Improving the Comparability of Diabetes Mortality Statistics in the U.S. and Mexico

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OBJECTIVE — The aim of this study was to increase the cross-state comparability of diabetes mortality statistics related in the U.S. and Mexico.

RESEARCH DESIGN AND METHODS — We used multinomial logistic regression to estimate the effects of individual and community factors on a death for which diabetes was recorded as one of the multiple contributing causes of death (MCD) being assigned to diabetes as the underlying cause of death (UCD) versus assignment to cardiovascular, other noncommunicable, or communicable diseases. We used the model to estimate state-level diabetes death rates that are standardized in the individual and community factors.

RESULTS — Deaths with diabetes as one of the MCD were more likely to be assigned to cardiovascular causes as the UCD if they occurred in hospitals or if an autopsy was performed and if the decedents were from states with higher BMI and systolic blood pressure, were more educated, or had insurance. Adjusting for individual- and community-level factors substantially increased the cross-state correlation of diabetes as the UCD and diabetes as one of the MCD mortality rates. The adjustment also reduced the number of direct diabetes deaths by 10% in the U.S. and by 24% in Mexico. In the U.S., deaths with diabetes as the UCD declined most in Utah, New Mexico, New Jersey, and Louisiana and increased in California and Hawaii. In Mexico, the numbers of adjusted diabetes deaths were smaller than those observed in all states by 3–34%. An additional 126,300 deaths due to ischemic heart disease and stroke in the U.S. and 19,497 in Mexico were attributable to high blood glucose.

CONCLUSIONS — There is a need to improve the comparability of diabetes cause-of-death assignment, especially in relation to cardiovascular diseases.

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The validity and comparability of cause-of-death statistics may be affected at the time of medical certification and, in countries without automated coding, in the process of assignment of an ICD code for the underlying cause of death (UCD). The validity and comparability of cause-of-death data related to diabetes can be affected in two ways. First, a number of studies have found that diabetes appears as one of the multiple contributing causes of death (MCD) on two-thirds or fewer of the death certificates of people with known diabetes (1–7). Second, even when diabetes appears as one of the MCDs, the ordering of causes on the death certificate can affect whether diabetes is registered as the UCD in subsequent coding and hence affect comparability (8–10). Lack of comparability in diabetes UCD statistics occurs partly because diabetic subjects have an increased risk of mortality from other diseases, especially cardiovascular diseases (11,12); it has been found that cardiovascular diseases may be the most common UCD among people with diabetes (3,13). Different certifiers may record diabetes or cardiovascular diseases on the death certificate or change the order of recorded causes. This specific obstacle to comparability has received substantially less attention than under-recording of diabetes on the death certificate.

We used individual death records to examine the cross-state comparability of diabetes cause-of-death statistics in the U.S. and Mexico. We analyzed the effects of individual- and community-level factors on cause-of-death assignment across states in these two countries. We used the results to estimate diabetes death rates by state that are standardized in the levels of individual- and community-level determinants of cause-of-death assignment to increase the comparability of diabetes mortality statistics.

RESEARCH DESIGN AND METHODS

Data sources

Data for causes of death were from the National Center for Health Statistics National Vital Statistics System in the U.S. and from Secretaría de Salud in Mexico. Both sources maintain records for all deaths in the country, including multiple causes of death and standard sociodemographic characteristics. All deaths coded to "Diabetes Mellitus" in the MCD dataset between 1999 and 2001 in the U.S. (640,543 deaths) and between 2004 and 2005 in Mexico (182,796 deaths) were included in the analysis to maximize predictive power. Analysis was limited to deaths of individuals aged >20 years because very few diabetes deaths occur at younger ages. Deaths for which injuries were the UCD were excluded from the analysis because they were assumed to be correctly assigned.

Statistical model

We used multinomial logistic regression to estimate the relative risk ratios (RRRs) of a death, for which diabetes was recorded as one of the MCD, being assigned to diabetes versus cardiovascular diseases, other noncommunicable diseases,

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Abbreviations: IHD, ischemic heart disease; MCD, multiple contributing causes of death; SBP, systolic blood pressure; UCD, underlying cause of death.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Table 1— ***Model variables, descriptions, and data sources***

Independent variable	Values	Data sources		Reference value for adjusted estimates	Reasons for inclusion in analysis
		U.S.*	Mexico*		
Sex	Male, female	Death record	Death record	Male	Indicators of socioeconomic determinants of access, utilization, and quality of care
Race and Hispanic ethnicity†	White NH men, white NH women, black NH men, black NH women, Hispanic men, Hispanic women, other NH men, other NH women	Death record	NA	White NH men	
Insurance status	Insured/not insured	NA	Death record	Insured	
Educational level	Less than high school, less than college, college or postgraduate	Death record	Death record	College educated	
Place of death	In-hospital (defined as hospital or health care facility), out-of-hospital	Death record	Death record	In hospital	Indicator of a more complete medical history before/at the time of death
Age	5-year intervals from 20 to 85+	Death record	Death record	Decedent's actual age	Incorporating the true age patterns of diabetes and other causes of death
SBP	Mean SBP by sex, 5-year age-groups, and state of residency	BRFSS corrected for bias in self-reported hypertension status based on NHANES	ENSANUT 2005–2006	Actual SBP of the decedent's state, age-group, and sex	Risk factors for diabetes and/or cardiovascular deaths; community-level data were used because death certificate does not include these data for individuals
BMI	Mean BMI by sex, 5-year age-groups, and state of residency	BRFSS corrected for bias in self-reported weight and height based on NHANES (14)	ENSA 2000	Actual BMI of the decedent's state, age-group, and sex	
Necropsy	Necropsy performed, not performed	NA	Death record	Performed	Indicators of specialized medical knowledge used in assigning causes of death
Cardiologists, endocrinologists, nephrologists	County-level estimate of cardiologists, endocrinologists, and nephrologists per 100,000 residents; ranges: 1.9–12.7, 0.1–4.3, and 0.1–3.7, respectively	Dartmouth Atlas of Health Care‡	NA	80th percentile of all national counties: 7.6/100,000, 1.3/100,000, and 1.8/100,000	

*NA refers to those variables for which data in one country were not available and not included in analysis for that country. †NH refers to non-Hispanic. ‡The Dartmouth Atlas of Health Care (year 1999) (http://www.dartmouthatlas.org) provides estimates for Hospital Referral Region, which are linked to zip codes that can in turn be mapped to county codes. Because zip codes do not map exactly to county boundaries, counties that did not have a value for cardiologists were assigned the same value as the adjacent county with the closest per capita income. BRFSS, Behavioral Risk Factor Surveillance System; ENSA, Encuesta Nacional de Salud (National Health Survey); ENSANUT, Encuesta Nacional de Salud y Nutricion (National Health and Nutritional Survey); NHANES, National Health and Nutrition Examination Survey.

or communicable diseases as the UCD. The multinomial logistic regression estimates the RRRs for observing a dependent variable with more than two outcome categories as a function of independent covariates; the statistical basis and applications to epidemiological data are described elsewhere (15,16). RRRs were estimated for assignment to each of the disease clusters relative to assignment to diabetes. The independent variables in the regression were exogenous individual- and community-level variables listed in Table 1.

We used the coefficients of the multinomial logistic regression to predict the probabilities that each death would be assigned to each of these four disease clusters if the individual and community characteristics were those of a fixed reference category, as defined in Table 1. Although any fixed category could be used for the purpose of comparability, the reference category in Table 1 is expected to represent the highest access to specialized health care and, hence, the greatest likelihood of a valid cause-of-death assignment, above and beyond comparability. We controlled for age to avoid the confounding effects of factors that may also be associated with age. However, we did not use a reference age category in the adjusted (predicted) probabilities because some causes of death are expected to have true age patterns, which should be preserved. For the same reason, we adjusted the regressions for BMI and systolic blood pressure (SBP) but did not standardize these variables in the prediction stage to retain true epidemiological differences. Predicted probabilities were aggregated by sex, age-groups, and state to produce comparable estimates of diabetes deaths, and those of other disease clusters for each state. All analyses were conducted separately for the U.S. and Mexico to account for potential differences in the case fatality of diabetic patients in the two countries.

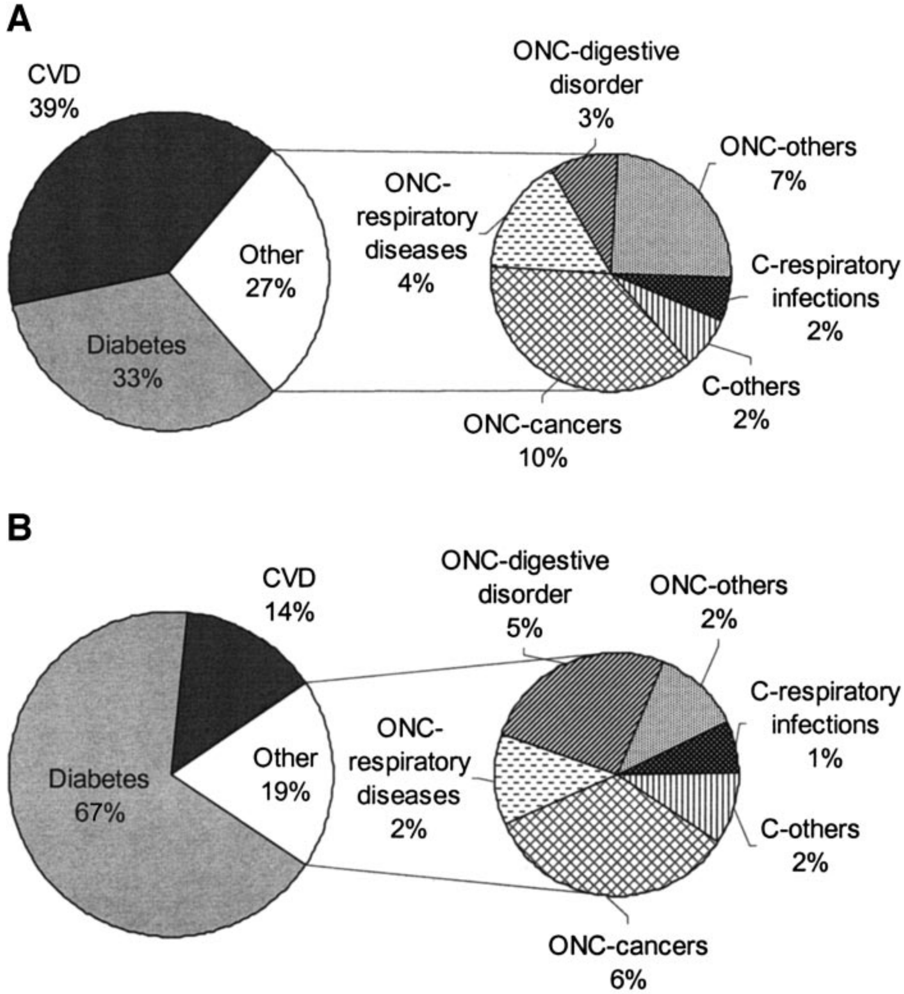

Figure 1—*Distribution of the UCD among deaths for which diabetes was included as one of the MCD. A: U.S., 2001. B: Mexico, 2005. C, communicable diseases; CVD, cardiovascular diseases; ONC, other noncommunicable diseases.*

RESULTS

Observed cause-of-death statistics (national and state patterns)

Excluding deaths from injuries, diabetes and cardiovascular diseases, respectively, comprised 33 and 39% of the UCDs among the universe of deaths with diabetes as one of the MCD in the U.S. and 67 and 14% in Mexico (Fig. 1). Cancers (10% in the U.S. and 6% in Mexico) and a number of other noncommunicable diseases accounted for the remaining proportion, except for a small proportion of deaths assigned to communicable diseases (4% in the U.S. and 3% in Mexico). Nearly 3 and 14% of all deaths in the U.S. and Mexico, respectively, are currently assigned to diabetes; 38 and 23% are assigned to cardiovascular diseases.

In both countries there were large discrepancies at the state level between the rates of diabetes as the UCD and the rates of deaths for which diabetes appears as one of the MCD on the death certificate (Fig. 2). For example, in 2001, age-standardized (using 2000 U.S. population aged ≥20 years) diabetes MCD rates in Hawaii, Utah, and Louisiana were between 10.0 and 10.7 per 10,000 but age-standardized diabetes UCD rates varied by a factor of >3 (1.8 in Hawaii, 4.4 in Utah, and 5.8 in Louisiana). Similarly, Baja California Sur and Guanajuato had age-standardized (using 2000 Mexico population aged ≥20 years) diabetes MCD rates of 16.0 and 16.6 per 10,000, but age-standardized diabetes UCD rates varied by a factor of 1.6 (8.0 in Baja California Sur and 13.0 in Guanajuato).

Regression analysis

In-hospital deaths, for which more clinical information may be available, had substantially higher probabilities than out-of-hospital deaths of being assigned to cardiovascular diseases (RRR 1.16 in the U.S. and 1.87 in Mexico) (Table 2). In-hospital deaths also had a higher probability of assignment to communicable diseases (RRR 2.89 in the U.S. and 2.84 in Mexico), possibly due to sepsis deaths. Assignment to other noncommunicable diseases was less likely for in-hospital deaths relative to out-of-hospital deaths (RRR 0.91) in the U.S. and more likely (RRR 1.42) in Mexico.

In the U.S., the number of cardiolo-

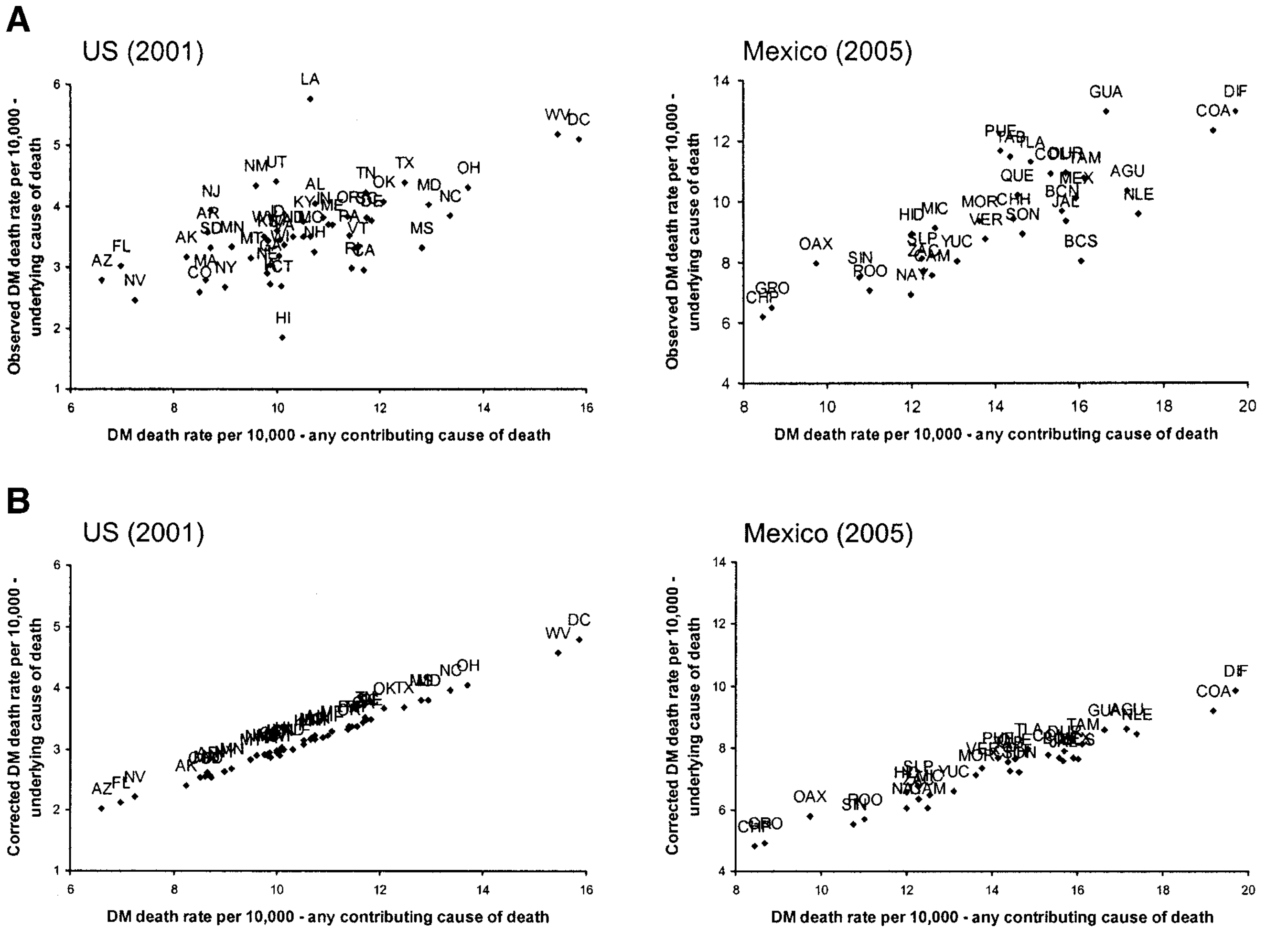

Figure 2—*Death rates of diabetes (DM) as the UCD versus anywhere in the MCD for U.S. states and the District of Columbia (2001) and Mexican states and the Federal District (2005). Deaths in individuals aged ≥20 years are included. Rates in each state are age standardized to the country's 2000 population.*

gists was inversely associated with assignment to cardiovascular, other noncommunicable, and communicable diseases, with a 4, 4, and 6% reduction in the probability relative to assignment to diabetes for each additional cardiologist per 100,000 residents, respectively. The probabilities of being assigned to cardiovascular, other noncommunicable, and communicable diseases relative to diabetes increased with additional numbers of endocrinologist and nephrologists (only some of these results were statistically significant). These results may reflect actual or perceived diabetes treatment or additional medical knowledge used in certification, with higher specialized diabetes care.

In the U.S., compared with white men, almost all other race-ethnicity-sex groups had lower probabilities of being assigned to cardiovascular and other noncommunicable causes relative to diabetes. The sex pattern was reversed in Mexico. Decedents with below high school education had a smaller likelihood of being assigned to cardiovascular diseases and other noncommunicable diseases in both the U.S. and Mexico compared with individuals who achieved college or more. There was a higher probability of being assigned to cardiovascular diseases (RRR 1.19) and other noncommunicable diseases (RRR 1.27) and a lower probability of being assigned to communicable diseases (RRR 0.77) if individuals were insured. These findings may all demonstrate differential treatment of diabetes and/or differential availability of information at the time of certification.

The probability of the death of a confirmed diabetic decedent being assigned to cardiovascular disease, relative to diabetes, increased with state BMI and SBP (RRRs 1.03 and 1.01 for each unit change in BMI and SBP, respectively, in the U.S. and 1.20 and 1.01, respectively, in Mexico). This finding probably represents a true epidemiological pattern in which, among those with confirmed diabetes, living in a population with higher BMI and SBP reflects an increased risk of cardiovascular mortality. For deaths assigned to other noncommunicable and communicable diseases, the probability increased with higher BMI in both countries, possibly because of the effects of BMI on noncommunicable diseases as well as general health status. There were no clear effects for SBP for noncardiovascular causes.

Adjusted cause-of-death statistics (national and state patterns)

After standardizing for the effects of individual- and community-level determinants, the relationship between diabetes UCD and diabetes MCD mortality across states was substantially strengthened in both the U.S. and Mexico (Fig. 2). In the U.S., diabetes UCD rates declined most in Utah, New Mexico, New Jersey, and Louisiana, with the adjusted rates being 32–

Table 2—*RRRs*, *P* values, and 95% CIs for the multinomial logistic regression

	U.S.								
	Cardiovascular diseases*			Other noncommunicable diseases†			Communicable diseases‡		
	RRR	*P* value	95% CI	RRR	*P* value	95% CI	RRR	*P* value	95% CI
Race and sex									
White NH men	1.00			1.00			1.00		
White NH women	0.78	<0.001	0.76–0.80	1.04	0.008	1.01–1.07	1.02	0.394	0.97–1.08
Black NH men	0.83	<0.001	0.81–0.86	0.83	<0.001	0.81–0.85	1.15	<0.001	1.09–1.22
Black NH women	0.66	<0.001	0.64–0.68	0.79	<0.001	0.76–0.81	0.89	0.001	0.84–0.95
Hispanic men	0.79	<0.001	0.76–0.81	0.79	<0.001	0.76–0.82	1.05	0.253	0.97–1.13
Hispanic women	0.59	<0.001	0.57–0.61	0.78	<0.001	0.75–0.82	0.86	0.001	0.79–0.94
Other NH men	1.01	0.605	0.96–1.07	0.91	0.004	0.86–0.97	1.27	<0.001	1.13–1.42
Other NH women	0.73	<0.001	0.69–0.77	0.87	<0.001	0.81–0.92	1.16	0.017	1.03–1.30
Place of death (in hospital)	1.16	<0.001	1.14–1.17	0.91	<0.001	0.90–0.92	2.89	<0.001	2.80–2.98
Educational level									
Below high school	0.94	<0.001	0.93–0.96	0.95	<0.001	0.93–0.97	0.97	0.232	0.93–1.02
Below college	1.00	0.886	0.98–1.01	1.01	0.357	0.99–1.03	1.00	0.858	0.97–1.04
College or more	1.00			1.00			1.00		
Age									
20–24 years	0.17	<0.001	0.13–0.24	0.30	<0.001	0.23–0.37	0.80	0.334	0.51–1.25
25–29 years	0.22	<0.001	0.18–0.27	0.27	<0.001	0.22–0.32	1.07	0.653	0.79–1.45
30–34 years	0.39	<0.001	0.35–0.44	0.30	<0.001	0.26–0.34	1.12	0.328	0.89–1.40
35–39 years	0.51	<0.001	0.47–0.56	0.30	<0.001	0.27–0.33	1.26	0.01	1.06–1.50
40–44 years	0.66	<0.001	0.62–0.71	0.39	<0.001	0.36–0.42	1.44	<0.001	1.25–1.65
45–49 years	0.76	<0.001	0.72–0.80	0.46	<0.001	0.44–0.49	1.29	<0.001	1.15–1.45
50–54 years	0.93	0.001	0.89–0.97	0.56	<0.001	0.53–0.59	1.10	0.059	1.00–1.23
55–59 years	0.98	0.272	0.95–1.02	0.70	<0.001	0.67–0.73	1.03	0.526	0.94–1.12
60–64 years	1.00	0.862	0.97–1.03	0.85	<0.001	0.82–0.88	0.96	0.352	0.89–1.04
65–69 years	1.00			1.00			1.00		
70–74 years	1.05	<0.001	1.03–1.08	1.10	<0.001	1.07–1.13	1.20	<0.001	1.13–1.27
75–79 years	1.04	0.01	1.01–1.08	1.31	<0.001	1.26–1.36	1.33	<0.001	1.23–1.44
80–84 years	1.11	<0.001	1.07–1.15	1.25	<0.001	1.20–1.30	1.62	<0.001	1.49–1.76
85+ years	1.15	<0.001	1.11–1.19	1.13	<0.001	1.09–1.18	2.14	<0.001	1.97–2.32
SBP	1.01	<0.001	1.01–1.01	0.98	<0.001	0.98–0.98	1.00	0.559	0.99–1.00
BMI	1.03	<0.001	1.02–1.03	1.02	<0.001	1.01–1.03	1.02	0.002	1.01–1.04
Cardiologists	0.96	<0.001	0.95–0.96	0.96	<0.001	0.95–0.96	0.94	<0.001	0.93–0.95
Endocrinologists	1.03	0.001	1.01–1.05	1.05	<0.001	1.03–1.07	1.13	<0.001	1.08–1.18
Nephrologists	1.07	<0.001	1.05–1.08	1.01	0.284	0.99–1.03	1.19	<0.001	1.14–1.23
	Mexico								
	Cardiovascular diseases			Other noncommunicable diseases			Communicable diseases		
	RRR	*P* value	95% CI	RRR	*P* value	95% CI	RRR	*P* value	95% CI
Sex (women)	1.26	<0.001	1.22–1.30	1.00	0.97	0.97–1.03	1.16	<0.001	1.08–1.24
Insurance (insured)	1.19	<0.001	1.15–1.23	1.27	<0.001	1.24–1.31	0.77	<0.001	0.73–0.82
Necropsy (performed)	1.42	<0.001	1.25–1.60	1.10	0.124	0.97–1.25	1.32	0.016	1.05–1.66
Place of death (in hospital)	1.87	<0.001	1.81–1.92	1.42	<0.001	1.38–1.46	2.84	<0.001	2.67–3.03
Educational level									
Below high school	0.73	<0.001	0.70–0.77	0.76	<0.001	0.73–0.79	0.97	0.486	0.87–1.07
Below college	0.89	0.001	0.84–0.95	0.91	0.003	0.86–0.97	0.92	0.184	0.80–1.04
College or more	1.00			1.00			1.00		
Age									
20–24 years	0.22	<0.001	0.11–0.46	0.45	<0.001	0.31–0.66	2.61	<0.001	1.60–4.26
25–29 years	0.17	<0.001	0.09–0.33	0.62	0.001	0.48–0.81	4.48	<0.001	3.20–6.27
30–34 years	0.33	<0.001	0.24–0.44	0.67	<0.001	0.55–0.81	2.56	<0.001	1.92–3.39
35–39 years	0.38	<0.001	0.30–0.48	0.90	0.158	0.79–1.04	3.24	<0.001	2.59–4.05
40–44 years	0.48	<0.001	0.42–0.55	0.85	0.002	0.77–0.94	2.13	<0.001	1.78–2.55

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Table 2—*Continued*

	Mexico								
	Cardiovascular diseases*			Other noncommunicable diseases†			Communicable diseases‡		
	RRR	*P* value	95% CI	RRR	*P* value	95% CI	RRR	*P* value	95% CI
45–49 years	0.63	<0.001	0.57–0.70	0.96	0.292	0.88–1.04	1.51	<0.001	1.28–1.78
50–54 years	0.65	<0.001	0.60–0.70	0.88	<0.001	0.83–0.94	1.24	0.001	1.09–1.42
55–59 years	0.73	<0.001	0.69–0.78	0.88	<0.001	0.83–0.93	1.06	0.399	0.93–1.20
60–64 years	0.85	<0.001	0.81–0.90	0.92	0.001	0.87–0.96	1.02	0.772	0.91–1.14
65–69 years	1.00			1.00			1.00		
70–74 years	1.52	<0.001	1.44–1.61	1.20	<0.001	1.14–1.27	1.44	<0.001	1.28–1.62
75–79 years	1.66	<0.001	1.57–1.76	1.27	<0.001	1.20–1.34	1.56	<0.001	1.38–1.76
80–84 years	1.83	<0.001	1.72–1.94	1.20	<0.001	1.14–1.28	1.79	<0.001	1.58–2.03
85+ years	1.72	<0.001	1.62–1.83	1.07	0.031	1.01–1.14	2.34	<0.001	2.06–2.64
BMI	1.20	<0.001	1.19–1.22	1.06	<0.001	1.05–1.08	1.15	<0.001	1.12–1.18
SBP	1.01	<0.001	1.01–1.02	1.00	0.092	0.99–1.00	1.01	<0.001	1.01–1.02

For each outcome and for each independent variable, RRR measures the probability of death being assigned to that disease category relative to diabetes and relative to the same probability if the independent variable were set to its reference value, which has an RRR of 1.0 (see ref. 15) for details). Diabetes includes type 1 and 2, malnutrition related, and other diabetes. The corresponding ICD-10 codes are E10–E14. We did not include deaths assigned to injuries (intentional and unintentional) as the underlying cause-of-death in the statistical analysis of coding comparability because assignment to external causes is substantially more likely to be valid/comparable. The corresponding ICD-10 codes are V01–Y89. NH refers to non-Hispanics. Age-group 65–69 years, educational level of college or more, and the race-sex combination of white-NH-men in the U.S. and men in Mexico were the absorbed categories (i.e., RRR = 1.0) for the models. All RRRs are in reference to these groups.*Cardiovascular diseases include rheumatic heart disease, hypertensive disease, ischemic heart disease, cerebrovascular disease, inflammatory heart diseases, and other cardiac diseases. The corresponding ICD-10 codes are: I00–I99. †Other noncommunicable diseases include malignant neoplasms, other neoplasms, endocrine disorders, neuropsychiatric conditions, sense organ diseases, respiratory diseases, digestive diseases, genitourinary diseases, skin diseases, musculoskeletal diseases, congenital anomalies, and oral conditions. The corresponding ICD-10 codes are C00–C97, D00–D48, D65–D89, E03–E07, E15–E16, E20–E34, E51–E88, F01–F99, G06–G98, H00–H61, H68–H93, J30–J98, K00–K92, N00–N64, N75–N98, L00–L98, M00–M99, and Q00–Q99. ‡Communicable diseases include infectious and parasitic diseases, respiratory infections, maternal conditions, conditions arising during the perinatal period, and nutritional deficiencies. The corresponding ICD-10 codes are A00–B99, G00–G04, N70–N73, J00–J06, J10–J18, J20–J22, H65–H66, O00–O99, P00–P96, E00–E02, E40–E46, E50, and D50–D64.

45% lower than the observed rates. The largest increase in diabetes death rates occurred in Hawaii and California, with 64 and 17% increases in diabetes death rates after adjustment, respectively. In Mexico, adjusted diabetes UCD rates were smaller than those observed in all states, with the largest decreases in Guanajuato, Tabasco, and Puebla (34% for each) and the smallest decreases in Baja California Sur (3%) and Nuevo León (12%).

After standardizing the individual- and community-level determinants to the reference values in Table 1 of the universe of deaths with diabetes as one of the MCD, the number of deaths with diabetes as the UCD declined from 71,276 (33% of diabetes MCD) to 63,874 (30%) in the U.S. (2001) and from 63,607 (67% of diabetes MCD) to 48,318 (51%) in Mexico (2005) (Table 3). Cardiovascular diseases increased from 85,134 (39% of diabetes MCD) to 98,583 (46%) in the U.S. and from 13,070 (14% of diabetes MCD) to 22,539 (24%) in Mexico. There was also an increase for communicable diseases in both countries but the change for other noncommunicable diseases was in the opposite direction for the two countries.

In addition to these direct diabetes deaths, high blood glucose increases the risk of mortality from cardiovascular diseases. By using data on blood glucose from the nationally representative National Health and Nutrition Examination Survey (NHANES) 1999–2002 in the U.S. and the Encuesta Nacional de Salud (National Health Survey [ENSA]) 2000 in Mexico and methods described in detail elsewhere (17), an estimated 106,543 deaths due to IHD (21% of all IHD deaths) and 19,757 deaths due to stroke (12% of all stroke deaths) were attributable to higher-than-optimal blood glucose in the U.S., as were 14,224 deaths due to IHD (26%) and 5,273 deaths due to stroke (19%) in Mexico.

CONCLUSIONS — Definitive identification of incomparable coding between diabetes and other diseases among diabetic patients requires detailed prospective studies, with standardized cause-of-death certification. In this analysis, we retrospectively investigated some of the individual and community determinants of cause-of-death assignment with the aim of enhancing the cross-state comparability of diabetes death rates in the U.S. and Mexico.

Standardizing the assignment of diabetes deaths in this analysis to a reference level of individual and community determinants led to significant changes in the diabetes pattern across states and race-sex groups and improved the cross-state comparability of the diabetes cause-of-death statistics. In addition to improved comparability, the reference level of individual and community determinants used in this analysis is one that is expected to provide the most valid cause-of-death statistics; standardizing to this reference level led to a reduction in the number of deaths assigned directly to diabetes in both the U.S. and Mexico.

This study is affected by a number of limitations. The occurrence of a death in the hospital, the number of specialized doctors per capita, and the autopsy variable were valuable proxies for clinical information and diagnostic skills at the community level. Better information on training and diagnostic facilities of the hospitals in which individuals died would allow a more direct assessment of these factors. The death certificate itself may contain errors (e.g., educational attainment and race, which are provided by next of kin). The finding on the role of race, ethnicity, and sex may reflect differences in quality of care experienced by minority patients (18) and differential practices in

Table 3— ***Observed and adjusted numbers and proportions of UCD assigned to different disease clusters among deaths with diabetes as one of the MCD in the U.S. (2001) and Mexico (2005)***

	U.S. (2001)							
	Diabetes		Cardiovascular diseases		Other noncommunicable diseases		Communicable diseases	
	Observed	Corrected	Observed	Corrected	Observed	Corrected	Observed	Corrected
20–44								
Male	1,580 (51)	1,476 (47)	864 (28)	946 (30)	507 (16)	481 (15)	174 (6)	222 (7)
Female	1,076 (49)	1,059 (48)	523 (24)	599 (27)	488 (22)	400 (18)	131 (6)	159 (7)
45–60								
Male	5,516 (38)	5,067 (35)	5,603 (39)	5,975 (42)	2,678 (19)	2,658 (19)	562 (4)	659 (5)
Female	4,015 (39)	3,564 (35)	3,367 (33)	4,377 (42)	2,495 (24)	1,911 (19)	450 (4)	475 (5)
60+								
Male	25,691 (30)	24,747 (29)	34,946 (41)	37,369 (44)	21,599 (25)	19,174 (23)	2,897 (3)	3,843 (5)
Female	33,398 (33)	27,960 (28)	39,831 (40)	49,316 (49)	23,700 (24)	18,406 (18)	3,511 (3)	4,757 (5)
20+								
Male	32,787 (32)	31,290 (30)	41,413 (40)	44,289 (43)	24,784 (24)	22,313 (22)	3,633 (4)	4,725 (5)
Female	38,489 (34)	32,584 (29)	43,721 (39)	54,293 (48)	26,683 (24)	20,717 (18)	4,092 (4)	5,391 (5)
	Mexico (2005)							
	Diabetes		Cardiovascular diseases		Other noncommunicable diseases		Communicable diseases	
	Observed	Corrected	Observed	Corrected	Observed	Corrected	Observed	Corrected
20–44								
Male	1,785 (73)	1,475 (60)	132 (5)	262 (11)	370 (15)	512 (21)	172 (7)	210 (9)
Female	1,307 (75)	1,119 (64)	96 (5)	145 (8)	244 (14)	360 (21)	102 (6)	125 (7)
45–60								
Male	7,134 (70)	5,455 (53)	1,128 (11)	2,107 (21)	1,659 (16)	2,234 (22)	331 (3)	455 (4)
Female	6,656 (70)	5,520 (58)	969 (10)	1,537 (16)	1,536 (16)	2,039 (22)	286 (3)	352 (4)
60+								
Male	20,339 (65)	14,642 (47)	4,817 (15)	8,822 (28)	5,189 (17)	6,539 (21)	874 (3)	1,216 (4)
Female	26,367 (67)	20,089 (51)	5,925 (15)	9,663 (25)	5,880 (15)	8,193 (21)	1,211 (3)	1,438 (4)
20+								
Male	29,264 (67)	21,578 (49)	6,079 (14)	11,194 (25)	7,218 (16)	9,285 (21)	1,377 (3)	1,881 (4)
Female	34,338 (68)	26,735 (53)	6,991 (14)	11,345 (22)	7,663 (15)	10,595 (21)	1,601 (3)	1,917 (4)

Data are *n* (%).

cause-of-death assignment or actual epidemiological differences in the natural history of diabetes. Finally, our analysis focused on comparability across states in the same country, which limits its application to cross-country comparability.

Above and beyond comparability, improving the overall validity of death certificates is important for public health planning. Improving validity and comparability requires better training in cause-of-death certification, accessible information on medical history (e.g., through linked records), and standardized (and ideally automated) coding. Together with such national efforts, the new revision of the ICD should provide further clarity on the assignment of the UCD as related to diabetes and cardiovascular diseases.

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