabetes populations, the current reliance on the underlying COD coding may be misleading.

Strengths and Limitations

The main strength of this study is that it is population based with a large sample size, a long follow-up time, and the ability to distinguish between type 1 and type 2 diabetes. There are several limitations, however, that should be acknowledged. Firstly, the NDSS is an administrative database, and there are inherent limitations with using administrative databases for research purposes (27). Namely, for our study, the lack of precise information about type of diabetes for all registrants was not available. The classification of diabetes, particularly in young patients, is challenging, and misclassification can occur. However, the proportions of type 1 and type 2 diabetes in this study (7.6 vs. 92.4%) are similar in other Australian data (28). Further, the proportion of type 2 diabetic patients who were also on insulin is consistent with other studies (29). Given these well-known demographics and our very large sample size, we believe that any misclassification in this study will not alter our results.

The NDSS is considered among the best available national data sources for estimating overall prevalence of diagnosed diabetes in Australia (20). However, the NDSS does not capture those with undiagnosed diabetes. Recent Australian data show that for every four cases of known diabetes, there is one undiagnosed case (30). The NDSS also may underestimate the total number of people with diet-controlled diabetes, as the diabetes-related products provided through the scheme may not be needed (30). In Australia, the proportion of known diabetes controlled by diet only was estimated to be 28% in 2000 (31). It is possible, therefore, that using the NDSS is reflective of the more serious diabetes cases. However, the NDSS coverage of type 1 diabetes is known to be very high as access to insulin-related products is through the NDSS (20). Further, we believe the coverage of type 2 diabetes is adequately reflective of people with type 2 diabetes in Australia given that the age distribution and the median age at diagnosis are similar to that seen in other populations (29). We therefore do not believe this potential source of bias will significantly impact our findings. Obtaining vital status and COD information can also be difficult for large-scale studies such as this in Australia where unique health identifiers are not available. Therefore, linkage is based on probabilistic algorithms that a given name, address, and date of birth will correctly link records belonging to the same individual. Again, this may introduce misclassification. However, for all primary analyses, we applied cutoffs that have a 98.97% positive match rate. Further, we performed sensitivity analyses using cutoffs with positive match rates of 99.9 and 96.75%, respectively, and our conclusions regarding patterns of mortality over time were unchanged.

Lastly, although the NDSS provides the largest data set for people with diagnosed diabetes, our findings are limited by a lack of covariates in the data set. Therefore, we were unable to explore the extent to which improvements in quality of care, medical treatments, and/or self-management behaviors contributed to the reductions in mortality over time. Furthermore, ethnicity is known to have a strong association with type 2 diabetes such that migrant populations have a higher prevalence of diabetes compared with Australian-born individuals (32,33). It is not known if ethnicity would impact on SMR estimates. Unfortunately, we were not able to explore this further due this information not being available in the general population.

Conclusion

We have shown that excess all-cause mortality in males and females with type 1 and type 2 diabetes has decreased over the past decade in Australia. These trends suggest continued success in the treatment of diabetes and its complications, though there is still a significant amount of excess mortality experienced among people with diabetes compared with the general population, and continued efforts to rectify this disparity are needed. Additionally, improvements in CVD-related mortality are offset by increases in the proportion of deaths attributed to cancer among people with diabetes. One of our most important and novel findings is that a substantial and increasing proportion of CVD deaths among people with diabetes are attributed to diabetes on death certificates, leading to underestimates in the CVD mortality burden among people with diabetes. If confirmed in other data collections, this has important ramifications for the understanding of mortality patterns.

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