Supplementary Online Content

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This supplementary material has been provided by the authors to give readers additional information about their work.

US county-level trends in mortality rates for major causes of death, 1980-2014

Supplementary Online Content

Contents

1 eAppendix: Supplemental information.

1.1 Garbage code redistribution

Garbage code redistribution methods developed for the Global Burden of Diseases, Injuries, and Risk Factors study (GBD)[1] were used in this study in order to reassign deaths to appropriate target causes. This method included four different approaches to determining the fraction of deaths assigned to each group of garbage codes that should be reassigned to a given target cause. Deaths assigned each group of garbage codes are addressed using one of these four approaches.

Both the first and second approaches used fixed proportions, i.e., the same proportions were applied to deaths assigned garbage codes regardless of which county those deaths occurred in. In the first approach, the fixed proportions were derived from relevant literature and/or expert opinion.

In the second approach, based on work by Ahern et al.[2], the fixed proportions were derived from regression models fit to all available deaths registration data. Specifically, for a particular group of related garbage codes, the following model was fit separately for each target code and sex:

$$T_{c[r,s],t,a} = \alpha + \gamma_{1,s} + \gamma_{2,r} + (\beta_1 + \beta_{2,a} + \gamma_{3,s} + \gamma_{4,r}) \cdot G_{c[r,s],t,a} + \epsilon_{c[r,s],t,a}$$

where:

- c indicates country, s and r indicate the super-region and region where c is located (according to the definition used by the GBD), t indicates the year, and a indicates the age group, in this case: <15 years, 15-49 years, 50-59 years, 60-69 years, 70-79 years, or 80+ years;
- $T_{c[r,s],t,a}$ is the proportion of deaths coded to the given target cause among all deaths coded either to the specified garbage code or any of its target causes, within country c, year t, and age group a;
- $G_{c[r,s],t,a}$ is the proportion of deaths coded to the specified garbage code among all deaths coded either to the specified garbage code or any of its target causes, within country c, year t, and age group a;
- α is the intercept;
- $\gamma_{1,s}$ and $\gamma_{2,r}$ are super-region- and region-level random intercepts;
- β_1 is the slope on $G_{c[r,s],t,a}$;
- $\beta_{2,a}$ is an age-group-specific slope on $G_{c[r,s],t,a}$;
- and $\gamma_{3,s}$ and $\gamma_{4,r}$ are super-region- and region-level random intercepts on $G_{c[r,s],t,a}$.

In general, an inverse relationship between $G_{c[r,s],t,a}$ and $T_{c[r,s],t,a}$ is expected: if deaths assigned to a garbage code are, in truth, due to a particular target cause, then as the overall proportion of deaths assigned garbage

codes increases, the deaths assigned to a target cause should decline. This relationship may, however, vary by country or age group, so this relationship was approximated for each country and age group based on the fitted regression model as $\beta_1 + \beta_{2,a} + \gamma_{3,s} + \gamma_{4,r}$. Within each country and age group, target causes where the overall effect was not negative were dropped and then the effects for the remaining targets were re-scaled to sum to 1. These re-scaled effects were used as the proportions for redistributing garbage codes to the appropriate target causes.

The third approach redistributed deaths assigned garbage codes to all relevant targets in proportion to the number of deaths observed at the state level in each target group prior to redistribution.

The fourth approach was specific to garbage codes related to Kaposi sarcoma and certain other infectious diseases and immunodeficiencies that are known to be frequently used when the underlying cause of death is HIV/AIDS. In these cases, the regional rate of change compared to 1980-84 was calculated for each set of garbage codes. The proportion of deaths assigned to these garbage codes that were due to HIV/AIDS was expected to have increased much more rapidly than the proportion due to other target causes as the HIV/AIDS epidemic expanded. Consequently, any increase greater than 5% was assumed to have been due to deaths that should have been coded as due to HIV/AIDS, while the remainder of deaths were assigned to other appropriate target codes. Separate redistribution proportions were derived by sex, age group, and 5-year time interval.

Note that the first approach is independent of the US deaths data used elsewhere in this analysis, while the third approach uses only this data in order to derive the redistribution proportions. In contrast, the second approach uses all available deaths registration data globally while the third uses data from countries in the same region as defined by the GBD (in this case, high income North America, i.e., the US and Canada). Regardless of how the redistribution proportions were derived, they were always applied by county such that there is no change in the total number of deaths in any county as a result of redistribution.

Deaths assigned each garbage code (or group of closely related garbage codes) were redistributed using one of the four methods described. Method 4, the HIV/AIDS method, is specific to a subset of garbage codes that are known to be commonly assigned when HIV/AIDS is the true underlying cause. Among the remaining garbage codes, the regression method (method 2), was generally used for garbage codes with a relatively small number of specified targets; this method tends to break down when there are a large number of targets because there is often insufficient data to estimate all of the relevant relationships. For garbage codes where the regression method was not appropriate or where the results of the regression method were implausible, published literature (method 1) was used as the basis for redistribution if available, and otherwise the observed proportions among the targets (method 3) was used. Garbage codes that have little information content (e.g., 'senility') were typically redistributed to all causes using method 3.

These garbage code redistribution methods were designed to be applied at the most detailed levels of the GBD cause hierarchy (i.e., levels 3 and 4). Although this analysis does not consider these more detailed causes, redistribution was carried out at this level and deaths were then aggregated to the second level of the GBD cause hierarchy prior to applying the small area models.

1.2 SAE model

The following model was estimated separately for males and females:

$$D_{j,t,a} \sim \text{Poisson}(m_{j,t,a} \cdot P_{j,t,a})$$
$$\log(m_{j,t,a}) = \beta_0 + \boldsymbol{\beta}_1 \cdot \boldsymbol{X}_{j,t} + \gamma_{1,a,t} + \gamma_{2,j} + \gamma_{3,j} \cdot t + \gamma_{4,j,t} + \gamma_{5,j} \cdot a + \gamma_{6,j,a}$$

where

- j, t, and a are indices for county, calendar year (1980-2014, renumbered sequentially from 0 to 34), and age group (0, 1-4, 5-9, ..., 75-79, and 80+, recoded sequentially from 0 to 17), respectively;
- $D_{j,t,a}$ and $P_{j,t,a}$ are the number of deaths and the population count, respectively, in county j, year t, and age group a;
- $m_{j,t,a}$ is the underlying mortality rate in county j, year t, and age group a;
- β_0 is an intercept;
- $\boldsymbol{X}_{j,t}$ is a vector of covariates for county j and year t, and $\boldsymbol{\beta}_1$ is the associated vector of regression coefficients;
- $\gamma_{1,a,t}$ is an age group- and year-level random intercept;
- $\gamma_{2,j}$ is a county-level random intercept;
- $\gamma_{3,j}$ is a county-level random slope on year;
- $\gamma_{4,j,t}$ is a county- and year-level random intercept;
- $\gamma_{5,j}$ is a county-level random slope on age group;
- and $\gamma_{6,j,a}$ is a county- and age group-level random intercept.

$\boldsymbol{\gamma_2}$, $\boldsymbol{\gamma_3}$, and $\boldsymbol{\gamma_5}$ were each assumed to follow a conditional autoregressive distribution[3] where the full conditional distribution is given by:

$$\gamma_j | \boldsymbol{\gamma}_{k \sim j}, \sigma^2, \rho \sim \text{Normal}\left(\frac{\rho \cdot \sum_{k \sim j} \gamma_k}{n_j \cdot \rho + 1 - \rho}, \frac{\sigma^2}{n_j \cdot \rho + 1 - \rho}\right)$$

where

- $k \sim j$ indicates the set of counties k that are adjacent to county j;
- n_j is the number of counties in $k \sim j$;
- and σ^2 and ρ are variance and correlation parameters, respectively.

These random effects allow for spatial variation beyond what is already explained by the covariates in the overall level ($\boldsymbol{\gamma_2}$), linear deviations from the overall time trend ($\boldsymbol{\gamma_3}$), and linear deviations from the overall age pattern ($\boldsymbol{\gamma_5}$). The σ^2 parameters control the amount of spatial variation in each of these dimensions while the ρ parameters, which vary between 0 and 1, determine the spatial smoothness. At the limit, as ρ goes to 0 this distribution reduces to a fully exchangeable model where the neighborhood configuration is non-informative: $\gamma_j|\sigma^2 \sim \text{Normal}(0, \sigma^2)$. At the other extreme, as ρ goes to 1, this distribution reduces to an intrinsic conditional autoregressive distribution where $\gamma_j|\boldsymbol{\gamma}_{k\sim j}, \sigma^2 \sim \text{Normal}\left(\frac{\sum_{k\sim j}\gamma_k}{n_j}, \frac{\sigma^2}{n_j}\right)$, indicating a high degree of spatial smoothness.

$\boldsymbol{\gamma_1}$ was also assumed to follow a conditional autoregressive distribution. Specifically, this was specified as the interaction between two distributions as defined above, but for age and time, respectively, rather than county. This was specified according to the procedure described by Clayton[4] and Knorr-Held[5] (i.e., a 'Type IV' interaction). This specification allows for smoothing over age group and time simultaneously, such that the level for a given age group and year is informed both by first order neighbors (i.e., adjacent years in the same age group and adjacent age groups in the same year) as well as second order neighbors (i.e., adjacent years in adjacent age groups). For this distribution there are three hyperparameters: σ^2, which controls the overall amount of variation, and ρ_{age} and ρ_{time} which control the smoothness over age and time, respectively.

$\boldsymbol{\gamma_4}$ and $\boldsymbol{\gamma_6}$ were assumed to follow identical and independently distributed Normal distributions. These random effects were included in order to allow for non-linear county-level deviations in the time or age pattern (linear deviations are captured by $\boldsymbol{\gamma_3}$ and $\boldsymbol{\gamma_5}$).

Gamma(1, 1000) priors were specified for the inverse variance ($\frac{1}{\sigma^2}$) of each random effect. Normal(0, 1.5) priors were specified for the logit-transform of the correlation parameters (ρ).

The Template Model Builder (TMB) package[6] in R version 3.2.4[7] was used to fit this model. Broadly speaking, there were three steps in this model fitting process. First, TMB was used to find the Laplace approximation to the marginal log-likelihood of the data and model parameters with respect to the hyperparameters (i.e., σ^2 and ρ terms) integrating over all fixed and random parameters (i.e., β and γ terms). Second, non-linear optimization routines in R were used to maximize this approximated marginal log-likelihood plus marginal prior for the hyperparameters and derive point estimates for all model parameters. Third, a generalized delta-method implemented in TMB was used to approximate the joint precision matrix for all model parameters.

After fitting the model, 1,000 draws from the posterior distribution were generated using a multivariate-normal

approximation. Posterior draws of $m_{j,t,a}$ were derived from each posterior draw of the model parameters. Finally, point estimates and 95% uncertainty intervals for $m_{j,t,a}$ were derived from the mean and 2.5th and 97.5th percentiles, respectively, of these 1,000 draws.

1.3 Model validation

1.3.1 Methods

The performance of the small area models used in this analysis, several variants on this model, and two previously published models, was assessed using a framework similar to that initially described by Srebotnjak et al.[8] Broadly, there were three steps in this process.

In the first step, a 'validation set' of counties was identified. These are counties with large populations where the effect of stochastic noise is expected to be small such that the directly observed mortality rate is very close to the underlying mortality rate and can therefore be treated as a 'gold standard.' To maximize the number of counties that were eligible to be included in the validation set, populations and deaths for each county were first pooled using a three-year moving window. The dataset was then subset to only counties with non-zero death counts in every age group in each year for both males and females. For each remaining county, 1,000 draws of the mortality rate for each age group, sex, and year were simulated assuming a Poisson distribution; age groups were combined in order to generate 1,000 draws of the age-standardized mortality rate for each sex and year; and the coefficient of variation of the age-standardized mortality rate and of each age-specific mortality rate in each year and sex was calculated (i.e., the standard deviation of the draws divided by the mean of the draws). Finally, counties where the coefficient of variation was less than 1% for the age-standardized mortality rates and less than 10% for the age-specific mortality rates across all years and both sexes were selected for the validation set.

In the second step, validation data sets were created and used to fit each model and derive predictions. A total of 60 validation data sets were generated: 10 each to examine the performance of the model for counties with a total population of 1,000, 3,000, 5,000, 10,000, 25,000, and 100,000, corresponding roughly to the 1st, 5th, 10th, 25th, 50th, and 80th percentile across all counties and years. To create each validation data set, a pre-specified number of individuals were sampled in each county in the validation dataset from the observed population age-sex distribution. Then, for each age and sex in each county in the validation dataset, deaths were sampled from a Poisson distribution with mean equal to the observed mortality rate times the sampled population size in that age group and sex. The data for all counties not in the validation dataset were included without modification. After creating the validation data sets, models were fit to these data and predictions derived in the same manner as for the observed data.

Finally, the predictions were compared to the directly observed age-standardized mortality rates. For each model corresponding to a different validation data set, and for each county-year in the validation set, the relative error ($100 \cdot (m_{gs} - m_{pred})/m_{gs}$, where m_{gs} is the gold standard age-standardized mortality rate, and m_{pred} is the predicted age-standardized mortality rate) was calculated and whether or not the gold standard was contained by the predicted lower and upper uncertainty intervals was recorded. Across all county-years in the validation set and across all 10 validation data sets at each population level, performance was summarized in terms of the mean relative error, the mean absolute relative error (i.e., the mean of the absolute value of the relative error), and the coverage (i.e., the percent of county-years where the gold standard estimate was between the lower and upper uncertainty intervals).

A total of six models were considered.

1. The model described in the previous section.

2. As in (1), but excluding the $\gamma_{4,j,t}$ and $\gamma_{6,j,a}$ terms. This simplifies the model in (1) by only allowing for linear county-level deviations from the overall age and time trend.

3. As in (2), but also excluding $\gamma_{3,j} \cdot t$ and $\gamma_{5,j} \cdot a$ terms. This further simplifies the model in (2) by assuming that the time and age pattern is the same across all counties (beyond differences accounted for by the included covariates).

4. As in (3), but replacing $\gamma_{1,a,t}$ with separate (i.e., not interacted) age and time random effects. This simplifies the model in (3) even further by assuming no interaction between the age pattern and time pattern, i.e., that the same age pattern applies in all years and, equivalently, that the same time pattern applies to all age groups.

5. The model described by Kulkarni et al.[9] In this approach, separate mixed effects models are specified for each age group and each year and a two-stage fitting procedure is used to estimate and incorporate spatial effects.

6. The model described by Wang et al.[10] This model is an extension of the Kulkarni model that adds an additional step wherein a non-parametric temporal smoothing model is applied to the predictions in larger counties. In both the analysis by Kulkarni and the analysis by Wang, smaller counties were merged with their neighbors until all counties were part of units with at least 5,000 males and 5,000 females. For this analysis, for comparability with models 1-4, no counties were merged beyond what was required to obtain historically stable analytic units.

Four variants on the model developed for this analysis were included in order to assess whether more complicated versions of this model allowing for more flexible interactions between age, time, and space, were appropriate, particularly for smaller populations. The previously published models were included to assess

whether or not the approach developed for this analysis improves on methods that were already available. The models by Wang and Kulkarni frequently failed to converge when fit to validation sets with population size 1,000, so results from these models are not reported at this level.

This validation framework was computationally intensive as it required fitting each model and generating predictions 120 times (once for males and once for females to each of the 60 validation data sets). Consequently, applying this validation framework to each cause individually was infeasible, so instead performance overall was assessed in terms of all-cause mortality.

1.3.2 Results

The mean relative error for the age-standardized mortality rate is presented in eTable 4. The mean relative error is a measure of bias, i.e., whether the rates estimated by the model were systematically higher or lower than the true rates. There was no evidence of bias in either model 1 or 2, where the mean relative error never exceeded +/- 1%. For models 3 and 4, the mean relative error was similarly less than 1% at all but the smallest population size considered (1,000), where it was approximately -2.5%. The mean relative error for the other two models was more substantial: above 1% even for the largest population size, and more than 2% and 5% at maximum for the models by Kulkarni and Wang, respectively.

The mean absolute relative error for the age-standardized mortality rate is given in eTable 5. This is a measure of the overall error, i.e., how much the model estimates differ from the true estimates. As anticipated, all models performed better in this regard for larger populations. At the smallest population size, models 1-4 performed roughly equally with around 6.5-7% error, although the model used in the final analysis (1) did have the lowest error overall. For larger population sizes, models 1 and 2 outperformed models 3 and 4 by a substantial margin. The models by Kulkarni and Wang performed worse than models 1 and 2 but better than models 3 and 4 at the largest population size, however they consistently had the highest mean absolute relative error at smaller population sizes.

eTable 6 shows the coverage for the age-standardized mortality rate. Ideally, coverage should be as close as possible to 95% as this indicates that the 95% uncertainty intervals are an appropriate reflection of an estimate's precision. Model 1 had good coverage for counties of all population sizes. Coverage for models 2-4 was generally too low, though it was better for model 2 as compared to models 3 and 4, and for small counties as compared to large counties. Coverage for the models by Kulkarni and Wang was also too low, but was better for larger populations than for smaller ones.

In summary, models 1 and 2 slightly outperformed models 3 and 4 in terms of the mean relative error and were substantially better when compared in terms of the mean absolute relative error. The models by Kulkarni and Wang performed less well in terms of both mean relative error and mean absolute relative error than all

other models. In terms of coverage, model 1 was superior to all of the other models.

1.4 Raking

After the modeling steps, results were adjusted to ensure consistency across two dimensions: cause hierarchy and geography.

Adjustments by cause were needed because SAE models were run independently for all-cause mortality and each of the 24 causes in the first and second level of the GBD cause hierarchy. Thus, the cause-specific model outputs do not necessarily nest as they should; that is, summing predicted deaths from the three level 1 causes does not result in precisely the predicted all-cause death count, although generally it will be close.

Adjustments were also needed in order to ensure consistency with national-level estimates from the GBD. These estimates are based on the same death registration data but also incorporated other data sources for certain causes where registration data are known to be sub-optimal (e.g., dementias). These data were not available at the county level, so instead county-level estimates were raked to the GBD national-level estimates to capitalize on the additional information content.

To accomplish these twin goals, an algorithm known as raking, and also called iterative proportional fitting, was utilized. Given an N-dimensional table whose internal entries denote uncertain values and whose marginals denote aggregated, more certain values, raking provides a means of fitting the internal entries to the marginals while preserving some internal relationships of the table. This is accomplished simply by proportionately scaling the rows to add up to their marginal totals, then scaling the columns the same way, and repeating until the entries in the table stabilize (i.e., converge).

Consider a two-dimensional table with r rows and c columns, where $n_{i,j}$ refers to the entry in the (i, j)th cell, and N_i and N_j refer to the fixed marginal values along the rows and columns, respectively. To illustrate, imagine that the US has only five counties, named Alpha, Bravo, Charlie, Delta, and Echo. The process below shows the raking of (synthetic) county deaths for level-1 causes (Communicable Diseases, Noncommunicable Diseases, and Injuries) to national deaths for level-1 causes and to county deaths for all-cause mortality.

Start with a table of values.

	County					
Cause	Alpha	Bravo	Charlie	Delta	Echo	United States
Communicable	29	50	7	22	17	119
Noncommunicable	178	202	49	91	45	407
Injuries	53	67	36	26	31	203
All-Cause	200	253	97	103	82	735

In iteration 1, find new values $n_{i,j}$ such that:

$$n^1_{i,j} = n^0_{i,j} * \frac{N_i}{\sum_{i=1}^{r} n^0_{i,j}}$$

	County					
Cause	Alpha	Bravo	Charlie	Delta	Echo	United States
Communicable	27.61	47.60	6.66	20.94	16.18	119.00
Noncommunicable	128.22	145.51	35.30	65.55	32.42	407.00
Injuries	50.51	63.85	34.31	24.78	29.54	203.00
All-Cause	200.00	253.00	97.00	103.00	82.00	735.00

In iteration 2, find new values $n_{i,j}$ such that:

$$n^2_{i,j} = n^1_{i,j} * \frac{N_j}{\sum_{j=1}^{c} n^1_{i,j}}$$

	County					
Cause	Alpha	Bravo	Charlie	Delta	Echo	United States
Communicable	26.76	46.87	8.48	19.39	16.98	119.00
Noncommunicable	124.28	143.27	44.89	60.68	34.02	407.00
Injuries	48.96	62.87	43.63	22.94	31.00	203.00
All-Cause	200.00	253.00	97.00	103.00	82.00	735.00

In iteration 3, repeat iteration 1 with $n^2_{i,j}$.

	County					
Cause	Alpha	Bravo	Charlie	Delta	Echo	United States
Communicable	26.88	47.08	8.51	19.47	17.06	119.00
Noncommunicable	124.24	143.22	44.88	60.66	34.00	407.00
Injuries	47.46	60.95	42.30	22.24	30.05	203.00
All-Cause	200.00	253.00	97.00	103.00	82.00	735.00

In iteration 4, repeat iteration 2 with $n^3_{i,j}$.

	County					
Cause	Alpha	Bravo	Charlie	Delta	Echo	United States
Communicable	27.07	47.40	8.63	19.59	17.24	119.00
Noncommunicable	125.13	144.22	45.49	61.03	34.37	407.00
Injuries	47.80	61.37	42.88	22.37	30.38	203.00
All-Cause	200.00	253.00	97.00	103.00	82.00	735.00

Continue until an additional iteration does not meaningfully change $n_{i,j}$.

	County					
Cause	Alpha	Bravo	Charlie	Delta	Echo	United States
Communicable	27.08	47.42	8.63	19.60	17.25	119.00
Noncommunicable	125.16	144.25	45.51	61.05	34.39	407.00
Injuries	47.77	61.33	42.86	22.36	30.36	203.00
All-Cause	200.00	253.00	97.00	103.00	82.00	735.00

Raking has been shown to converge[11] if the sum of the margins are equal (i.e., if $\sum_{i=1}^{r} N_i = \sum_{j=1}^{c} N_j$) and there are no zeros or negative numbers in the margins. Raking works on tables of arbitrary dimensionality, and requires only a single iteration for a one-dimensional table.

It should be noted that this algorithm was applied to mortality rates rather than death counts, and as such, an extra population-weighting step was required when raking to national estimates. There were two stages in raking. First, one-dimensional raking was applied to fit county-level all-cause estimates to national all-cause estimates. Second, two-dimensional raking was applied at each level of the cause hierarchy. That is, after raking all-cause county-level to national estimates, the following groups of causes were raked:

1. The three level 1 causes (Communicable, Noncommunicable, and Injuries) to county-level all-cause estimates and national Communicable, Noncommunicable, and Injury results.

2. The seven children of the Communicable cause to county-level Communicable estimates and national estimates for those child causes.

3. The ten children of the Noncommunicable cause to county-level Noncommunicable estimates and national estimates for those child causes.

4. The four children of the Injuries cause to county-level Injuries estimates and national estimates for those child causes.

1.5 Calculating years of life lost

Years of life lost (YLLs) were calculated for each cause as in the GBD.[1] For each age group, the number of deaths was calculated by multiplying the estimated mortality rate by the population. YLLs were then calculated for each age group by multiplying the number of deaths by the life expectancy at the average age at death in that age group from a reference life table. The reference life table from the GBD was used in this analysis; this life table was constructed from the lowest observed mortality rate among all countries in 2013 for each age group and corresponds to a life expectancy at birth of 86.6 years.

As an example, the data in the table below show the population (column 2) and the estimated mortality rates from cardiovascular diseases (column 3) in the US in 2014. Deaths (column 4) were calculated by multiplying the population by the estimated mortality rate. Life expectancy at the average age of death within each age group (column 5) was extracted from the GBD reference life table. YLLs in each age group (column 6) were then calculated by multiplying deaths by life expectancy. Total YLLS were calculated by summing across all ages.

Age Group	Population	Mortality Rate	Deaths	Life Expectancy	YLLs
0	3,991,801	8.3	331	86.18	28,551
1-4	16,142,348	1.1	174	84.20	14,629
5-9	21,022,679	0.4	88	79.32	6,981
10-14	20,537,438	0.6	128	73.86	9,455
15-19	21,700,738	1.6	352	69.06	24,336
20-24	22,467,579	3.6	809	64.31	52,029
25-29	21,943,503	6.7	1,471	59.43	87,389
30-34	21,222,396	12.4	2,626	54.48	143,041
35-39	19,345,592	22.0	4,262	49.53	211,091
40-44	20,432,008	40.6	8,286	44.62	369,711
45-49	22,263,758	73.9	16,443	39.80	654,382
50-54	23,899,275	125.6	30,016	35.08	1,052,861
55-59	21,541,555	193.0	41,575	30.48	1,267,073
60-64	20,198,375	279.9	56,540	25.91	1,464,742
65-69	14,333,828	420.9	60,331	21.47	1,295,080
70-74	10,102,967	671.5	67,843	17.23	1,168,681
75-79	7,298,604	1,153.5	84,191	13.28	1,117,654
80+	12,227,811	3,850.5	470,832	5.88	2,768,105
Total			846,298		11,735,793

1.6 References

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2 eFigures

eFigure 1: Example of garbage code redistribution in King County, WA (2013).

eFigure 2: Percent of deaths assigned garbage codes (1980-2014).

eFigure 3: Annual distribution of deaths by cause before and after garbage code redistribution (1980-2014).

eFigure 4: County-level mortality from unintentional injuries.

eFigure 5: County-level mortality from other non-communicable diseases.

eFigure 6: County-level mortality from neonatal disorders.

eFigure 7: County-level mortality from digestive diseases.

eFigure 8: County-level mortality from HIV/AIDS and tuberculosis.

eFigure 9: County-level mortality from musculoskeletal disorders.

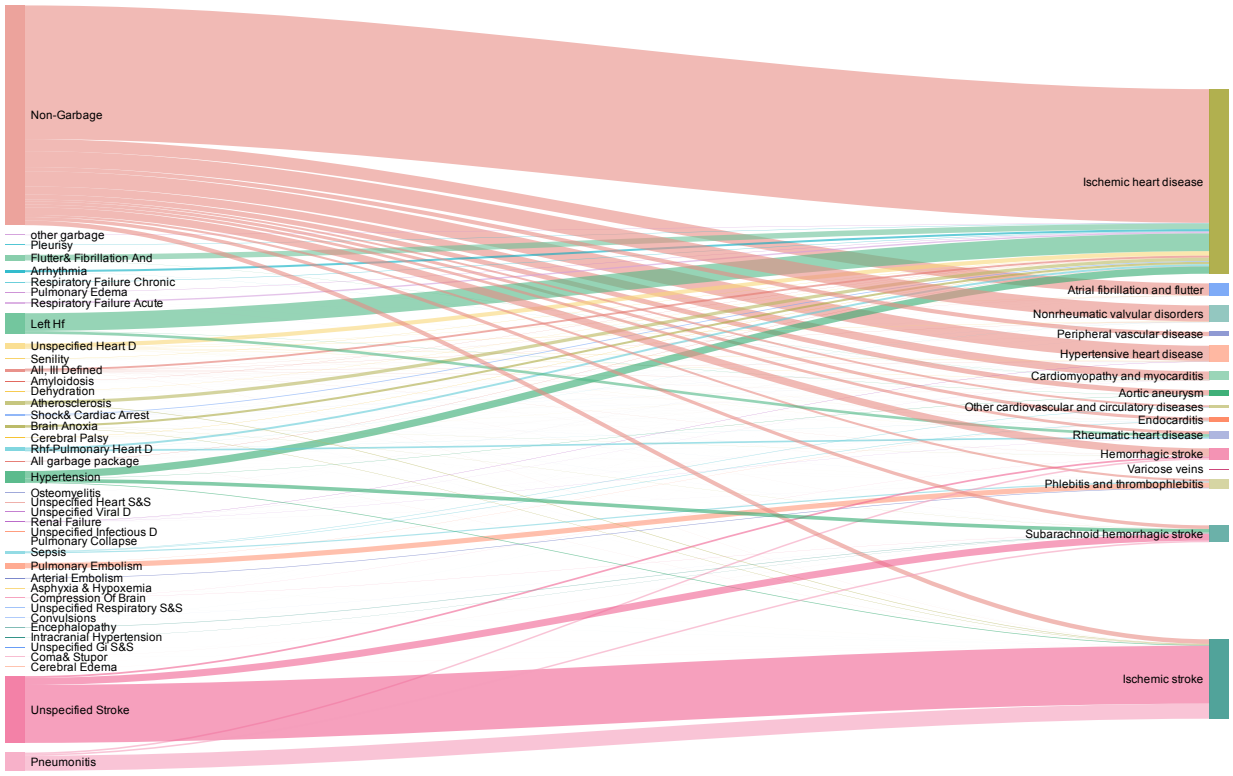
eFigure 10: County-level mortality from other communicable, maternal, neonatal, and nutritional diseases.

eFigure 11: County-level mortality from maternal disorders.

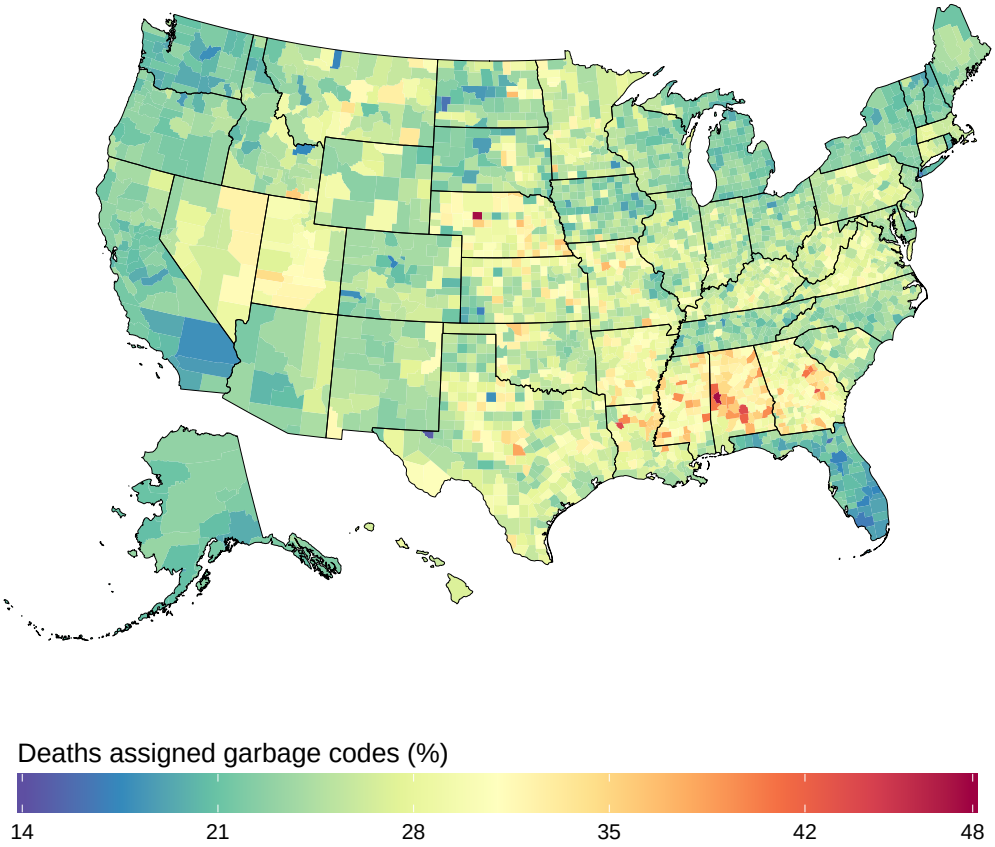
eFigure 12: County-level mortality from nutritional deficiencies.

eFigure 13: County-level mortality from forces of nature, war, and legal intervention.

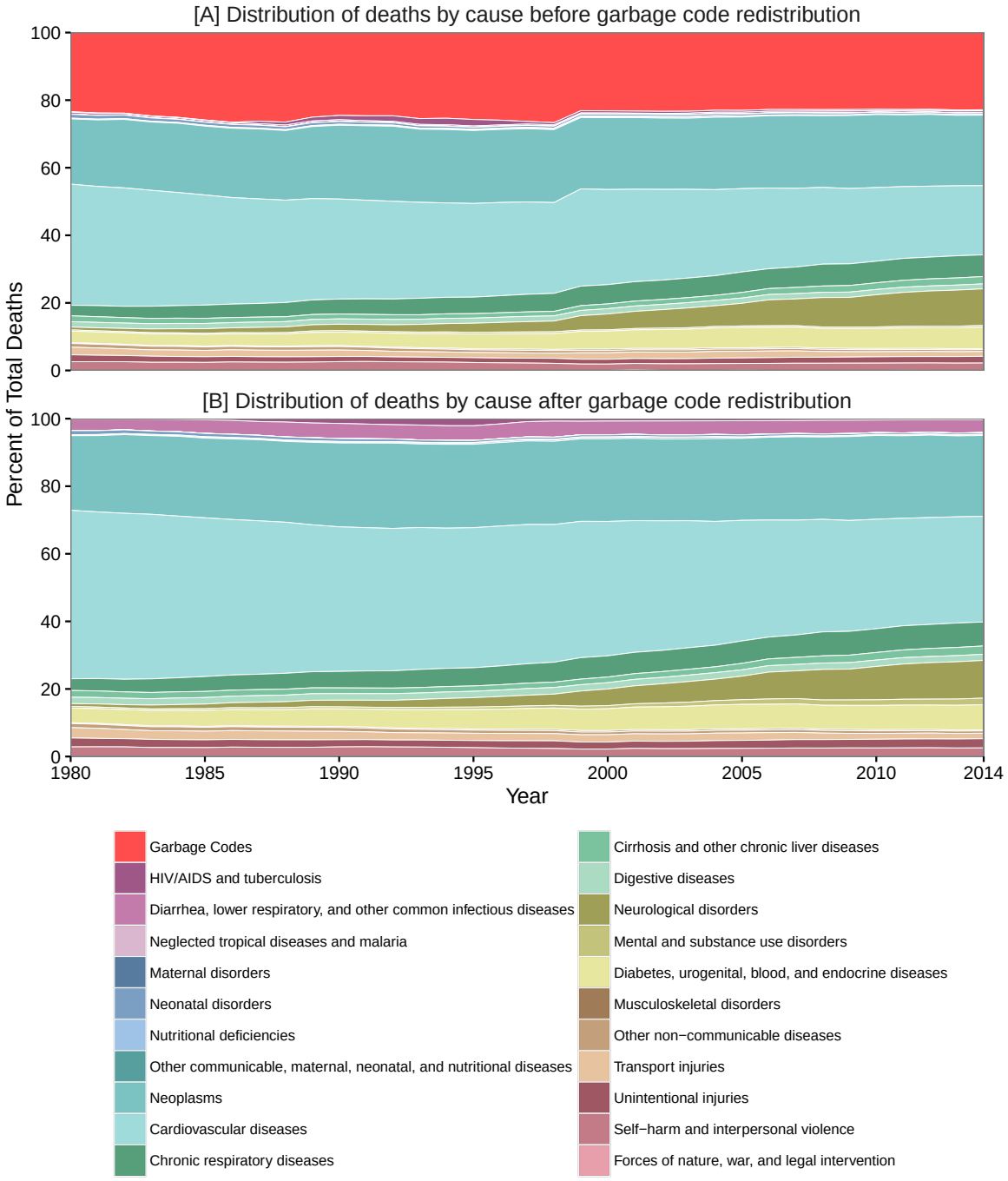
eFigure 14: County-level mortality from neglected tropical diseases and malaria.



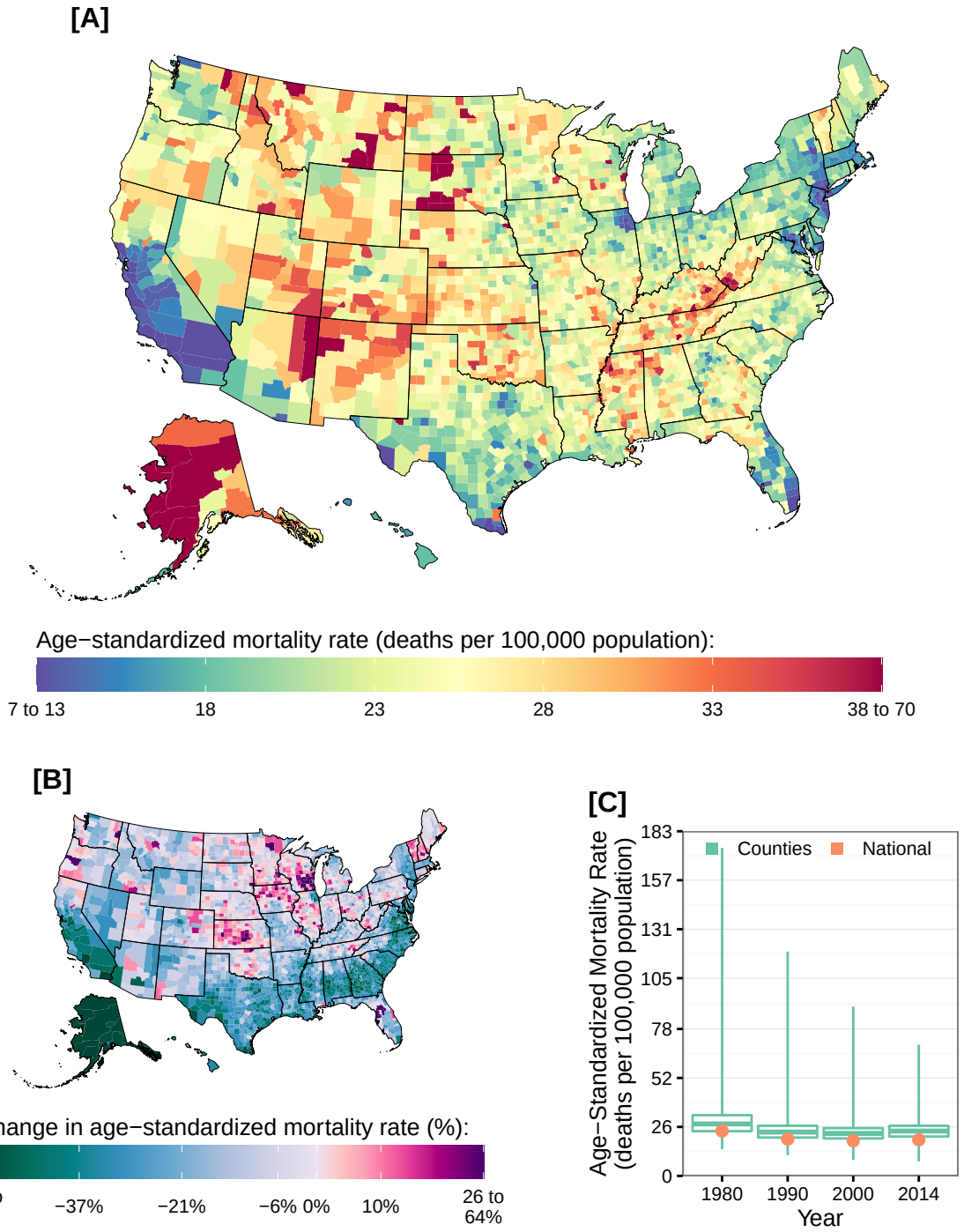
eFigure 1: Example of garbage code redistribution in King County, WA (2013). The left axis represents ICD codes that were mapped to cardiovascular diseases in the GBD cause hierarchy and the right axis represents these cardiovascular diseases. The width of each band is proportional to the number of deaths transferred from a given set of ICD codes to a specific cardiovascular disease. Garbage codes are ICD codes which are implausible or insufficiently specific for the underlying cause of death. All categories on the left axis other than "Non-Garbage" refer to sets of garbage codes. The category "Non-Garbage" includes deaths where the original underlying cause of death code could be mapped directly to a cause in the GBD cause hierarchy.



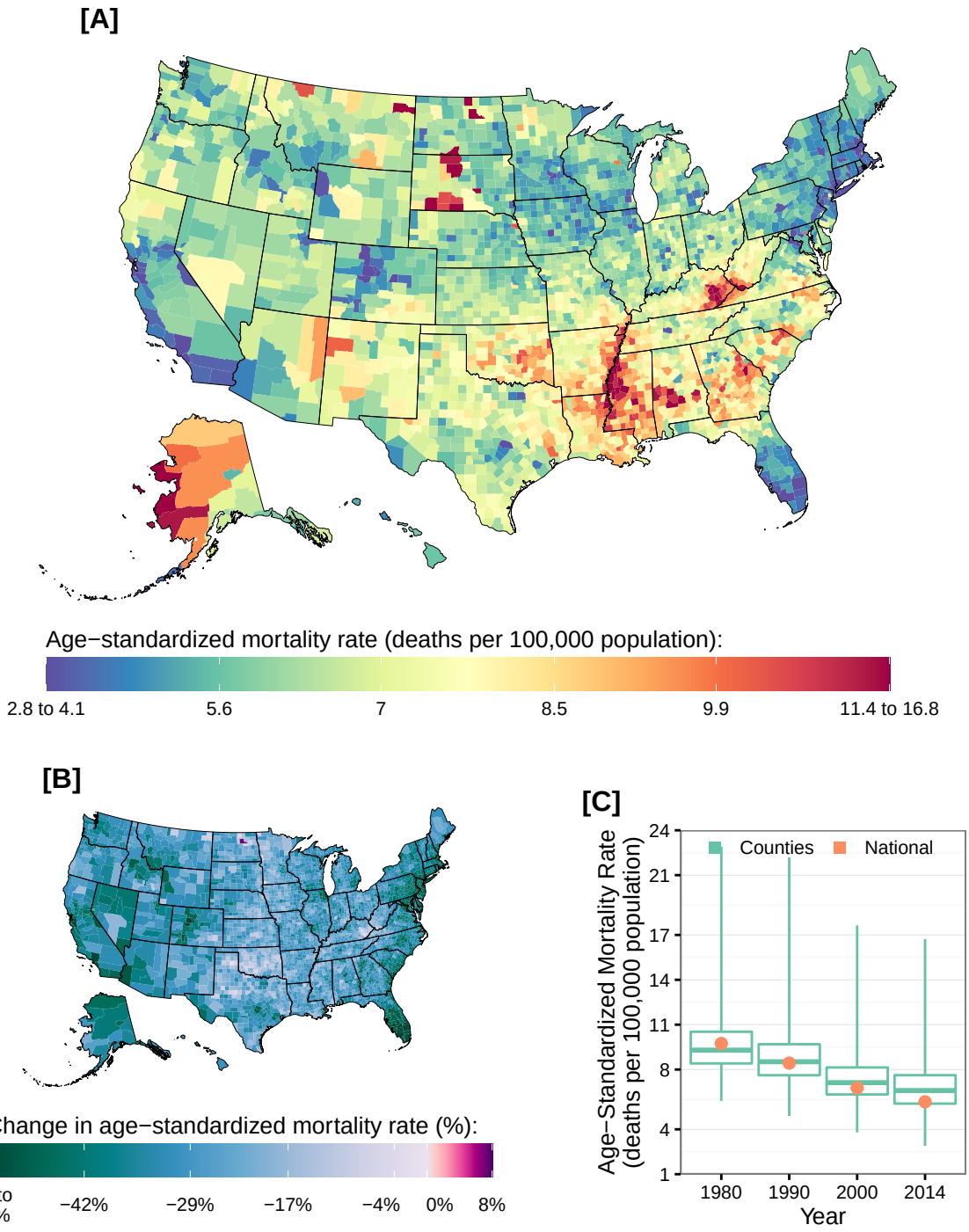
eFigure 2: Percent of deaths assigned garbage codes (1980-2014).



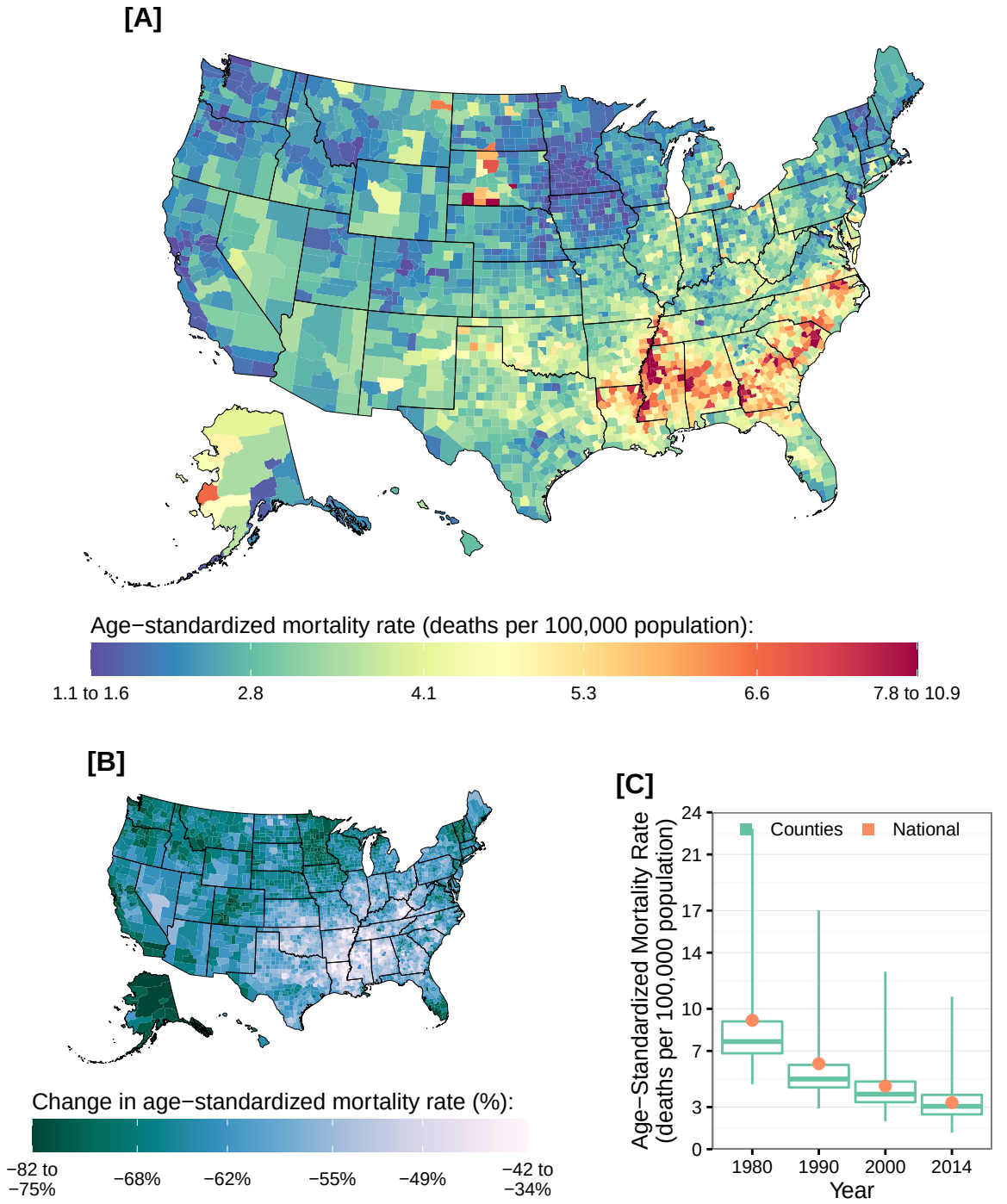
eFigure 3: Annual distribution of deaths by cause before [A] and after [B] garbage code redistribution (1980-2014).



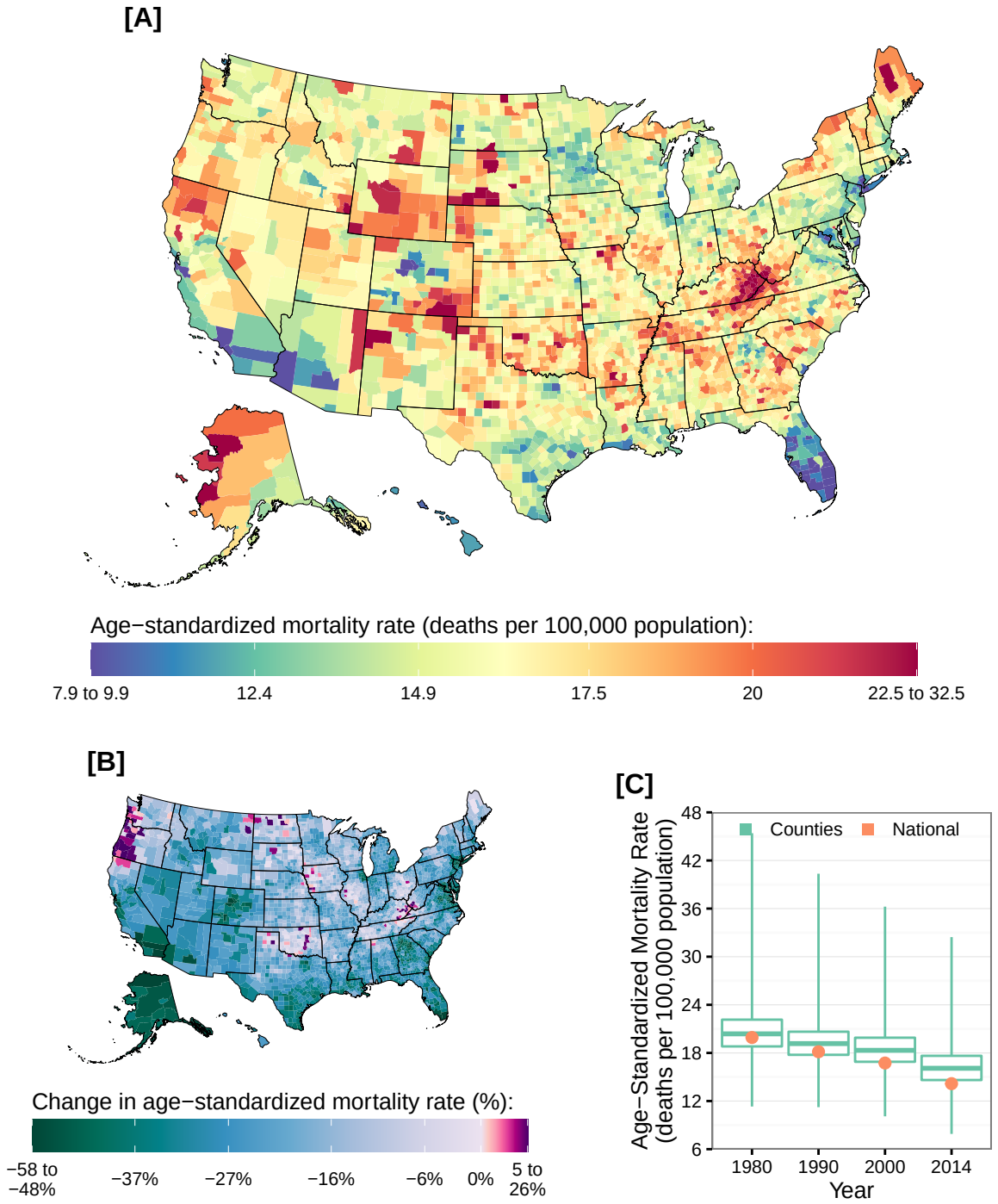
eFigure 4: County-level mortality from unintentional injuries. [A] Age-standardized mortality rate for both sexes combined in 2014; [B] Percent change in the age-standardized mortality rate for both sexes combined between 1980 and 2014; [C] Age-standardized mortality rate in 1980, 1990, 2000, and 2014. In panels [A] and [B], the color scale is truncated at approximately the 1st and 99th percentile as indicated by the range given in the color scale. In panel [C], the boxes indicate the 25th, 50th, and 75th percentile across all counties while the lines indicate the full range across counties and the dots indicate the national-level rate.



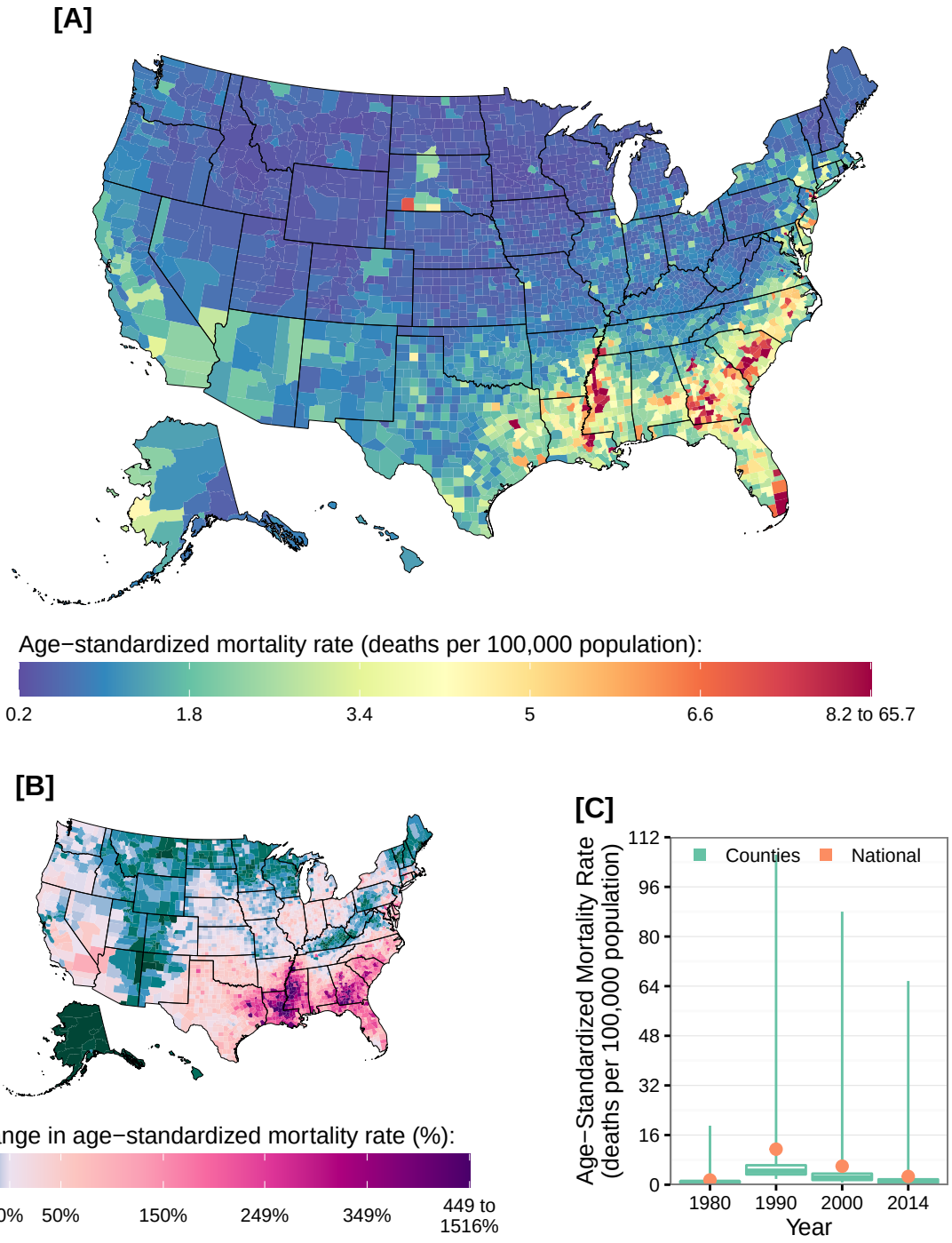
eFigure 5: County-level mortality from other non-communicable diseases. [A] Age-standardized mortality rate for both sexes combined in 2014; [B] Percent change in the age-standardized mortality rate for both sexes combined between 1980 and 2014; [C] Age-standardized mortality rate in 1980, 1990, 2000, and 2014. In panel [A], the color scale is truncated at approximately the 1st and 99th percentile as indicated by the range given in the color scale. In panel [B], the color scale is similarly truncated at the 1st percentile, but not at the 99th percentile, to avoid combining counties with decreases in the mortality rate and counties with increases in the mortality rate into a single group. In panel [C], the boxes indicate the 25th, 50th, and 75th percentile across all counties while the lines indicate the full range across counties and the dots indicate the national-level rate.



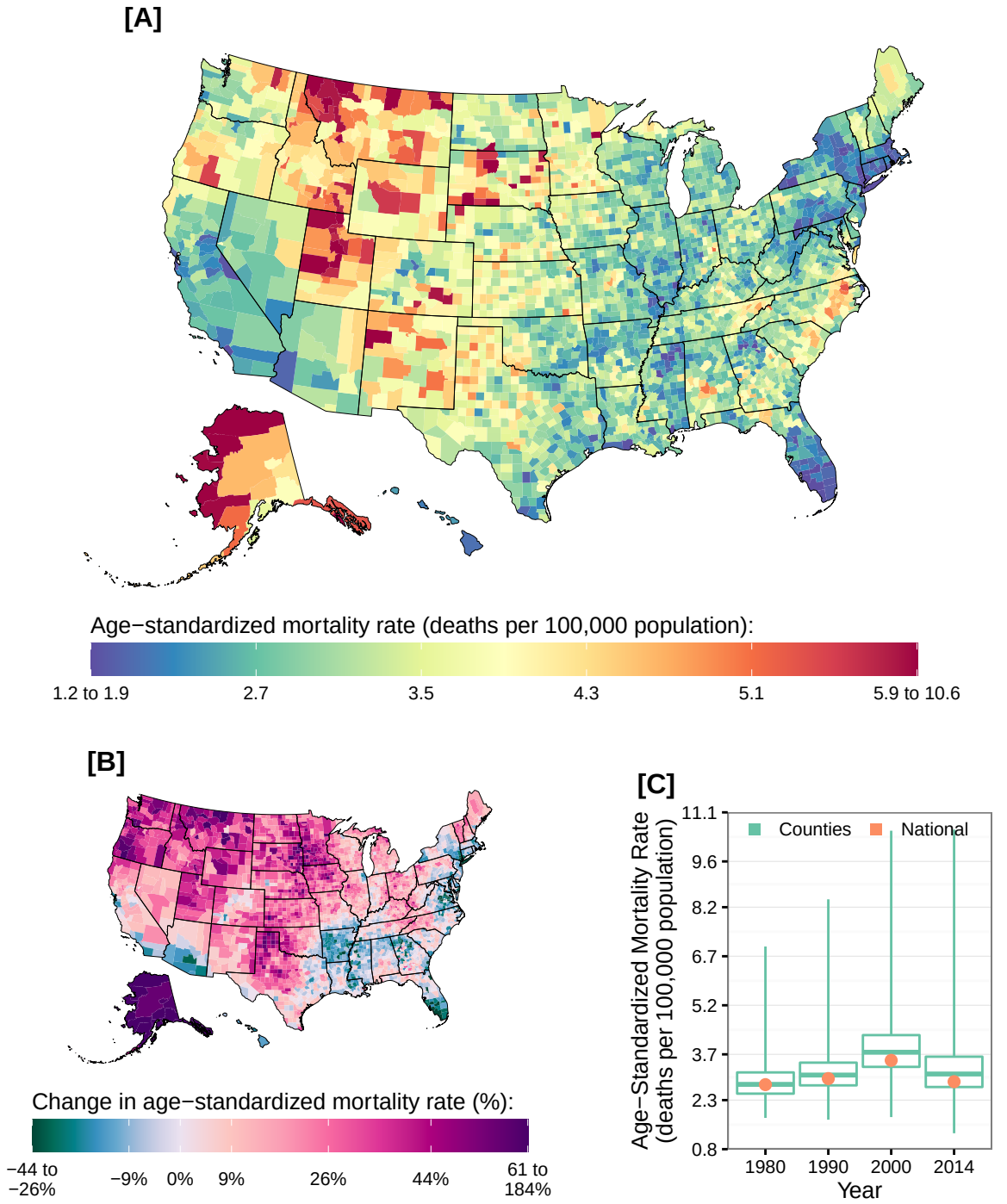
eFigure 6: County-level mortality from neonatal disorders. [A] Age-standardized mortality rate for both sexes combined in 2014; [B] Percent change in the age-standardized mortality rate for both sexes combined between 1980 and 2014; [C] Age-standardized mortality rate in 1980, 1990, 2000, and 2014. In panels [A] and [B], the color scale is truncated at approximately the 1st and 99th percentile as indicated by the range given in the color scale. In panel [C], the boxes indicate the 25th, 50th, and 75th percentile across all counties while the lines indicate the full range across counties and the dots indicate the national-level rate.



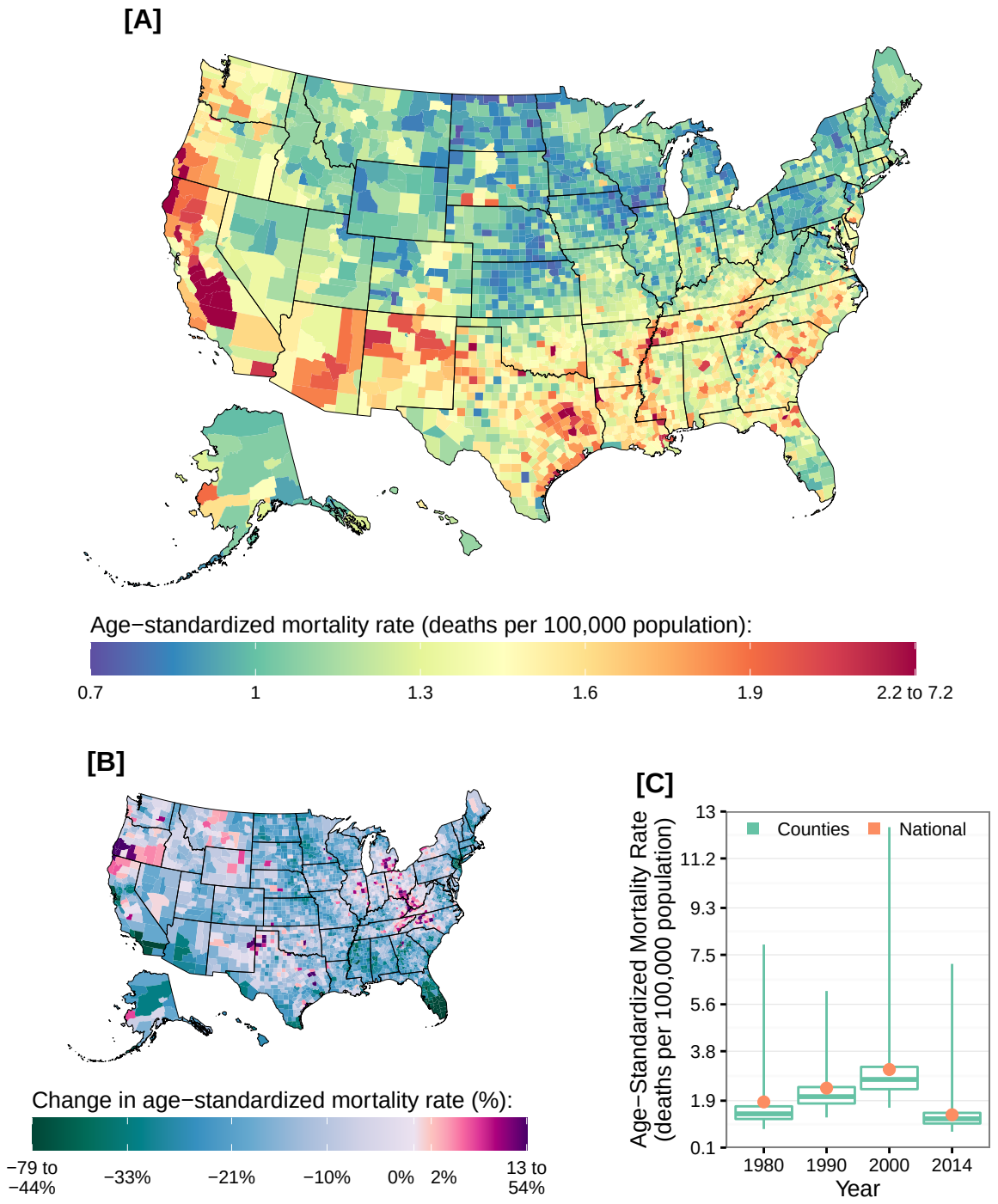
eFigure 7: County-level mortality from digestive diseases. [A] Age-standardized mortality rate for both sexes combined in 2014; [B] Percent change in the age-standardized mortality rate for both sexes combined between 1980 and 2014; [C] Age-standardized mortality rate in 1980, 1990, 2000, and 2014. In panels [A] and [B], the color scale is truncated at approximately the 1st and 99th percentile as indicated by the range given in the color scale. In panel [C], the boxes indicate the 25th, 50th, and 75th percentile across all counties while the lines indicate the full range across counties and the dots indicate the national-level rate.



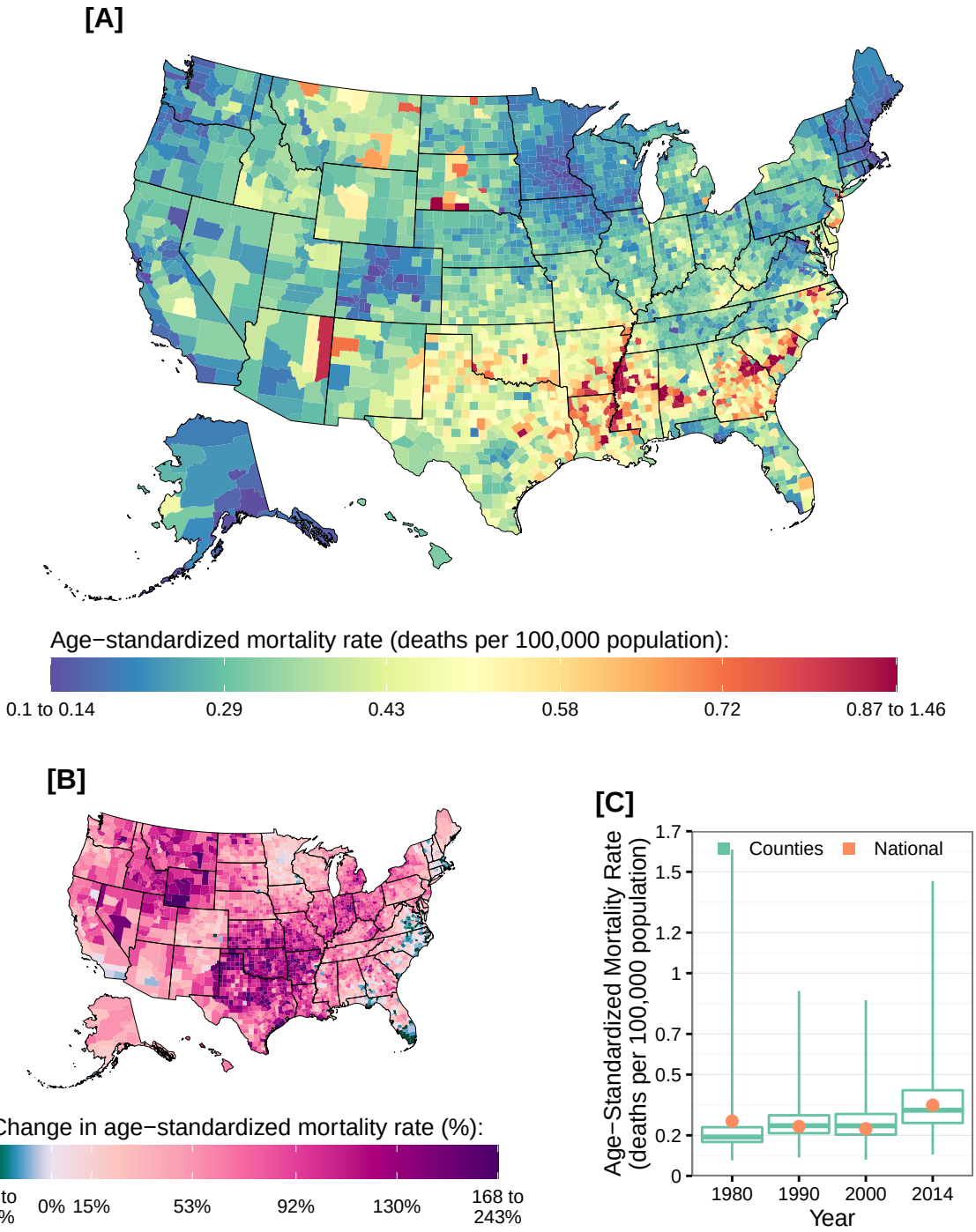
eFigure 8: County-level mortality from HIV/AIDS and tuberculosis. [A] Age-standardized mortality rate for both sexes combined in 2014; [B] Percent change in the age-standardized mortality rate for both sexes combined between 1980 and 2014; [C] Age-standardized mortality rate in 1980, 1990, 2000, and 2014. In panels [A] and [B], the color scale is truncated at approximately the 1st and 99th percentile as indicated by the range given in the color scale. In panel [C], the boxes indicate the 25th, 50th, and 75th percentile across all counties while the lines indicate the full range across counties and the dots indicate the national-level rate.



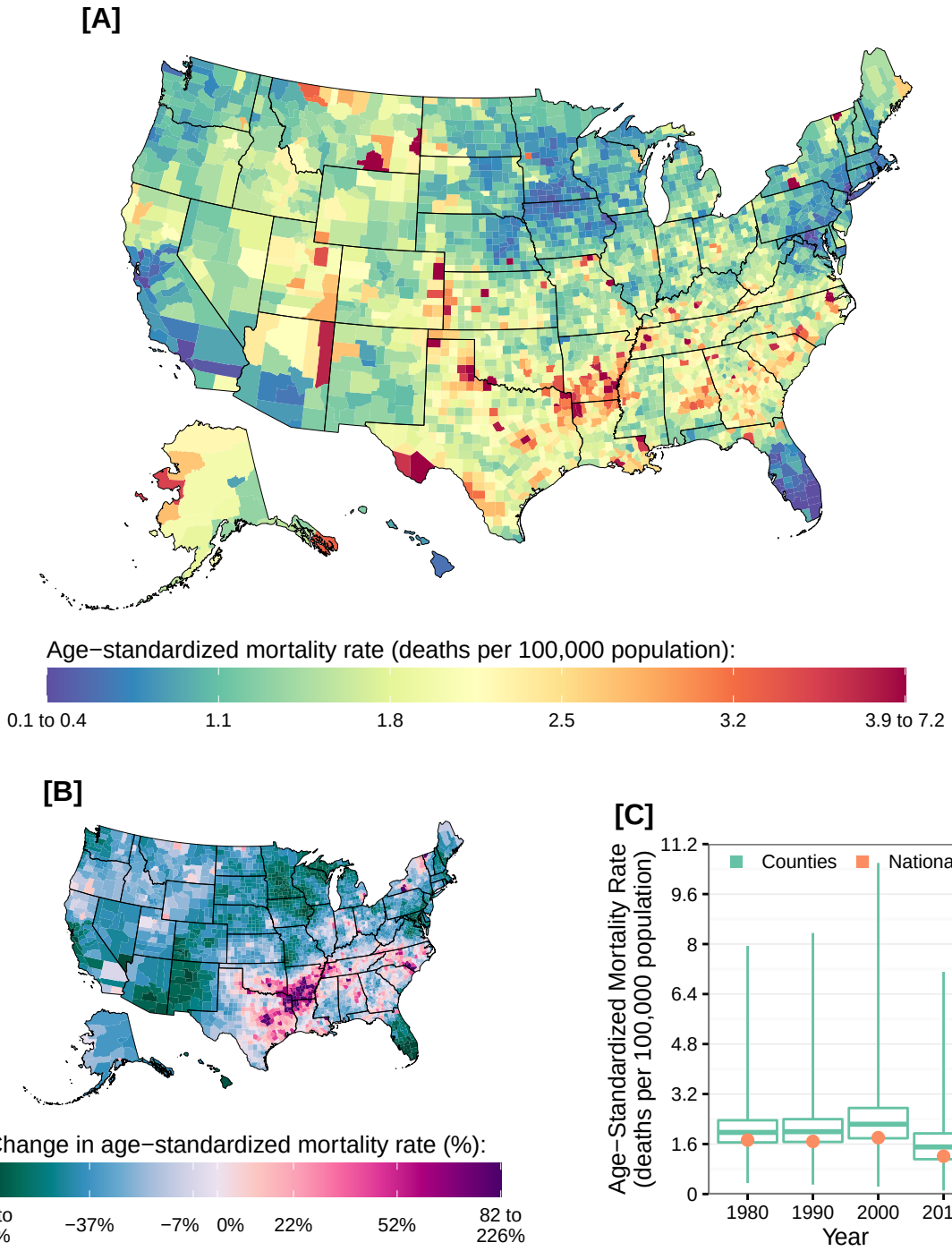
eFigure 9: County-level mortality from musculoskeletal disorders. [A] Age-standardized mortality rate for both sexes combined in 2014; [B] Percent change in the age-standardized mortality rate for both sexes combined between 1980 and 2014; [C] Age-standardized mortality rate in 1980, 1990, 2000, and 2014. In panels [A] and [B], the color scale is truncated at approximately the 1st and 99th percentile as indicated by the range given in the color scale. In panel [C], the boxes indicate the 25th, 50th, and 75th percentile across all counties while the lines indicate the full range across counties and the dots indicate the national-level rate.



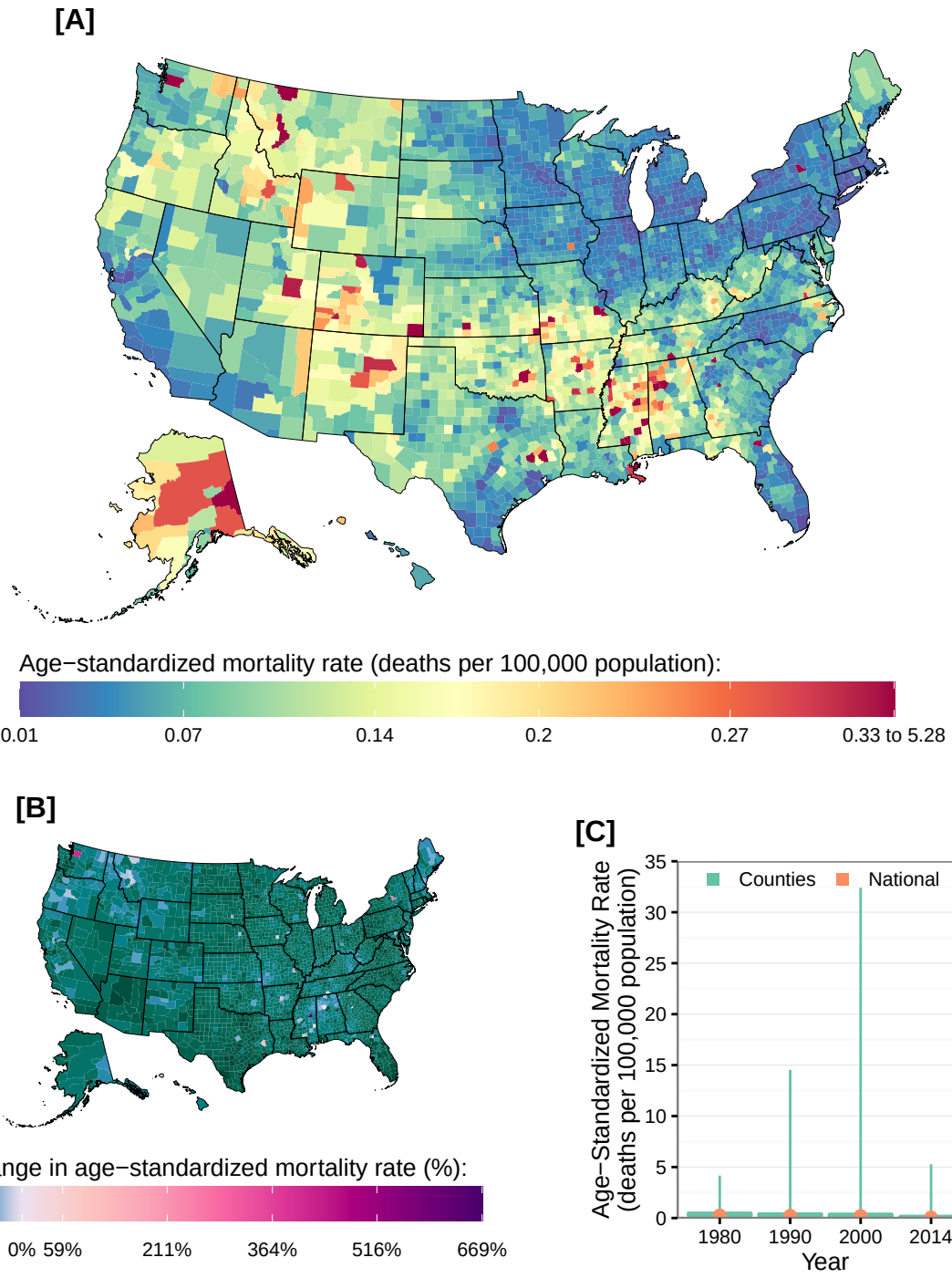
eFigure 10: County-level mortality from other communicable, maternal, neonatal, and nutritional diseases. [A] Age-standardized mortality rate for both sexes combined in 2014; [B] Percent change in the age-standardized mortality rate for both sexes combined between 1980 and 2014; [C] Age-standardized mortality rate in 1980, 1990, 2000, and 2014. In panels [A] and [B], the color scale is truncated at approximately the 1st and 99th percentile as indicated by the range given in the color scale. In panel [C], the boxes indicate the 25th, 50th, and 75th percentile across all counties while the lines indicate the full range across counties and the dots indicate the national-level rate.



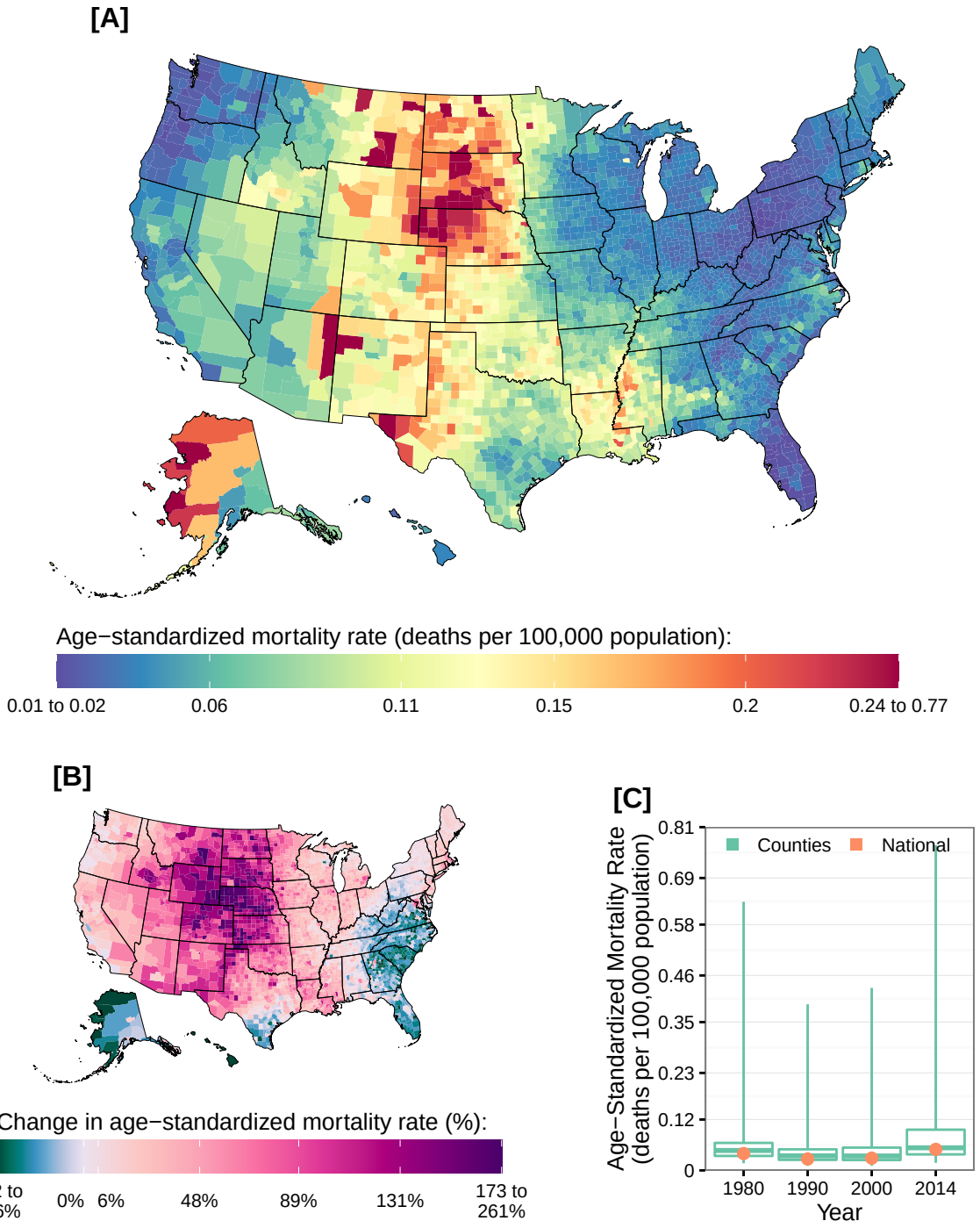
eFigure 11: County-level mortality from maternal disorders. [A] Age-standardized mortality rate for both sexes combined in 2014; [B] Percent change in the age-standardized mortality rate for both sexes combined between 1980 and 2014; [C] Age-standardized mortality rate in 1980, 1990, 2000, and 2014. In panels [A] and [B], the color scale is truncated at approximately the 1st and 99th percentile as indicated by the range given in the color scale. In panel [C], the boxes indicate the 25th, 50th, and 75th percentile across all counties while the lines indicate the full range across counties and the dots indicate the national-level rate.



eFigure 12: County-level mortality from nutritional deficiencies. [A] Age-standardized mortality rate for both sexes combined in 2014; [B] Percent change in the age-standardized mortality rate for both sexes combined between 1980 and 2014; [C] Age-standardized mortality rate in 1980, 1990, 2000, and 2014. In panels [A] and [B], the color scale is truncated at approximately the 1st and 99th percentile as indicated by the range given in the color scale. In panel [C], the boxes indicate the 25th, 50th, and 75th percentile across all counties while the lines indicate the full range across counties and the dots indicate the national-level rate.



eFigure 13: County-level mortality from forces of nature, war, and legal intervention. [A] Age-standardized mortality rate for both sexes combined in 2014; [B] Percent change in the age-standardized mortality rate for both sexes combined between 1980 and 2014; [C] Age-standardized mortality rate in 1980, 1990, 2000, and 2014. In panel [A], the color scale is truncated at approximately the 1st and 99th percentile as indicated by the range given in the color scale. In panel [B], the color scale is similarly truncated at the 1st percentile, but not at the 99th percentile, to avoid combining counties with decreases in the mortality rate and counties with increases in the mortality rate into a single group. In panel [C], the boxes indicate the 25th, 50th, and 75th percentile across all counties while the lines indicate the full range across counties and the dots indicate the national-level rate.



eFigure 14: County-level mortality from neglected tropical disease and malaria. [A] Age-standardized mortality rate for both sexes combined in 2014; [B] Percent change in the age-standardized mortality rate for both sexes combined between 1980 and 2014; [C] Age-standardized mortality rate in 1980, 1990, 2000, and 2014. In panels [A] and [B], the color scale is truncated at approximately the 1st and 99th percentile as indicated by the range given in the color scale. In panel [C], the boxes indicate the 25th, 50th, and 75th percentile across all counties while the lines indicate the full range across counties and the dots indicate the national-level rate.

3 eTables

eTable 1: Data sources used for covariates.

eTable 2: Counties combined to ensure historically stable units of analysis.

eTable 3: GBD cause list and associated ICD9 and ICD10 codes.

eTable 4: Mean relative error for age-standardized mortality rates derived from the SAE model.

eTable 5: Mean absolute relative error for age-standardized mortality rates derived from the SAE model.

eTable 6: Coverage for age-standardized mortality rates derived from the SAE model.

eTable 1: Data sources used for covariates.

Data Sources	Data Processing
Percent of the population age 25 and older who have completed high school	
1980 census [1]; 1990 census [2]; 2000 census [3]; 2009-2014 ACS [4-9]	Linear interpolation was used fill in intermediate years between data sources. The rate of change calculated between 2007 and 2012 was applied to fill in estimates for 2013 and 2014.
Percent of the population who are Hispanic	
1980 census [10]; 1990-2014 NCHS Bridged Race Files [11-13]	Linear interpolation was used to fill in intermediate years between data sources.
Percent of the population who are Black and some other race	
1980-1989 Census Bureau Intercensal County Estimates by Age, Sex, and Race [14]; 1990-2014 NCHS Bridged Race Files [11-13]	Linear interpolation was used to fill in intermediate years between data sources.
Percent of land area in a Native American reservation	
2013 Cartographic Boundary File, State-County for United States [15]; AIANNH Areas National Shapefile [16]	Geographic boundaries of AIANNH Areas were intersected with county boundaries using ArcGIS. The area of the intersection and the area of the county were calculated using an Albers Equal Area Conic projection. The proportion of the land area that is in a reservation was generated by dividing the area of the reservation by the total area in each county.
Household Median Income	
1980 census [17]; 1989, 1993, 1995-2014 Small Area Income and Poverty Estimates [18]; 1980-2014 Bureau of Labor Statistics, Consumer Price Index [19]	Data were adjusted for inflation using the consumer price index, and linear interpolation was used to generate values between observed data points. Income was then log-transformed.
Population Density	
1980-1989 Census Bureau Intercensal County Estimates by Age, Sex, and Race [14]; 1990-2014 NCHS Bridged Race Files [11-13]; 2013 Cartographic Boundary File, State-County for United States [15]	The area of each county was calculated using an Albers Equal Area Conic projection. The total population of each county was divided by the total area of the county, and was then log-transformed.

[1] Missouri Census Data Center. 1980 Census Summary Tape File 3, Table NT48A. MCDC Data Archive (Uexplore/Dexter). http://mcdc2.missouri.edu/applications/uexplore.shtml. Accessed April 22, 2013.

[2] Minnesota Population Center. 1990 Census Summary Tape File 3, Table P057. National Historical Geographic Information System: Version 2.0. Minneapolis, MN: University of Minnesota 2011. http://www.nhgis.org. Accessed July 18, 2013.

[3] U.S. Census Bureau. 2000 Census Summary Tape File 3, Table DP2; using American FactFinder; http://factfinder2.census.gov. Accessed April 18, 2013.

[4] U.S. Census Bureau. American Community Survey, 2009 American Community Survey 5-Year Estimates, Table S1501; using American FactFinder; http://factfinder2.census.gov. Accessed April 17, 2013.

[5] U.S. Census Bureau. American Community Survey, 2010 American Community Survey 5-Year Estimates, Table S1501; using American FactFinder; http://factfinder2.census.gov. Accessed April 17, 2013.

[6] U.S. Census Bureau. American Community Survey, 2011 American Community Survey 5-Year Estimates, Table S1501; using American FactFinder; http://factfinder2.census.gov. Accessed April 17, 2013.

[7] U.S. Census Bureau. American Community Survey, 2012 American Community Survey 5-Year Estimates, Table S1501; using American FactFinder; http://factfinder2.census.gov. Accessed December 18, 2013.

[8] U.S. Census Bureau. American Community Survey, 2013 American Community Survey 5-Year Estimates, Table S1501; using American FactFinder; http://factfinder2.census.gov. Accessed December 23, 2014.

[9] U.S. Census Bureau. American Community Survey, 2014 American Community Survey 5-Year Estimates, Table S1501; using American FactFinder; http://factfinder2.census.gov. Accessed December 8, 2015.

[10] Minnesota Population Center. 1980 Census Summary Tape File 1, Table NT8. National Historical Geographic Information System: Version 2.0. Minneapolis, MN: University of Minnesota 2011. http://www.nhgis.org. Accessed January 13, 2016.

[11] National Center for Health Statistics, Centers for Disease Control and Prevention, US Census Bureau. United States Bridged-Race Intercensal Population Estimates 1990-1999. Hyattsville, United States: National Center for Health Statistics, Centers for Disease Control and Prevention, 2004. Accessed November 21, 2011.

[12] National Center for Health Statistics, Centers for Disease Control and Prevention, US Census Bureau. United States Bridged-Race Intercensal Population Estimates 2000-2009. Hyattsville, United States: National Center for Health Statistics, Centers for Disease Control and Prevention, 2012. Accessed October 30, 2012.

[13] National Center for Health Statistics, Centers for Disease Control and Prevention, United States Census

Bureau. United States Vintage 2014 Bridged-Race Postcensal Population Estimates 2010-2014. Hyattsville, United States: National Center for Health Statistics, Centers for Disease Control and Prevention, 2015. Accessed December 18, 2015.

[14] U.S. Census Bureau. Intercensal County Estimates by Age, Sex, Race: 1980-1989. http://www.census.gov/popest/data/counties/asrh/1980s/PE-02.html. Accessed January 8, 2015.

[15] U.S. Census Bureau. TIGER/Line Shapefile, 2013 Cartographic Boundary File, State-County for United States, 1:20,000,000. https://catalog.data.gov/dataset/2013-cartographic-boundary-file-state-county-for-united-states-1-20000000. Accessed February 2, 2015.

[16] U.S. Census Bureau. TIGER/Line Shapefile, 2012, Series Information File for the Nation, Current American Indian/Alaska Native/Native Hawaiian Areas (AIANNH) National Shapefile. http://catalog.data.gov/dataset/tiger-line-shapefile-2012-series-information-file-for-the-nation-current-american-indian-alaska. Accessed February 10, 2015.

[17] Minnesota Population Center. Summary Tape File 3, Table NT69. National Historical Geographic Information System: Version 2.0. Minneapolis, MN: University of Minnesota 2011. http://www.nhgis.org. Accessed November 12, 2015.

[18] U.S. Census Bureau. Small Area Income and Poverty Estimates. https://www.census.gov/did/www/saipe/data/statecounty/data/index.html. Accessed December 28, 2015.

[19] U.S Bureau of Labor Statistics. Consumer Price Index: All Urban Consumers History, All Items 1913-2015. http://www.bls.gov/data/. Accessed March 24, 2015.

eTable 2: Counties combined to ensure historically stable units of analysis.

State	Group	Areas
Alaska	1	Kusilvak Census Area (2158), Wade Hampton Census Area (2270)*
	2	Kobuk Census Area (2140)*, Northwest Arctic Borough (2188)
	3	Aleutian Islands Census Area (2010)*, Aleutians East Borough (2013), Aleutians West Census Area (2016)
	4	Dillingham Census Area (2070), Lake and Peninsula Borough (2164)
	5	Denali Borough (2068), Yukon-Koyukuk Census Area (2290)
	6	Hoonah-Angoon Census Area (2105), Skagway Municipality (2230), Skagway-Yakutat-Angoon Census Area (2231)*, Skagway-Hoonah-Angoon Census Area (2232)*, Yakutat City and Borough (2282)
	7	Ketchikan Gateway Borough (2130), Petersburg Borough (2195), Prince of Wales-Hyder Census Area (2198), Prince of Wales-Outer Ketchikan Census Area (2201)*, Wrangell City and Borough (2275), Wrangell-Petersburg Census Area (2280)*
Arizona	1	La Paz County (4012), Yuma County (4027)
Colorado	1	Adams County (8001), Arapahoe County (8005), Boulder County (8013), Broomfield County (8014), Denver County (8031), Jefferson County (8059), Weld County (8123)
Florida	1	Dade County (12025)*, Miami-Dade County (12086)
Hawaii	1	Kalawao County (15005), Maui County (15009)
Maryland	1	Montgomery County (24031), Prince George's County (24033)
Montana	1	Park County (30067), Yellowstone National Park (30113)*
New Mexico	1	Cibola County (35006), Valencia County (35061)
South Dakota	1	Oglala Lakota County (46102), Shannon County (46113)*
	2	Jackson County (46071), Washabaugh County (46131)*
Virginia	1	Fairfax County (51059), Fairfax City (51600)
	2	Rockingham County (51165), Harrisonburg City (51660)
	3	James City County (51095), Williamsburg City (51830)
	4	Prince William County (51153), Manassas City (51683), Manassas Park City (51685)
	5	Rockbridge County (51163), Buena Vista City (51530)
	6	Spotsylvania County (51177), Fredericksburg City (51630)
	7	Augusta County (51015), Staunton City (51790), Waynesboro City (51820)
	8	Pittsylvania County (51143), Danville City (51590)
	9	Greensville County (51081), Emporia City (51595)
	10	Albemarle County (51003), Charlottesville City (51540)
	11	Bedford County (51019), Bedford City (51515)*
	12	Halifax County (51083), South Boston City (51780)*
	13	Southampton County (51175), Franklin City (51620)
	14	Alleghany County (51005), Clifton Forge City (51560)*
	15	York County (51199), Newport News City (51700)

*County no longer exists due to boundary or name change.

eTable 3: GBD cause list and associated ICD9 and ICD10 codes.

Cause	Level	ICD9	ICD10
Communicable, maternal, neonatal, and nutritional diseases	1	001-001.9, 002.0-030.9, 032-034.9, 036-036.40, 036.5, 036.8-037.9, 039-039.4, 039.8-040, 040.1-041.09, 042-066.9, 070-070.21, 070.3-070.31, 070.4-070.43, 070.49-070.53, 070.59-074.1, 074.20, 074.3-075.9, 078.4-078.7, 079-079.7, 080-083.9, 084.0-084.5, 084.7-084.9, 085.0, 086-088.9, 090-101.6, 104-104.9, 120-124.9, 125.4-125.9, 127-127.1, 128-129.0, 136-136.29, 137-139.0, 244.2, 260-263.9, 265-269.9, 280.1-280.8, 281.0-281.9, 320.0-320.89, 321-323.9, 381-383.9, 390-390.9, 392, 392.9, 461-461.9, 464.0, 464.01, 464.11-464.2, 464.21, 464.31-464.4, 464.8-464.9, 466-469, 470.0, 475-475.9, 476.9, 480-482.89, 483.0-483.9, 484.0-484.7, 487-489, 613-614.9, 630-636.92, 638-638.92, 640-679.14, 716.0-716.09, 730.4-730.6, 760-760.64, 760.8-768, 768.2-770, 770.1-775, 775.4-779.34, 779.6-779.89, 787.91	A00-A00.9, A01.0-A14, A15-A28.9, A30-A30.9, A32-A39.4, A39.8-A39.9, A48.1-A48.2, A48.4-A48.52, A49.1, A50-A58, A60-A60.9, A63-A63.8, A65-A65.0, A68-A70, A74, A74.8-A75.9, A77-A96.9, A98-A98.8, B00-B06.9, B10-B10.89, B15-B17.9, B19-B27.99, B29.4, B33-B33.1, B33.3-B33.8, B47-B48.8, B50-B53.8, B55.0, B56-B57.5, B60-B60.8, B63, B65-B67.99, B69-B72.0, B74.3-B75, B77-B77.9, B83-B83.8, B90-B92, B94.1-B94.2, B95-B95.5, D50.1-D50.8, D51-D52.0, D52.8-D53.9, D64.3, D86.81, E00-E02, E40-E46.9, E51-E61.9, E63-E64.0, E64.2-E64.9, F07.1, G00.0-G00.8, G03-G03.8, G04-G05.8, G14-G14.6, H70-H70.93, I00, I02, I02.9, I98.0-I98.1, J01-J01.91, J02.0, J03.0-J03.01, J04.0, J05-J05.0, J05.11, J09-J15.8, J16-J16.9, J20-J21.9, J36-J36.0, K67.0-K67.8, K74.7-K74.8, K93.0, M03.1, M12.1-M12.19, M49.0-M49.1, M73.0-M73.1, M89.6-M89.69, N70-N71.9, N73-N74.8, N96, N98-N98.9, O00-O07.9, O09-O16.9, O20-O26.93, O28-O36.93, O40-O48.1, O60-O77.9, O80-O92.79, O96-P04.2, P04.5-P05.9, P07-P15.9, P19-P22.9, P23.0-P23.4, P24-P29.9, P35-P37.2, P37.5-P39.9, P50-P61.9, P70, P70.3-P72.9, P74-P78.9, P80-P81.9, P83-P84, P90-P94.9, P96, P96.3-P96.4, P96.8-P96.89, R19.7
HIV/AIDS and tuberculosis	2	010-019.9, 042-044.9, 137-137.9, 138.0-138.9, 730.4-730.6	A10-A14, A15-A19.9, B20-B24.9, B90-B90.9, K67.3, K93.0, M49.0, P37.0
Tuberculosis	3-4	010-019.9, 137-137.9, 138.0-138.9, 730.4-730.6	A10-A14, A15-A19.9, B90-B90.9, K67.3, K93.0, M49.0, P37.0
HIV/AIDS	3	042-044.9	B20-B24.9
HIV/AIDS - Tuberculosis	4		B20.0
HIV/AIDS resulting in other diseases	4	042.0-042.9, 043.0-043.9, 044.1-044.9	B20.1-B23.9, B24.0
Diarrhea, lower respiratory, and other common infectious diseases	2	001-001.9, 002.0-009.9, 032-033.9, 036-036.40, 036.5, 036.8-037.9, 047-049.9, 052-053.9, 055-055.9, 062-064.9, 073.0-073.6, 139.0, 320.0-320.89, 321-323, 323.1, 323.4-323.9, 381-383.9, 461-461.9, 464.0, 464.01, 464.11-464.2, 464.21, 464.31-464.4, 464.8-464.9, 466-469, 470.0, 475-475.9, 476.9, 480-482.89, 483.0-483.9, 484.0-484.4, 484.6-484.7, 487-489, 771.3, 787.91	A00-A00.9, A01.0-A09.9, A33-A37.91, A39-A39.4, A39.8-A39.9, A48.1, A70, A83-A87.9, B01-B02.9, B05-B05.9, B94.1, D86.81, F07.1, G00.0-G00.8, G03-G03.8, G04-G05.8, H70-H70.93, J01-J01.91, J04.0, J05-J05.0, J05.11, J09-J15.8, J16-J16.9, J20-J21.9, J36-J36.0, P23.0-P23.4, P35.8, R19.7

eTable 3: GBD cause list and associated ICD9 and ICD10 codes (continued).

Cause	Level	ICD9	ICD10
Diarrheal diseases	3-4	001-001.9, 003-006.9, 007.4-007.8, 008.01-008.02, 008.04, 008.2-009.9, 787.91	A00-A00.9, A02-A04.1, A04.3, A04.5-A07, A07.2-A07.4, A08-A09.9, R19.7
Intestinal infectious diseases	3	002.0-002.9, 007-007.3, 007.9-008.00, 008.03, 008.09-008.1	A01.0-A01.4, A04.2, A04.4, A07.0-A07.1, A07.8-A07.9
Typhoid fever	4	2	A01.0-A01.09
Paratyphoid fever	4	002.1-002.9	A01.1-A01.4
Other intestinal infectious diseases	4	007-007.3, 007.9-008.00, 008.03, 008.09-008.1	A04.2, A04.4, A07.0-A07.1, A07.8-A07.9
Lower respiratory infections	3-4	073.0-073.6, 466-469, 470.0, 480-482.89, 483.0-483.9, 484.1-484.2, 484.6-484.7, 487-489	A48.1, A70, J09-J15.8, J16-J16.9, J20-J21.9, P23.0-P23.4
Upper respiratory infections	3-4	461-461.9, 464.0, 464.01, 464.11-464.2, 464.21, 464.31-464.4, 464.8-464.9, 475-475.9, 476.9	J01-J01.91, J04.0, J05-J05.0, J05.11, J36-J36.0
Otitis media	3-4	381-383.9	H70-H70.93
Meningitis	3	036-036.40, 036.5, 036.8-036.9, 047-049.9, 320.0-320.89, 321-322.9	A39-A39.4, A39.8-A39.9, A87-A87.9, D86.81, G00.0-G00.8, G03-G03.8
Pneumococcal meningitis	4	320.1	G00.1
H influenzae type B meningitis	4	320	G00.0
Meningococcal meningitis	4	036-036.40, 036.5, 036.8-036.9	A39-A39.4, A39.8-A39.9
Other meningitis	4	047-049.9, 320.2-320.89, 321-322.9	A87-A87.9, D86.81, G00.2-G00.8, G03-G03.8
Encephalitis	3-4	062-064.9, 139.0, 323, 323.4-323.9	A83-A86.4, B94.1, F07.1, G04-G05.8
Diphtheria	3-4	032-032.9	A36-A36.9
Whooping cough	3-4	033-033.9, 484.3-484.4	A37-A37.91
Tetanus	3-4	037-037.9, 771.3	A33-A35.0
Measles	3-4	055-055.9, 323.1, 484.0	B05-B05.9
Varicella and herpes zoster	3-4	052-053.9	B01-B02.9, P35.8
Neglected tropical diseases and malaria	2	030-030.9, 060-061.8, 065-066.9, 071-071.9, 080, 080.2-083.9, 084.0-084.5, 084.7-084.9, 085.0, 086-088.9, 120-124.9, 125.4-125.9, 127-127.1, 128-129.0	A30-A30.9, A68-A68.9, A69.2-A69.9, A75-A75.9, A77-A79.9, A82-A82.9, A90-A96.9, A98-A98.8, B33.0-B33.1, B50-B53.8, B55.0, B56-B57.5, B60-B60.8, B65-B67.99, B69-B72.0, B74.3-B75, B77-B77.9, B83-B83.8, B92, P37.1
Malaria	3-4	084.0-084.5, 084.7-084.9	B50-B53.8
Chagas disease	3-4	086-086.2, 086.9	B57-B57.5
Leishmaniasis	3	85	B55.0
Visceral leishmaniasis	4	85	B55.0
African trypanosomiasis	3-4	086.3-086.5	B56-B56.9
Schistosomiasis	3-4	120-120.9	B65-B65.9
Cysticercosis	3-4	123.1	B69-B69.9
Cystic echinococcosis	3-4	122-122.4, 122.8-122.9	B67-B67.4, B67.8-B67.99
Dengue	3-4	061-061.8	A90-A91.9
Yellow fever	3-4	060-060.9	A95-A95.9
Rabies	3-4	071-071.9	A82-A82.9
Intestinal nematode infections	3	127	B77-B77.9
Ascariasis	4	127	B77-B77.9
Ebola	3-4		A98.4

eTable 3: GBD cause list and associated ICD9 and ICD10 codes (continued).

Cause	Level	ICD9	ICD10
Other neglected tropical diseases	3-4	065-066.9, 080, 080.2-083.9, 087-088.9, 122.5-122.7, 123-123.0, 123.2-124.9, 125.4-125.9, 127, 127.1, 128-129.0	A68-A68.9, A69.2-A69.9, A75-A75.9, A77-A79.9, A92-A94.0, A96-A96.9, A98-A98.3, A98.5-A98.8, B33.0-B33.1, B60-B60.8, B67.5-B67.7, B70-B72.0, B74.3-B75, B83-B83.8, P37.1
Maternal disorders	2	630-636.92, 638-638.92, 640-679.14	N96, N98-N98.9, O00-O07.9, O09-O16.9, O20-O26.93, O28-O36.93, O40-O48.1, O60-O77.9, O80-O92.79, O96-O99.91
Maternal hemorrhage	3-4	640-641.93, 661-661.93, 665, 666-666.9	O20-O20.9, O43.2-O43.239, O44-O46.93, O62-O62.9, O67-O67.9, O70, O72-O72.3
Maternal sepsis and other maternal infections	3-4	659.3-659.33, 670-670.9	O23-O23.93, O85-O86.89, O91-O91.23
Maternal hypertensive disorders	3-4	642-642.94	O10-O16.9
Maternal obstructed labor and uterine rupture	3-4	652-653.93, 660-660.93, 665.0-665.34	O32-O33.9, O64-O66.9, O71-O71.9
Maternal abortion, miscarriage, and ectopic pregnancy	3-4	630-636.92, 638-638.92, 646.3-646.33	N96, O00-O07.9
Indirect maternal deaths	3-4	646-646.24, 646.4-649.9, 674-674.94	O24-O25.3, O98-O99.91
Late maternal deaths	3-4		O96-O97.9
Maternal deaths aggravated by HIV/AIDS	3-4		
Other maternal disorders	3-4	643-645.23, 650-651.93, 654-659.23, 659.4-659.93, 662-664.94, 665.4-665.94, 667-669.94, 671-673.9, 675-679.14	N98-N98.9, O09-O09.93, O21-O22.93, O26-O26.93, O28-O31.8, O34-O36.93, O40-O43.199, O43.8-O43.93, O47-O48.1, O60-O61.9, O63-O63.9, O68-O69.9, O70.0-O70.9, O73-O77.9, O80-O84.9, O87-O90.9, O92-O92.79
Neonatal disorders	2	760-760.64, 760.8-768, 768.2-770, 770.1-771, 771.4-775, 775.4-779.34, 779.6-779.89	P00-P04.2, P04.5-P05.9, P07-P15.9, P19-P22.9, P24-P29.9, P36-P36.9, P38-P39.9, P50-P61.9, P70, P70.3-P72.9, P74-P78.9, P80-P81.9, P83-P84, P90-P94.9, P96, P96.3-P96.4, P96.8-P96.89
Neonatal preterm birth complications	3-4	761.0-761.1, 765-765.9, 769-769.9, 770.2-770.9, 776.6, 777.5-777.6	P01.0-P01.1, P07-P07.39, P22-P22.9, P25-P28.9, P61.2, P77-P77.9
Neonatal encephalopathy due to birth asphyxia and trauma	3-4	761.7-763.9, 767-768, 768.2-768.9, 770.1-770.18, 772.1-772.9, 779.0-779.2	P01.7, P02-P03.9, P10-P15.9, P20-P21.9, P24-P24.9, P90-P91.9
Neonatal sepsis and other neonatal infections	3-4	771.4-771.9	P36-P36.9, P38-P39.9
Hemolytic disease and other neonatal jaundice	3-4	773-774.9	P55-P59.9
Other neonatal disorders	3-4	760-760.64, 760.8-761, 761.2-761.6, 764-764.99, 766-766.9, 770, 771, 772-772.0, 775, 775.4-776.5, 776.7-777.4, 777.7-779, 779.3-779.34, 779.6-779.89	P00-P01, P01.2-P01.6, P01.8-P01.9, P04-P04.2, P04.5-P05.9, P08-P09, P19-P19.9, P29-P29.9, P50-P54.9, P60-P61.1, P61.3-P61.9, P70, P70.3-P72.9, P74-P76.9, P78-P78.9, P80-P81.9, P83-P84, P92-P94.9, P96, P96.3-P96.4, P96.8-P96.89

eTable 3: GBD cause list and associated ICD9 and ICD10 codes (continued).

Cause	Level	ICD9	ICD10
Nutritional deficiencies	2	244.2, 260-263.9, 265-269.9, 280.1-280.8, 281.0-281.9, 716.0-716.09	D50.1-D50.8, D51-D52.0, D52.8-D53.9, D64.3, E00-E02, E40-E46.9, E51-E61.9, E63-E64.0, E64.2-E64.9, M12.1-M12.19
Protein-energy malnutrition	3-4	260-263.9	E40-E46.9, E64.0
Iodine deficiency	3-4	244.2	E00-E02
Iron-deficiency anemia	3-4	280.1-280.8	D50.1-D50.8, D64.3
Other nutritional deficiencies	3-4	265-269.9, 281.0-281.9, 716.0-716.09	D51-D52.0, D52.8-D53.9, E51-E61.9, E63-E64, E64.2-E64.3, M12.1-M12.19
Other communicable, maternal, neonatal, and nutritional diseases	2	020-029, 034-034.9, 039-039.4, 039.8-040, 040.1-041.09, 045-046.9, 050-051.9, 054-054.9, 056-059.9, 070-070.21, 070.3-070.31, 070.4-070.43, 070.49-070.53, 070.59-070.9, 072-073, 073.7-074.1, 074.20, 074.3-075.9, 078.4-078.7, 079-079.7, 080.0, 090-101.6, 104-104.9, 136-136.29, 138, 139, 323.0-323.02, 323.2-323.3, 390-390.9, 392, 392.9, 484.5, 613-614.9, 771.0-771.2	A20-A28.9, A32-A32.9, A38-A38.9, A48.2, A48.4-A48.52, A49.1, A50-A58, A60-A60.9, A63-A63.8, A65-A65.0, A69-A69.1, A74, A74.8-A74.9, A80-A81.9, A88-A89.9, B00-B00.9, B03-B04, B06-B06.9, B10-B10.89, B15-B17.9, B19-B19.9, B25-B27.99, B29.4, B33, B33.3-B33.8, B47-B48.8, B63, B91, B94.2, B95-B95.5, G14-G14.6, I00, I02, I02.9, I98.0-I98.1, J02.0, J03.0-J03.01, K67.0-K67.2, K67.8, K74.7-K74.8, M03.1, M49.1, M73.0-M73.1, M89.6-M89.69, N70-N71.9, N73-N74.8, P35-P35.3, P35.9, P37, P37.2, P37.5-P37.9
Sexually transmitted diseases excluding HIV	3	054.1, 090-099.9, 613-614.9	A50-A58, A60-A60.9, A63-A63.8, B63, I98.0, K67.0-K67.2, M03.1, M73.0-M73.1, N70-N71.9, N73-N74.8
Syphilis	4	090-097.9	A50-A53.9, I98.0, K67.2, M03.1, M73.1
Chlamydial infection	4	099, 099.1-099.6	A55-A56.8, K67.0
Gonococcal infection	4	098-098.9	A54-A54.9, K67.1, M73.0
Other sexually transmitted diseases	4	099.0, 099.8-099.9	A57-A58, A63-A63.8
Hepatitis	3-4	070-070.21, 070.3-070.31, 070.4-070.43, 070.49-070.53, 070.59-070.9	B15-B17.9, B19-B19.9, B94.2, P35.3
Other infectious diseases	3-4	020-029, 034-034.9, 039-039.4, 039.8-040, 040.1-041.09, 045-046.9, 050-051.9, 054-054.0, 054.10-054.9, 056-059.9, 072-073, 073.7-074.1, 074.20, 074.3-075.9, 078.4-078.7, 079-079.7, 080.0, 100-101.6, 104-104.9, 136-136.29, 138, 139, 323.0-323.02, 323.2-323.3, 390-390.9, 392, 392.9, 484.5, 771.0-771.2	A20-A28.9, A32-A32.9, A38-A38.9, A48.2, A48.4-A48.52, A49.1, A65-A65.0, A69-A69.1, A74, A74.8-A74.9, A80-A81.9, A88-A89.9, B00-B00.9, B03-B04, B06-B06.9, B10-B10.89, B25-B27.99, B29.4, B33, B33.3-B33.8, B47-B48.8, B91, B95-B95.5, G14-G14.6, I00, I02, I02.9, I98.1, J02.0, J03.0-J03.01, K67.8, K74.7-K74.8, M49.1, M89.6-M89.69, P35-P35.2, P35.9, P37, P37.2, P37.5-P37.9
Non-communicable diseases	1	035-035.9, 036.41-036.43, 036.6, 070.22-070.23, 070.32-070.33, 070.44, 070.54, 074.2, 074.21-074.23, 102-103.9, 133-133.6, 135-135.9, 136.6, 140-148.9	A39.5-A39.53, A46-A46.0, A66-A67.9, B18-B18.9, B33.2-B33.24, B86, C0-C13.9, C15-C25.9, C3-C34.92, C37-C38.8, C4-C41.9, C43-C45.9

eTable 3: GBD cause list and associated ICD9 and ICD10 codes (continued).

Cause	Level	ICD9	ICD10
Non-communicable diseases (continued)	1	150-158.9, 160-164.9, 170-175.9, 180-183.8, 184.0-184.4, 184.8, 185-186.9, 187.1-187.8, 188-188.9, 189.0-189.8, 190-194.8, 200-208.92, 209.0-209.17, 209.21-209.27, 209.31-209.57, 209.61, 209.63-209.67, 210.0-210.9, 211.0-211.8, 212.0-212.8, 213-213.9, 217-220.9, 221.0-221.8, 222.0-222.8, 223.0-223.89, 224-228.9, 229.0, 229.8, 230.1-230.8, 231.0-231.2, 232-232.9, 233.0-233.2, 233.31-233.32, 233.4-233.5, 233.7, 234.0-234.8, 235.0, 235.4, 235.6-235.8, 236.0-236.2, 236.4-236.5, 236.7, 236.91-237.3, 237.5-237.9, 238.0-238.5, 239.2-239.4, 239.6, 240-243.9, 244.0-244.1, 244.3-244.8, 245-246.9, 250-259.9, 270-273.9, 275-276, 277-277.2, 277.4-277.9, 278.0-278.8, 282-284.9, 286-286.5, 286.7-289.7, 290-292.9, 294.1-295.95, 303-303.93, 304.0-304.83, 305-305.93, 307.1, 307.51, 307.54, 327.2-327.8, 330-331.2, 331.5-337.9, 340-341.9, 345-345.91, 349-349.8, 353.6-353.9, 356-356.9, 357.0-357.7, 358-359.9, 376.0-376.1, 391-391.9, 392.0, 393-398.99, 402-404.93, 410-414.9, 416.1, 417-417.9, 420-423, 423.1-425.9, 427-427.32, 427.6-427.89, 429.0-429.1, 430-435.9, 437.0-437.2, 437.4-437.8, 441-443.9, 446-457.9, 459, 459.1-459.39, 470, 470.9-474.9, 476-476.1, 477-479, 490-504.9, 506-506.9, 508-509, 515, 516-517.8, 518.6-518.7, 518.9, 519.0-519.4, 530-536.1, 536.4-536.49, 537-537.6, 537.8-537.84, 538-543.9, 550-553.6, 555-558.9, 560-560.39, 560.8-560.9, 562-562.13, 564-564.7, 565-566.9, 569.0-569.44, 569.5-569.71, 569.84-569.85, 571-571.9, 572.3-572.9, 573.0-573.4, 573.8-577.9, 579-583.9, 585-585.9, 588-590.9, 592-593.89, 594-599.69, 599.8-599.89, 601-602.9, 604-604.99, 608.2-608.24, 610-610.9, 617-618.9, 620-620.9, 621.4-621.9, 622.3-622.7, 629-629.81, 680-689, 694-695.59, 707-707.9, 710-711.99, 714-714.33, 714.8-714.9, 728.86, 728.88, 730.1-730.19, 732-732.9, 733.0-733.19, 740-749.04, 749.2-758.9, 759.0-759.89, 760.7-760.79	C47-C54.9, C56-C57.8, C58-C58.0, C60-C63.8, C64-C67.9, C68.0-C68.8, C69-C75.8, C81-C86.6, C88-C96.9, D00.00-D00.2, D01.0-D01.3, D02.0-D02.3, D03-D06.9, D07.0-D07.2, D07.4-D07.5, D09.0, D09.2-D09.3, D09.8, D10.0-D10.7, D11-D12.9, D13.0-D13.7, D14.0-D14.32, D15-D16.9, D22-D27.9, D28.0-D28.7, D29.0-D29.8, D30.0-D30.8, D31-D36, D36.1-D36.7, D37.01-D37.5, D38.0-D38.5, D39.1-D39.2, D39.8, D40.0-D40.8, D41.0-D41.8, D42-D43.9, D44.0-D44.8, D45-D45.9, D47-D47.0, D47.2-D47.9, D48.0-D48.62, D49.2-D49.4, D49.6, D49.81, D52.1, D55-D58.9, D59.0-D59.3, D59.5-D59.6, D60-D61.9, D63.1, D64.0, D64.4, D66-D67, D68.0-D69.8, D70-D75.89, D76-D78.89, D86-D86.8, D86.82-D86.9, D89-D89.3, E03-E07.1, E09-E14.9, E15.0, E16.0-E16.9, E20-E34.8, E36-E36.8, E65-E68, E70-E85.29, E87.71, E88-E89.9, F00-F03.91, F06.2, F10-F16.99, F18-F29.9, F50.0-F50.5, G10-G13.8, G20-G26.0, G30-G31.9, G35-G37.9, G40-G41.9, G45-G46.8, G47.3-G47.39, G61-G61.9, G70-G73.7, G90-G90.9, G93.7, G95-G95.9, G97-G97.9, H05.0-H05.119, I01-I01.9, I02.0, I05-I09.9, I11-I13.9, I20-I25.9, I27.1, I28-I28.8, I30-I31.1, I31.8-I43.9, I47-I48.92, I51.0-I51.5, I60-I61.9, I62.0-I62.03, I63-I63.9, I65-I66.9, I67.0-I67.3, I67.5-I67.7, I68.0-I68.2, I69.0-I69.398, I70.2-I70.799, I71-I73.9, I77-I89.9, I91.9, I95.2-I95.3, I97-I98, I98.2, I98.9, J30-J35.9, J37-J47.9, J60-J63.8, J65-J68.9, J70-J70.9, J82, J84-J84.9, J91-J92.9, J95-J95.9, K20-K29.91, K31-K31.89, K35-K38.9, K40-K46.9, K50-K52.9, K55-K62.9, K63.5, K64-K64.9, K66.8, K67, K68-K68.9, K70-K70.9, K71.3-K71.51, K71.7, K72.1-K74.69, K74.9, K75.2-K77.8, K80-K83.9, K85-K86.9, K90-K91.9, K92.8-K92.89, K94-K95.89, L00-L05.92, L08-L08.9, L10-L14.0, L51-L51.9, L88-L89.95, L93-L93.2

eTable 3: GBD cause list and associated ICD9 and ICD10 codes (continued).

Cause	Level	ICD9	ICD10
Non-communicable diseases (continued)	1	775.0-775.3, 779.4-779.5, 780.57, 780.59, 780.62-780.63, 786.03, 787.1, 788.0, 790.2-790.22, 790.3, 798-798.0, E850-E850.29, E850.9-E854.39, E860-E860.19	L97-L98.499, M00-M03.0, M03.2-M03.6, M05-M09.8, M30-M36.8, M40-M43.19, M65-M65.08, M71.0-M71.19, M80-M82.8, M86.3-M86.49, M87-M87.19, M88-M89.09, M89.5-M89.59, M89.7-M89.9, N00-N08.8, N10-N12.9, N14-N16.8, N18-N18.9, N20-N23.0, N25-N32.0, N32.3-N32.4, N34-N34.3, N36-N36.9, N39-N39.2, N41-N41.9, N44-N44.04, N45-N45.9, N49-N49.9, N60-N60.99, N65-N65.1, N72-N72.0, N75-N77.8, N80-N81.9, N83-N83.9, N84.0-N84.1, N87-N87.9, N99-N99.9, P04.3-P04.49, P70.0-P70.2, P96.0-P96.2, P96.5, Q00-Q07.9, Q10.4-Q18.9, Q20-Q28.9, Q30-Q36, Q37-Q45.9, Q50-Q87.89, Q89-Q89.8, Q90-Q93.9, Q95-Q99.8, R50.2, R50.82-R50.83, R73-R73.9, R78.0-R78.5, R95, X45-X45.9
Neoplasms	2	140-148.9, 150-158.9, 160-164.9, 170-175.9, 180-183.8, 184.0-184.4, 184.8, 185-186.9, 187.1-187.8, 188-188.9, 189.0-189.8, 190-194.8, 200-208.92, 209.0-209.17, 209.21-209.27, 209.31-209.57, 209.61, 209.63-209.67, 210.0-210.9, 211.0-211.8, 212.0-212.8, 213-213.9, 217-217.8, 219.0, 220-220.9, 221.0-221.8, 222.0-222.8, 223.0-223.89, 224-228.9, 229.0, 229.8, 230.1-230.8, 231.0-231.2, 232-232.9, 233.0-233.2, 233.31-233.32, 233.4-233.5, 233.7, 234.0-234.8, 235.0, 235.4, 235.6-235.8, 236.1-236.2, 236.4-236.5, 236.7, 236.91-237.3, 237.5-237.9, 238.0-238.5, 239.2-239.4, 239.6, 569.0, 569.43-569.44, 569.84-569.85, 610-610.9	C0-C13.9, C15-C25.9, C3-C34.92, C37-C38.8, C4-C41.9, C43-C45.9, C47-C54.9, C56-C57.8, C58-C58.0, C60-C63.8, C64-C67.9, C68.0-C68.8, C69-C75.8, C81-C86.6, C88-C96.9, D00.00-D00.2, D01.0-D01.3, D02.0-D02.3, D03-D06.9, D07.0-D07.2, D07.4-D07.5, D09.0, D09.2-D09.3, D09.8, D10.0-D10.7, D11-D12.9, D13.0-D13.7, D14.0-D14.32, D15-D16.9, D22-D24.9, D26.0, D27-D27.9, D28.0-D28.1, D28.7, D29.0-D29.8, D30.0-D30.8, D31-D36, D36.1-D36.7, D37.01-D37.5, D38.0-D38.5, D39.1-D39.2, D39.8, D40.0-D40.8, D41.0-D41.8, D42-D43.9, D44.0-D44.8, D45-D45.9, D47-D47.0, D47.2-D47.9, D48.0-D48.62, D49.2-D49.4, D49.6, D49.81, K31.7, K62.0-K62.1, K63.5, N60-N60.99, N84.0-N84.1, N87-N87.9
Lip and oral cavity cancer	3-4	140-145.9, 210.0-210.6, 235.0	C0-C08.9, D00.00-D00.07, D10.0-D10.5, D11-D11.9, D37.01-D37.04, D37.09
Nasopharynx cancer	3-4	147-147.9, 210.7-210.9	C11-C11.9, D00.08, D10.6, D37.05
Other pharynx cancer	3-4	146-146.9, 148-148.9	C09-C10.9, C12-C13.9, D10.7
Esophageal cancer	3-4	150-150.9, 211.0, 230.1	C15-C15.9, D00.1, D13.0
Stomach cancer	3-4	151-151.9, 209.23, 209.63, 211.1, 230.2	C16-C16.9, D00.2, D13.1, D37.1
Colon and rectum cancer	3-4	153-154.9, 209.1-209.17, 209.5-209.57, 211.3-211.4, 230.3-230.6	C18-C21.9, D01.0-D01.3, D12-D12.9, D37.3-D37.5
Liver cancer	3-4	155-155.9, 211.5	C22-C22.9, D13.4

eTable 3: GBD cause list and associated ICD9 and ICD10 codes (continued).

Cause	Level	ICD9	ICD10
Gallbladder and biliary tract cancer	3-4	156-156.9, 209.25-209.27, 209.65-209.67	C23-C24.9, D13.5
Pancreatic cancer	3-4	157-157.9, 211.6-211.7	C25-C25.9, D13.6-D13.7
Larynx cancer	3-4	161-161.9, 212.1, 231.0, 235.6	C32-C32.9, D02.0, D14.1, D38.0
Tracheal, bronchus, and lung cancer	3-4	162-162.9, 209.21, 209.61, 212.2-212.3, 231.1-231.2, 235.7	C33-C34.92, D02.1-D02.3, D14.2-D14.32, D38.1
Malignant skin melanoma	3-4	172-172.9	C43-C43.9, D03-D03.9, D22-D23.9, D48.5
Non-melanoma skin cancer	3	173-173.99, 222.4, 232-232.9, 238.2	C44-C44.99, D04-D04.9, D49.2
Non-melanoma skin cancer (squamous-cell carcinoma)	4	173-173.99, 222.4, 232-232.9, 238.2	C44-C44.99, D04-D04.9, D49.2
Breast cancer	3-4	174-175.9, 217-217.8, 233.0, 238.3, 239.3, 610-610.9	C50-C50.929, D05-D05.92, D24-D24.9, D48.6-D48.62, D49.3, N60-N60.99
Cervical cancer	3-4	180-180.9, 219.0, 233.1	C53-C53.9, D06-D06.9, D26.0
Uterine cancer	3-4	182-182.8, 233.2	C54-C54.9, D07.0-D07.2, N87-N87.9
Ovarian cancer	3-4	183-183.0, 220-220.9, 236.2	C56-C56.9, D27-D27.9, D39.1-D39.12
Prostate cancer	3-4	185-185.9, 222.2, 236.5	C61-C61.9, D07.5, D29.1, D40.0
Testicular cancer	3-4	186-186.9, 222.0, 222.3, 236.4	C62-C62.92, D29.2-D29.8, D40.1-D40.8
Kidney cancer	3-4	189.0-189.1, 209.24, 209.64, 223.0-223.1, 236.91	C64-C65.9, D30.0-D30.12, D41.0-D41.12
Bladder cancer	3-4	188-188.9, 223.3, 233.7, 236.7, 239.4	C67-C67.9, D09.0, D30.3, D41.4-D41.8, D49.4
Brain and nervous system cancer	3-4	191-192.9	C70-C72.9
Thyroid cancer	3-4	193-193.9, 226-226.9	C73-C73.9, D09.3, D09.8, D34-D34.9, D44.0
Mesothelioma	3-4	158.9, 163-163.9, 212.4	C45-C45.9
Hodgkin lymphoma	3-4	201-201.98	C81-C81.99
Non-Hodgkin lymphoma	3-4	200-200.9, 202-202.98	C82-C86.6, C96-C96.9
Multiple myeloma	3-4	203-203.9	C88-C90.9
Leukemia	3	204-208.92	C91-C95.92
Acute lymphoid leukemia	4	204.0-204.02	C91.0-C91.02
Chronic lymphoid leukemia	4	204.1-204.12	C91.1-C91.12
Acute myeloid leukemia	4	205.0-205.02, 205.3-205.32, 206.0-206.02, 207.0	C92.0-C92.02, C92.3-C92.62, C93.0-C93.02, C94.0-C94.02, C94.2-C94.22, C94.4-C94.5
Chronic myeloid leukemia	4	205.1-205.12, 206.1-206.12, 207.1	C92.1-C92.12

eTable 3: GBD cause list and associated ICD9 and ICD10 codes (continued).

Cause	Level	ICD9	ICD10
Other neoplasms	3-4	152-152.9, 158-158.8, 160-160.9, 164-164.9, 170-171.9, 181-181.9, 182.9, 183.2-183.8, 184.0-184.4, 184.8, 187.1-187.8, 189.2-189.8, 190-190.9, 194-194.8, 209.0-209.03, 209.22, 209.31-209.43, 211.2, 211.8, 212.0, 212.5-212.8, 213-213.9, 221.0-221.8, 222.1, 222.8, 223.2, 223.8-223.89, 224-225.9, 227-228.9, 229.0, 229.8, 230.7-230.8, 233.31-233.32, 233.4-233.5, 234.0-234.8, 235.4, 235.8, 236.1, 236.99-237.3, 237.5-237.9, 238.0-238.1, 238.4-238.5, 239.2, 239.6, 569.0, 569.43-569.44, 569.84-569.85	C17-C17.9, C3-C31.9, C37-C38.8, C4-C41.9, C47-C5, C51-C52.9, C57-C57.8, C58-C58.0, C60-C60.9, C63-C63.8, C66-C66.9, C68.0-C68.8, C69-C7, C74-C75.8, D07.4, D09.2-D09.22, D13.2-D13.39, D14.0, D15-D16.9, D28.0-D28.1, D28.7, D29.0, D30.2-D30.22, D30.4-D30.8, D31-D33.9, D35-D36, D36.1-D36.7, D37.2, D38.2-D38.5, D39.2, D39.8, D41.2-D41.3, D42-D43.9, D44.1-D44.8, D45-D45.9, D47-D47.0, D47.2-D47.9, D48.0-D48.4, D49.6, D49.81, K31.7, K62.0-K62.1, K63.5, N84.0-N84.1
Cardiovascular diseases	2	036.41-036.43, 036.6, 074.2, 074.21-074.23, 391-391.9, 392.0, 393-398.99, 402-402.91, 410-414.9, 417-417.9, 420-423, 423.1-425.9, 427-427.32, 427.6-427.89, 429.0-429.1, 430-435.9, 437.0-437.2, 437.5-437.8, 441-443.9, 447-454.9, 456, 456.3-457.9, 459, 459.1-459.39	A39.5-A39.53, B33.2-B33.24, D86.85, G45-G46.8, I01-I01.9, I02.0, I05-I09.9, I11-I11.9, I20-I25.9, I28-I28.8, I30-I31.1, I31.8-I43.9, I47-I48.92, I51.0-I51.5, I60-I61.9, I62.0-I62.03, I63-I63.9, I65-I66.9, I67.0-I67.3, I67.5-I67.6, I68.0-I68.2, I69.0-I69.398, I70.2-I70.799, I71-I73.9, I77-I83.93, I86-I89.9, I91.9, I98
Rheumatic heart disease	3-4	391-391.9, 392.0, 393-398.99	I01-I01.9, I02.0, I05-I09.9
Ischemic heart disease	3-4	410-414.9	I20-I25.9
Cerebrovascular disease	3	430-435.9, 437.0-437.2, 437.5-437.8	G45-G46.8, I60-I61.9, I62.0-I62.03, I63-I63.9, I65-I66.9, I67.0-I67.3, I67.5-I67.6, I68.1-I68.2, I69.0-I69.398
Ischemic stroke	4	433-435.9, 437.0-437.1, 437.5-437.8	G45-G46.8, I63-I63.9, I65-I66.9, I67.2-I67.3, I67.5-I67.6, I69.3-I69.398
Hemorrhagic stroke	4	430-432.9, 437.2	I60-I61.9, I62.0-I62.03, I67.0-I67.1, I68.1-I68.2, I69.0-I69.298
Hypertensive heart disease	3-4	402-402.91	I11-I11.9
Cardiomyopathy and myocarditis	3-4	036.43, 036.6, 074.23, 422-422.99, 425-425.9, 429.0-429.1	A39.52, B33.2-B33.24, D86.85, I40-I43.9, I51.4-I51.5
Atrial fibrillation and flutter	3-4	427.3-427.32	I48-I48.92
Aortic aneurysm	3-4	441-441.9	I71-I71.9
Peripheral vascular disease	3-4	443.0-443.9	I70.2-I70.799, I73-I73.9
Endocarditis	3-4	036.42, 074.22, 421-421.9, 424.9-424.91	A39.51, I33-I33.9, I38-I39.9
Other cardiovascular and circulatory diseases	3-4	036.41, 074.2, 074.21, 417-417.9, 420-420.99, 423, 423.1-424.8, 424.99, 427-427.2, 427.6-427.89, 442-443, 447-454.9, 456, 456.3-457.9, 459, 459.1-459.39	A39.5-A39.50, A39.53, I28-I28.8, I30-I31.1, I31.8-I32.8, I34-I37.9, I47-I47.9, I51.0-I51.3, I68.0, I72-I72.9, I77-I83.93, I86-I89.9, I91.9, I98
Chronic respiratory diseases	2	135-135.9, 136.6, 327.2-327.8, 470, 470.9-474.9, 476-476.1, 477-479, 490-504.9, 506-506.9, 508-509, 515, 516-517.8, 518.6, 518.9, 519.1-519.4, 780.57, 786.03	D86-D86.2, D86.89-D86.9, G47.3-G47.39, J30-J35.9, J37-J47.9, J60-J63.8, J65-J68.9, J70-J70.1, J70.8-J70.9, J82, J84-J84.9, J91-J92.9
Chronic obstructive pulmonary disease	3-4	490-492.9, 494-494.9, 496-499	J40-J44.9, J47-J47.9
Pneumoconiosis	3	500-504.9	J60-J63.8, J65-J65.0, J92.0
Silicosis	4	502-502.9, 503.0, 503.9	J62-J62.9

eTable 3: GBD cause list and associated ICD9 and ICD10 codes (continued).

Cause	Level	ICD9	ICD10
Asbestosis	4	501	J61-J61.0, J92.0
Coal workers pneumoconiosis	4	500-500.9, 501.0-501.9	J60-J60.0
Other pneumoconiosis	4	503, 503.1, 504-504.9	J63-J63.8, J65-J65.0
Asthma	3-4	493-493.92	J45-J46.9
Interstitial lung disease and pulmonary sarcoidosis	3-4	135-135.9, 136.6, 515, 516-516.9	D86-D86.2, D86.89-D86.9, J84-J84.9
Other chronic respiratory diseases	3-4	327.2-327.8, 470, 470.9-474.9, 476-476.1, 477-479, 495-495.9, 506-506.9, 508-509, 517-517.8, 518.6, 518.9, 519.1-519.4, 780.57, 786.03	G47.3-G47.39, J30-J35.9, J37-J39.9, J66-J68.9, J70-J70.1, J70.8-J70.9, J82, J91-J92, J92.9
Cirrhosis and other chronic liver diseases	2-4	070.22-070.23, 070.32-070.33, 070.44, 070.54, 456.0-456.21, 571-571.9, 572.3-572.9, 573.0-573.3, 573.8-573.9	B18-B18.9, I85-I85.9, I98.2, K70-K70.9, K71.3-K71.51, K71.7, K72.1-K74.69, K74.9, K75.8-K76.0, K76.6-K76.7, K76.9
Digestive diseases	2	455-455.9, 530-536.1, 537-537.6, 537.8-537.84, 538, 540-543.9, 550-551.1, 551.3-552.1, 552.3-553.6, 555-558.9, 560-560.39, 560.8-560.9, 562-562.13, 564-564.1, 564.5-564.7, 565-566.9, 569.1-569.42, 569.5, 569.7-569.71, 573.4, 574-577.9, 579-579.2, 579.4-579.9, 787.1	I84-I84.9, K20-K29.91, K31-K31.6, K31.8-K31.89, K35-K38.9, K40-K42.9, K44-K46.9, K50-K52.9, K55-K62, K62.2-K62.6, K62.8-K62.9, K64-K64.9, K66.8, K67, K68-K68.9, K75.2-K75.4, K76.1-K76.5, K76.8-K76.89, K77-K77.8, K80-K83.9, K85-K86.9, K90-K90.9, K92.8-K92.89, M09.1
Peptic ulcer disease	3-4	531-534.91	K25-K28.9, K31, K31.1-K31.6, K31.8, K31.82-K31.89
Gastritis and duodenitis	3-4	535-535.9	K29-K29.91
Appendicitis	3-4	540-542.9	K35-K37.9, K38.3-K38.9
Paralytic ileus and intestinal obstruction	3-4	560-560.39, 560.8-560.9	K56-K56.9
Inguinal, femoral, and abdominal hernia	3-4	550-551.1, 551.3-552.1, 552.3-553.03, 553.6	K40-K42.9, K44-K46.9
Inflammatory bowel disease	3-4	555-556.9, 558-558.9, 569.5	K50-K52.9, M09.1
Vascular intestinal disorders	3-4	557-557.9	K55-K55.9
Gallbladder and biliary diseases	3-4	574-576.9	K80-K83.9
Pancreatitis	3-4	577-577.9, 579.4	K85-K86.9
Other digestive diseases	3-4	455-455.9, 530-530.9, 536-536.1, 537-537.6, 537.8-537.84, 538, 543-543.9, 553.1-553.3, 562-562.13, 564-564.1, 564.5-564.7, 565-566.9, 569.1-569.42, 569.7-569.71, 573.4, 579-579.2, 579.8-579.9, 787.1	I84-I84.9, K20-K24, K31.0, K31.81-K31.819, K38-K38.2, K57-K62, K62.2-K62.6, K62.8-K62.9, K64-K64.9, K66.8, K67, K68-K68.9, K75.2-K75.4, K76.1-K76.5, K76.8-K76.89, K77-K77.8, K90-K90.9, K92.8-K92.89
Neurological disorders	2	290-290.9, 294.1-294.9, 330-331.2, 331.5-337.9, 340-341.9, 345-345.91, 349, 349.2-349.8, 353.6-353.9, 356-356.9, 357.0-357.1, 357.3-357.4, 357.7, 358-359.9, 728.86, 728.88, 775.2	F00-F03.91, G10-G13.8, G20-G21.0, G21.2-G24, G24.1-G25.0, G25.2-G25.3, G25.5, G25.8-G26.0, G30-G31.1, G31.8-G31.9, G35-G37.9, G40-G41.9, G61-G61.9, G70-G72, G72.2-G73.7, G90-G90.9, G95-G95.9, M33-M33.99
Alzheimer disease and other dementias	3-4	290-290.9, 294.1-294.9, 331-331.2	F00-F03.91, G30-G31.1, G31.8-G31.9
Parkinson disease	3-4	332-332.9	G20-G21.0, G21.2-G22.0

eTable 3: GBD cause list and associated ICD9 and ICD10 codes (continued).

Cause	Level	ICD9	ICD10
Epilepsy	3-4	345-345.91	G40-G41.9
Multiple sclerosis	3-4	340-340.9	G35-G35.9
Motor neuron disease	3-4	335-335.29, 335.8-335.9	G12.2-G12.9
Other neurological disorders	3-4	330-330.9, 331.5-331.9, 333-334.9, 335.3, 336-337.9, 341-341.9, 349, 349.2-349.8, 353.6-353.9, 356-356.9, 357.0-357.1, 357.3-357.4, 357.7, 358-359.9, 728.86, 728.88, 775.2	G10-G12.1, G13-G13.8, G23-G24, G24.1-G25.0, G25.2-G25.3, G25.5, G25.8-G26.0, G36-G37.9, G61-G61.9, G70-G72, G72.2-G73.7, G90-G90.9, G95-G95.9, M33-M33.99
Mental and substance use disorders	2	291-292.9, 295-295.95, 303-303.93, 304.0-304.83, 305-305.93, 307.1, 307.51, 307.54, 357.5, 760.7-760.79, 780.59, 790.3, E850-E850.29, E850.9-E854.39, E860-E860.19	F06.2, F10-F16.99, F18-F29.9, F50.0-F50.5, G31.2, G72.1, P04.3-P04.49, P96.1, Q86.0, R78.0-R78.5, X45-X45.9
Schizophrenia	3-4	295-295.95	F06.2, F20-F23.9, F25-F29.9
Alcohol use disorders	3-4	291-291.9, 303-303.93, 305.0-305.03, 357.5, 790.3, E860-E860.19	F10-F10.99, G31.2, G72.1, P04.3, Q86.0, R78.0, X45-X45.9
Drug use disorders	3	292-292.9, 304.0-304.83, 305, 305.1-305.93, 760.7-760.79, E850-E850.29, E850.9-E854.39	F11-F16.99, F18-F19.99, P04.4-P04.49, P96.1, R78.1-R78.5
Opioid use disorders	4	304.0-304.03, 305.5-305.53, E850.0-E850.29	F11-F11.99, P96.1, R78.1
Cocaine use disorders	4	304.2-304.23, 305.6-305.63	F14-F14.99, R78.2
Amphetamine use disorders	4	304.4-304.43, 305.7-305.73	F15-F15.99
Other drug use disorders	4	292-292.9, 304.1-304.13, 304.5-304.83, 305, 305.1-305.13, 305.3-305.43, 305.8-305.93	F13-F13.99, F16-F16.99, F18-F19.99, R78.3-R78.5
Eating disorders	3	307.1, 307.51, 307.54	F50.0-F50.5
Anorexia nervosa	4	307.1, 307.54	F50.0-F50.1
Bulimia nervosa	4	307.51	F50.2-F50.5

eTable 3: GBD cause list and associated ICD9 and ICD10 codes (continued).

Cause	Level	ICD9	ICD10
Diabetes, urogenital, blood, and endocrine diseases	2	218-219, 219.1-219.9, 236.0, 240-243.9, 244.0-244.1, 244.3-244.8, 245-246.9, 250-259.9, 270-273.9, 275-276, 277-277.2, 277.4-277.9, 278.0-278.8, 282-284.9, 286-286.5, 286.7-289.7, 349.0-349.1, 357.2, 357.6, 403-404.93, 518.7, 519.0-519.09, 536.4-536.49, 539-539.9, 551.2-551.29, 552.2-552.29, 564.2-564.4, 569.6-569.69, 579.3, 580-583.9, 585-585.9, 588-590.9, 592-593.89, 594-599.69, 599.8-599.89, 601-602.9, 604-604.99, 608.2-608.24, 617-618.9, 620-620.9, 621.4-621.9, 622.3-622.7, 629-629.81, 775.0-775.1, 775.3, 779.4-779.5, 780.62-780.63, 788.0, 790.2-790.22	D25-D26, D26.1-D26.9, D28.2, D52.1, D55-D58.9, D59.0-D59.3, D59.5-D59.6, D60-D61.9, D63.1, D64.0, D64.4, D66-D67, D68.0-D69.8, D70-D75.89, D76-D78.89, D86.8, D86.82-D86.84, D86.86-D86.87, D89-D89.3, E03-E07.1, E09-E14.9, E15.0, E16.0-E16.9, E20-E34.8, E36-E36.8, E65-E68, E70-E85.29, E87.71, E88-E89.9, G21.1-G21.19, G24.0-G24.09, G25.1, G25.4, G25.6-G25.79, G72.0, G93.7, G97-G97.9, I12-I13.9, I95.2-I95.3, I97-I97.9, I98.9, J70.2-J70.5, J95-J95.9, K43-K43.9, K62.7, K91-K91.9, K94-K95.89, M87.1-M87.19, N00-N08.8, N10-N12.9, N14-N16.8, N18-N18.9, N20-N23.0, N25-N32.0, N32.3-N32.4, N34-N34.3, N36-N36.9, N39-N39.2, N41-N41.9, N44-N44.04, N45-N45.9, N49-N49.9, N65-N65.1, N72-N72.0, N75-N77.8, N80-N81.9, N83-N83.9, N99-N99.9, P70.0-P70.2, P96.2, P96.5, R50.2, R50.82-R50.83, R73-R73.9
Diabetes mellitus	3-4	250-250.39, 250.5-250.99, 357.2, 775.0-775.1, 790.2-790.22	E10-E10.11, E10.3-E11.1, E11.3-E12.1, E12.3-E13.11, E13.3-E14.1, E14.3-E14.9, P70.0-P70.2, R73-R73.9
Acute glomerulonephritis	3-4	580-580.9	N00-N01.9
Chronic kidney disease	3	250.4-250.49, 403-404.93, 581-583.9, 585-585.9, 589-589.9	D63.1, E10.2-E10.29, E11.2-E11.29, E12.2, E13.2-E13.29, E14.2, I12-I13.9, N02-N08.8, N15.0, N18-N18.9
Chronic kidney disease due to diabetes mellitus	4	250.4-250.49	E10.2-E10.29, E11.2-E11.29, E12.2, E13.2-E13.29, E14.2
Chronic kidney disease due to hypertension	4	403-404.93	I12-I13.9
Chronic kidney disease due to glomerulonephritis	4	581-583.9	N03-N06.9
Chronic kidney disease due to other causes	4	589-589.9	N02-N02.9, N07-N08.8, N15.0
Urinary diseases and male infertility	3	588-588.9, 590-590.9, 592-593.89, 594-596.81, 596.89-598.1, 598.8-599.69, 599.8-599.89, 601-602.9, 604-604.99, 608.2-608.24, 788.0	N10-N12.9, N15, N15.1-N16.8, N20-N23.0, N25-N32.0, N32.3-N32.4, N34-N34.3, N36-N36.9, N39-N39.2, N41-N41.9, N44-N44.04, N45-N45.9, N49-N49.9
Interstitial nephritis and urinary tract infections	4	590-590.9, 595-595.9, 597-597.9, 599.0	N10-N12.9, N15, N15.1-N16.8, N30-N30.91, N34-N34.3, N39.0-N39.2
Urolithiasis	4	592-592.9, 594-594.9, 788.0	N20-N23.0
Other urinary diseases	4	588-588.9, 593-593.89, 596-596.81, 596.89-596.9, 598-598.1, 598.8-599, 599.1-599.69, 599.8-599.89, 601-602.9, 604-604.99, 608.2-608.24	N25-N29.8, N31-N32.0, N32.3-N32.4, N36-N36.9, N39, N41-N41.9, N44-N44.04, N45-N45.9, N49-N49.9

eTable 3: GBD cause list and associated ICD9 and ICD10 codes (continued).

Cause	Level	ICD9	ICD10
Gynecological diseases	3	218-219, 219.1-219.9, 236.0, 256.4, 617-618.9, 620-620.9, 621.4-621.9, 622.3-622.7, 629-629.81	D25-D26, D26.1-D26.9, D28.2, E28.2, N72-N72.0, N75-N77.8, N80-N81.9, N83-N83.9
Uterine fibroids	4	218-219, 219.1-219.9, 236.0	D25-D26, D26.1-D26.9, D28.2
Polycystic ovarian syndrome	4	256.4	E28.2
Endometriosis	4	617-617.9	N80-N80.9
Genital prolapse	4	618-618.9	N81-N81.9
Other gynecological diseases	4	620-620.9, 621.4-621.9, 622.3-622.7, 629-629.81	N72-N72.0, N75-N77.8, N83-N83.9
Hemoglobinopathies and hemolytic anemias	3	282-284.9	D55-D58.9, D59.1, D59.3, D59.5, D60-D61.9, D64.0, D64.4
Thalassemias	4	282.4-282.49	D56-D56.9
Sickle cell disorders	4	282.6-282.68	D57-D57.219, D57.4-D57.819
G6PD deficiency	4	282.2-282.3	D55-D55.2
Other hemoglobinopathies and hemolytic anemias	4	282-282.1, 282.69-284.9	D55.3-D55.9, D58-D58.9, D59.1, D59.3, D59.5, D60-D61.9, D64.0, D64.4
Endocrine, metabolic, blood, and immune disorders	3-4	240-243.9, 244.0-244.1, 244.3-244.8, 245-246.9, 251-256.39, 256.8-259.9, 270-273.9, 275-276, 277-277.2, 277.4-277.9, 278.0-278.8, 286-286.5, 286.7-289.7, 349.0-349.1, 357.6, 518.7, 519.0-519.09, 536.4-536.49, 539-539.9, 551.2-551.29, 552.2-552.29, 564.2-564.4, 569.6-569.69, 579.3, 596.82-596.83, 598.2, 775.3, 779.4-779.5, 780.62-780.63	D52.1, D59.0, D59.2, D59.6, D66-D67, D68.0-D69.8, D70-D75.89, D76-D78.89, D86.8, D86.82-D86.84, D86.86-D86.87, D89-D89.3, E03-E07.1, E09-E09.9, E15.0, E16.0-E16.9, E20-E28.1, E28.3-E34.8, E36-E36.8, E65-E68, E70-E85.29, E87.71, E88-E89.9, G21.1-G21.19, G24.0-G24.09, G25.1, G25.4, G25.6-G25.79, G72.0, G93.7, G97-G97.9, I95.2-I95.3, I97-I97.9, I98.9, J70.2-J70.5, J95-J95.9, K43-K43.9, K62.7, K91-K91.9, K94-K95.89, M87.1-M87.19, N14-N14.4, N65-N65.1, N99-N99.9, P96.2, P96.5, R50.2, R50.82-R50.83
Musculoskeletal disorders	2	416.1, 437.4, 446-446.9, 695.4-695.59, 710-711.99, 714-714.33, 714.8-714.9, 730.1-730.19, 732-732.9, 733.0-733.19	I27.1, I67.7, L93-L93.2, M00-M03.0, M03.2-M03.6, M05-M09.0, M09.2-M09.8, M30-M32.9, M34-M36.8, M40-M43.19, M65-M65.08, M71.0-M71.19, M80-M82.8, M86.3-M86.49, M87-M87.09, M88-M89.09, M89.5-M89.59, M89.7-M89.9
Rheumatoid arthritis	3-4	714-714.33, 714.8-714.9	M05-M06.9, M08.0-M08.89
Other musculoskeletal disorders	3-4	416.1, 437.4, 446-446.9, 695.4-695.59, 710-711.99, 730.1-730.19, 732-732.9, 733.0-733.19	I27.1, I67.7, L93-L93.2, M00-M03.0, M03.2-M03.6, M07-M08, M08.9-M09.0, M09.2-M09.8, M30-M32.9, M34-M36.8, M40-M43.19, M65-M65.08, M71.0-M71.19, M80-M82.8, M86.3-M86.49, M87-M87.09, M88-M89.09, M89.5-M89.59, M89.7-M89.9

eTable 3: GBD cause list and associated ICD9 and ICD10 codes (continued).

Cause	Level	ICD9	ICD10
Other non-communicable diseases	2	035-035.9, 102-103.9, 133-133.6, 376.0-376.1, 680-689, 694-695.3, 707-707.9, 740-749.04, 749.2-758.9, 759.0-759.89, 798-798.0	A46-A46.0, A66-A67.9, B86, D86.3, H05.0-H05.119, L00-L05.92, L08-L08.9, L10-L14.0, L51-L51.9, L88-L89.95, L97-L98.499, P96.0, Q00-Q07.9, Q10.4-Q18.9, Q20-Q28.9, Q30-Q36, Q37-Q45.9, Q50-Q86, Q86.1-Q87.89, Q89-Q89.8, Q90-Q93.9, Q95-Q99.8, R95
Congenital anomalies	3	740-749.04, 749.2-758.9, 759.0-759.89	P96.0, Q00-Q07.9, Q10.4-Q18.9, Q20-Q28.9, Q30-Q36, Q37-Q45.9, Q50-Q86, Q86.1-Q87.89, Q89-Q89.8, Q90-Q93.9, Q95-Q99.8
Neural tube defects	4	740-741.93, 742.0	Q00-Q01.9, Q05-Q05.9
Congenital heart anomalies	4	745-747.9	Q20-Q28.9
Cleft lip and cleft palate	4	749-749.04, 749.2-749.25	Q35-Q36, Q37-Q37.9
Down syndrome	4	758	Q90-Q90.9
Other chromosomal abnormalities	4	758, 758.1-758.6, 758.8-758.9	Q91-Q93.9, Q95-Q95.9, Q97-Q97.9, Q99-Q99.8
Other congenital anomalies	4	742, 742.1-744.9, 748-748.9, 749.6-757.9, 759.0-759.89	P96.0, Q02-Q04.9, Q06-Q07.9, Q10.4-Q18.9, Q30-Q34.9, Q38-Q45.9, Q50-Q86, Q86.1-Q87.89, Q89-Q89.8
Skin and subcutaneous diseases	3	035-035.9, 102-103.9, 133-133.6, 680-689, 694-695.3, 707-707.9	A46-A46.0, A66-A67.9, B86, D86.3, L00-L05.92, L08-L08.9, L10-L14.0, L51-L51.9, L88-L89.95, L97-L98.499
Cellulitis	4	681-682.9	L03-L03.91
Pyoderma	4	035-035.9, 102-103.9, 680-680.9, 683-689	A46-A46.0, A66-A67.9, L00-L02.93, L04-L05.92, L08-L08.9, L88, L97-L98.499
Decubitus ulcer	4	707-707.9	L89-L89.95
Other skin and subcutaneous diseases	4	694-695.3	D86.3, L10-L14.0, L51-L51.9
Sudden infant death syndrome	3-4	798-798.0	R95
Injuries	1	E800-E800.3, E801-E801.3, E802-E802.3, E803-E803.3, E804-E804.3, E805-E805.3, E806-E806.3, E807-E807.3, E810.0-E810.7, E811.0-E811.7, E812.0-E812.7, E813.0-E813.7, E814.0-E814.7, E815.0-E815.7, E816.0-E816.7, E817.0-E817.7, E818.0-E818.7, E819.0-E819.7, E820.0-E820.7, E821.0-E821.7, E822.0-E822.7, E823.0-E823.7, E824.0-E824.7, E825.0-E825.7, E826.0-E826.4, E827.0-E827.4, E828.0-E828.4, E829.0-E829.4, E830-E838.9, E840-E849.9, E850.3-E850.89, E854.8, E856-E857.09, E860.2-E869.99, E870-E876.9, E878-E879.9, E880-E886.99, E888-E928.89, E929.1-E929.5, E930-E979.9, E990-E999.1	V00-V86.99, V87.2-V87.3, V88.2-V88.3, V90-V98.8, W00-W46.2, W49-W62.9, W64-W70.9, W73-W75.9, W77-W81.9, W83-W94.9, W97.9, W99-X06.9, X08-X39.9, X46-X47, X47.1-X47.8, X48-X48.9, X50-X54.9, X57-X58.9, X60-Y08.9, Y35-Y84.9, Y87.0-Y87.1, Y88-Y88.3, Y89.0-Y89.1

eTable 3: GBD cause list and associated ICD9 and ICD10 codes (continued).

Cause	Level	ICD9	ICD10
Transport injuries	2	E800-E800.3, E801-E801.3, E802-E802.3, E803-E803.3, E804-E804.3, E805-E805.3, E806-E806.3, E807-E807.3, E810.0-E810.7, E811.0-E811.7, E812.0-E812.7, E813.0-E813.7, E814.0-E814.7, E815.0-E815.7, E816.0-E816.7, E817.0-E817.7, E818.0-E818.7, E819.0-E819.7, E820.0-E820.7, E821.0-E821.7, E822.0-E822.7, E823.0-E823.7, E824.0-E824.7, E825.0-E825.7, E826.0-E826.4, E827.0-E827.4, E828.0-E828.4, E829.0-E829.4, E830-E838.9, E840-E849.9, E929.1	V00-V86.99, V87.2-V87.3, V88.2-V88.3, V90-V98.8
Road injuries	3	E800.3, E801.3, E802.3, E803.3, E804.3, E805.3, E806.3, E807.3, E810.0-E810.6, E811.0-E811.7, E812.0-E812.7, E813.0-E813.7, E814.0-E814.7, E815.0-E815.7, E816.0-E816.7, E817.0-E817.7, E818.0-E818.7, E819.0-E819.7, E820.0-E820.6, E821.0-E821.6, E822.0-E822.7, E823.0-E823.7, E824.0-E824.7, E825.0-E825.7, E826.0-E826.1, E826.3-E826.4, E827.0, E827.3-E827.4, E828.0, E828.4, E829.0-E829.4	V01-V04.99, V06-V80.929, V82-V82.9, V87.2-V87.3
Pedestrian road injuries	4	E811.7, E812.7, E813.7, E814.7, E815.7, E816.7, E817.7, E818.7, E819.7, E822.7, E823.7, E824.7, E825.7, E826.0, E827.0, E828.0, E829.0	V01-V04.99, V06-V09.9
Cyclist road injuries	4	E800.3, E801.3, E802.3, E803.3, E804.3, E805.3, E806.3, E807.3, E810.6, E811.6, E812.6, E813.6, E814.6, E815.6, E816.6, E817.6, E818.6, E819.6, E820.6, E821.6, E822.6, E823.6, E824.6, E825.6, E826.1	V10-V19.9
Motorcyclist road injuries	4	E810.2-E810.3, E811.2-E811.3, E812.2-E812.3, E813.2-E813.3, E814.2-E814.3, E815.2-E815.3, E816.2-E816.3, E817.2-E817.3, E818.2-E818.3, E819.2-E819.3, E820.2-E820.3, E821.2-E821.3, E822.2-E822.3, E823.2-E823.3, E824.2-E824.3, E825.2-E825.3	V20-V29.9
Motor vehicle road injuries	4	E810.0-E810.1, E811.0-E811.1, E812.0-E812.1, E813.0-E813.1, E814.0-E814.1, E815.0-E815.1, E816.0-E816.1, E817.0-E817.1, E818.0-E818.1, E819.0-E819.1, E820.0-E820.1, E821.0-E821.1, E822.0-E822.1, E823.0-E823.1, E824.0-E824.1, E825.0-E825.1	V30-V79.9, V87.2-V87.3

eTable 3: GBD cause list and associated ICD9 and ICD10 codes (continued).

Cause	Level	ICD9	ICD10
Other road injuries	4	E810.4-E810.5, E811.4-E811.5, E812.4-E812.5, E813.4-E813.5, E814.4-E814.5, E815.4-E815.5, E816.4-E816.5, E817.4-E817.5, E818.4-E818.5, E819.4-E819.5, E820.4-E820.5, E821.4-E821.5, E822.4-E822.5, E823.4-E823.5, E824.4-E824.5, E825.4-E825.5, E826.3-E826.4, E827.3-E827.4, E828.4, E829.4	V80-V80.929, V82-V82.9
Other transport injuries	3-4	E800-E800.2, E801-E801.2, E802-E802.2, E803-E803.2, E804-E804.2, E805-E805.2, E806-E806.2, E807-E807.2, E810.7, E820.7, E821.7, E826.2, E827.2, E828.2, E830-E838.9, E840-E849.9, E929.1	V00-V00.898, V05-V05.99, V81-V81.9, V83-V86.99, V88.2-V88.3, V90-V98.8
Unintentional injuries	2	E850.3-E850.89, E854.8, E856-E857.09, E860.2-E869.99, E870-E876.9, E878-E879.9, E880-E886.99, E888-E906.99, E910-E928.89, E929.2-E929.5, E930-E949.9	W00-W46.2, W49-W62.9, W64-W70.9, W73-W75.9, W77-W81.9, W83-W94.9, W97.9, W99-X06.9, X08-X32.9, X39-X39.9, X46-X47, X47.1-X47.8, X48-X48.9, X50-X54.9, X57-X58.9, Y38.9-Y84.9, Y88-Y88.3
Falls	3-4	E880-E886.99, E888-E888.9, E929.3	W00-W19.9
Drowning	3-4	E910-E910.99	W65-W70.9, W73-W74.9
Fire, heat, and hot substances	3-4	E890-E899.09, E924-E924.99, E929.4	X00-X06.9, X08-X19.9
Poisonings	3-4	E850.3-E850.89, E854.8, E856-E857.09, E860.2-E869.99, E929.2	X46-X47, X47.1-X47.8, X48-X48.9
Exposure to mechanical forces	3	E913-E913.19, E916-E922.99, E928.1-E928.7	W20-W38.9, W40-W43.9, W45.0-W45.2, W46-W46.2, W49-W52, W75-W75.9
Unintentional firearm injuries	4	E922-E922.99, E928.7	W32-W34.9
Unintentional suffocation	4	E913-E913.19	W75-W75.9
Other exposure to mechanical forces	4	E916-E921.99, E928.1-E928.6	W20-W31.9, W35-W38.9, W40-W43.9, W45.0-W45.2, W46-W46.2, W49-W52
Adverse effects of medical treatment	3-4	E870-E876.9, E878-E879.9, E930-E949.9	Y38.9-Y84.9, Y88-Y88.3
Animal contact	3	E905-E906.99	W52.0-W62.9, W64-W64.9, X20-X29.9
Venomous animal contact	4	E905-E905.99	X20-X29.9
Non-venomous animal contact	4	E906-E906.99	W52.0-W62.9, W64-W64.9
Foreign body	3	E911-E912.09, E913.8-E915.09	W44-W45, W45.3-W45.9, W78-W80.9, W83-W84.9
Pulmonary aspiration and foreign body in airway	4	E911-E912.09, E913.8-E913.99	W78-W80.9, W83-W84.9
Foreign body in other body part	4	E914-E915.09	W44-W45, W45.3-W45.9
Environmental heat and cold exposure	3-4	E900-E902.99, E926-E926.99, E929.5	W88-W94.9, W97.9, W99-W99.9, X30-X32.9, X39-X39.9
Other unintentional injuries	3-4	E903-E904.99, E913.2-E913.39, E923-E923.99, E925-E925.99, E927-E928.09, E928.8-E928.89	W39-W39.9, W77-W77.9, W81-W81.9, W85-W87.9, X50-X54.9, X57-X58.9

eTable 3: GBD cause list and associated ICD9 and ICD10 codes (continued).

Cause	Level	ICD9	ICD10
Self-harm and interpersonal violence	2	E950-E969	X60-Y08.9, Y87.0-Y87.1
Self-harm	3-4	E950-E959	X60-X84.9, Y87.0
Interpersonal violence	3	E960-E969	X85-Y08.9, Y87.1
Assault by firearm	4	E965-E965.4	X93-X94.0, X94.3-X94.7, X94.9-X95.9, X96.5
Assault by sharp object	4	E966	X99-X99.9
Assault by other means	4	E960-E964, E965.5-E965.9, E967-E969	X85-X92.9, X94.1-X94.2, X94.8, X96-X96.4, X96.6-X98.9, Y00-Y08.9, Y87.1
Forces of nature, war, and legal intervention	2	E907-E909.9, E970-E979.9, E990-E999.1	X33-X38.9, Y35-Y38.893, Y89.0-Y89.1
Exposure to forces of nature	3-4	E907-E909.9	X33-X38.9
Collective violence and legal intervention	3-4	E970-E979.9, E990-E999.1	Y35-Y38.893, Y89.0-Y89.1

eTable 3: GBD cause list and associated ICD9 and ICD10 codes (continued).

Cause	Level	ICD9	ICD10
Garbage Code		000-000.9, 002, 031-031.9, 038-038.9, 039.6, 040.0, 041.1-041.9, 067-069, 076-078.3, 078.8-078.9, 079.8-079.99, 084, 084.6, 085, 085.1-085.9, 089-089.9, 105-119, 125-125.3, 126-126.9, 127.2-127.9, 130-132.9, 133.8-134.9, 136.3-136.5, 136.8-136.9, 139.1-139.9, 149-149.9, 159-159.9, 165-169, 176-179.9, 183.9-184, 184.5, 184.9, 187, 187.9, 189, 189.9, 194.9-199.9, 209, 209.2-209.20, 209.29-209.30, 209.6-209.60, 209.62, 209.69-210, 211, 211.9-212, 212.9, 214-216.9, 221, 221.9-222, 222.9-223, 223.9, 229, 229.1, 229.9-230.0, 230.9-231, 231.8-231.9, 233, 233.3-233.30, 233.39, 233.6, 233.9-234, 234.9-235, 235.1-235.3, 235.5, 235.9-236, 236.3, 236.6, 236.9-236.90, 237.4, 238, 238.6-239.1, 239.5, 239.7-239.9, 244, 244.9, 247-249.91, 264-264.9, 274-274.9, 276.0-276.9, 277.3-277.39, 278, 279-280.0, 280.9-281, 285-285.9, 286.6, 289.8-289.9, 293-294.0, 296-302.9, 304, 304.9-304.93, 306-307.0, 307.2-307.50, 307.52-307.53, 307.59-320, 320.9, 324-327.19, 328-329, 331.3-331.4, 338-339.89, 342-344.9, 346-348.9, 349.81-353.5, 354-355.9, 357, 357.8-357.9, 360-376, 376.10-380.9, 384-389.9, 399-401.9, 405-409.4, 415-416.0, 416.2-416.9, 418-419.9, 423.0, 426-426.9, 427.4-427.5, 427.9-429, 429.2-429.9, 436-437, 437.3, 437.9-440.9, 444-445.89, 458-458.9, 459.0, 459.5-460.9, 462-464, 464.00, 464.1-464.10, 464.20, 464.3-464.30, 464.5-464.51, 465-465.9, 482.9-483, 484, 484.8-486.9, 505-505.9, 507-507.9, 510-514.9, 515.0-515.9, 518-518.53, 518.8-518.89, 519, 519.8-529.9, 536.2-536.3, 536.8-536.9, 537.7, 537.89-537.9, 544-549, 553.8-553.9, 559-559.0, 560.4-560.7, 561, 562.2-563, 564.8-564.9, 567-569, 569.49, 569.79-569.83, 569.86-570.9, 572-572.2, 573	A01, A14.9, A29, A31-A31.9, A40-A45.9, A47-A48.0, A48.3, A48.8-A49.02, A49.2-A49.9, A59-A59.9, A61-A62, A64-A64.0, A71-A73, A74.0, A76, A97, A99-A99.0, B07-B09, B11-B14, B28-B29, B30-B32.4, B34-B46.9, B49-B49.9, B54-B55, B55.1-B55.9, B58-B59.9, B61-B62, B64, B68-B68.9, B73-B74.2, B76-B76.9, B78-B82.9, B83.9-B85.4, B87-B89, B93-B94.0, B94.8-B94.9, B95.6-B99.9, C14-C14.9, C26-C29, C35-C36, C39-C39.9, C42, C46-C46.9, C55-C55.9, C57.9, C59-C6, C63.9, C68, C68.9, C75.9-C80.9, C87, C97-D00.0, D01, D01.4-D02, D02.4-D02.9, D07, D07.3-D07.39, D07.6-D09, D09.1-D09.19, D09.7, D09.9-D10, D10.9, D13, D13.9-D14, D14.4, D17-D21.9, D28, D28.9-D29, D29.9-D30, D30.9, D36.0, D36.9-D37.0, D37.6-D38, D38.6-D39.0, D39.7, D39.9-D40, D40.9-D41, D41.9, D44, D44.9, D46-D46.9, D47.1, D48, D48.7-D49.1, D49.5, D49.7-D49.8, D49.89-D50.0, D50.9, D54, D59, D59.4, D59.8-D59.9, D62-D63.0, D63.8-D64, D64.1-D64.2, D64.8-D65.9, D68, D69.9, D75.9, D79-D85, D87-D88, D89.8-D99, E07.8-E08.9, E15, E16, E17-E19, E34.9-E35.8, E37-E39, E47-E50.9, E62, E64.1, E69, E85.3-E87.70, E87.79-E87.99, E90-E998, F04-F06.1, F06.3-F07.0, F07.2-F09.9, F17-F17.9, F30-F50, F50.8-G00, G00.9-G02.8, G03.9, G06-G09.9, G15-G19, G27-G29, G32-G34, G38-G39, G42-G44.89, G47-G47.29, G47.4-G60.9, G62-G69, G74-G89.4, G91-G93.6, G93.8-G94.8, G96-G96.9, G98-H05, H05.12-H69.93, H71-H99, I00.0, I03-I04, I10-I10.9, I14-I19, I26-I27.0, I27.2-I27.9, I28.9-I29.9, I31.2-I31.4, I44-I46.9, I49-I51, I51.6-I59, I62, I62.1-I62.9, I64-I64.9, I67, I67.4, I67.8-I68

eTable 3: GBD cause list and associated ICD9 and ICD10 codes (continued).

Cause	Level	ICD9	ICD10
Garbage Code (continued)		573.5, 578-578.9, 584-584.9, 586-587.9, 591-591.9, 593.9, 599.7-599.72, 599.9-600.91, 603-603.9, 605-608.1, 608.3-609, 611-612.1, 615-616.9, 619-619.9, 621-621.35, 622-622.2, 622.8-628.9, 629.89-629.9, 637-637.92, 639-639.9, 690-693.9, 695.8-706.9, 708-709.9, 712-713.8, 714.4, 715-716, 716.1-728.85, 728.87, 728.89-730.09, 730.2-730.39, 730.7-731.9, 733, 733.2-739.9, 749.1-749.14, 759, 759.9, 770.0, 779.9-780.56, 780.58, 780.6-780.61, 780.64-786.02, 786.04-787.04, 787.2-787.9, 787.99-788, 788.1-790.1, 790.29, 790.4-797.9, 798.1-E80, E800.8-E800.9, E801.8-E801.9, E802.8-E802.9, E803.8-E803.9, E804.8-E804.9, E805.8-E805.9, E806.8-E806.9, E807.8-E810, E810.8-E811, E811.8-E812, E812.8-E813, E813.8-E814, E814.8-E815, E815.8-E816, E816.8-E817, E817.8-E818, E818.8-E819, E819.8-E820, E820.8-E821, E821.8-E822, E822.8-E823, E823.8-E824, E824.8-E825, E825.8-E826, E826.8-E827, E827.8-E828, E828.8-E829, E829.8-E83, E839, E85, E855-E855.99, E858-E859, E87, E877, E88, E887-E887.09, E928.9-E929.0, E929.8-E929.9, E980-E989	I68.8-I69, I69.4-I70.1, I70.8-I70.92, I74-I76, I90, I92-I95.1, I95.8-I96.9, I98.4-I98.8, I99-J00.0, J02, J02.8-J03, J03.8-J04, J04.1-J04.31, J05.1-J05.10, J06-J08, J15.9, J17-J19.6, J22-J29, J48-J59, J64-J64.9, J69-J69.9, J71-J81.9, J83, J85-J90.9, J93-J94.9, J96-K19, K30, K31.9-K34, K39, K47-K49, K53-K54, K63-K63.4, K63.8-K63.9, K65-K66.1, K66.9, K69, K71-K71.2, K71.6, K71.8-K72.01, K75-K75.1, K78-K79, K84, K87-K89, K92-K92.2, K92.9-K93, K93.1-K93.8, K96-K99, L06-L07, L09, L15-L50.9, L52-L87.9, L90-L92.9, L94-L96, L98.5-L99.8, M04, M10-M12.09, M12.2-M29, M37-M39, M43.2-M49, M49.2-M64, M65.1-M71, M71.2-M73, M73.8-M79.9, M83-M86.29, M86.5-M86.9, M87.2-M87.9, M89.1-M89.49, M90-M99.9, N09, N13-N13.9, N17-N17.9, N19-N19.9, N24, N32.1-N32.2, N32.8-N33.8, N35-N35.9, N37-N38, N39.3-N40.9, N42-N43.42, N44.1-N44.8, N46-N48.9, N50-N59, N61-N64.9, N66-N69, N78-N79, N82-N82.9, N84, N84.2-N86, N88-N95.9, N97-N97.9, O08-O08.9, O17-O19, O27, O37-O39, O49-O59, O78-O79, O93-O95.9, P06, P16-P18, P23, P23.5-P23.9, P30-P34.2, P37.3-P37.4, P40-P49, P62-P69, P73, P79, P82, P85-P89, P96.9-P99.9, Q08-Q10.3, Q19, Q29, Q36.0-Q36.9, Q46-Q49, Q88, Q89.9, Q94, Q99.9-R19.6, R19.8-R50.1, R50.8-R50.81, R50.84-R72.9, R74-R78, R78.6-R94.8, R95.0-T71.161, T71.163-U03, U05-U99, V87-V87.1, V87.4-V88.1, V88.4-V89.9, V99-V99.0, W47-W48, W63, W71-W72, W76-W76.9, W82, W95-W97, W98, X07, X40-X44.9, X47.0, X47.9, X49-X49.9, X55-X56, X59-X59.9, Y09-Y34.9, Y85-Y87, Y87.2, Y89, Y89.9

eTable 4: Mean relative error (%) for age-standardized mortality rates derived from the SAE model.

	Population Size					
Model	1,000	3,000	5,000	10,000	25,000	100,000
1	-0.63	-0.03	-0.04	0.15	0.09	0.13
2	-0.33	0.01	-0.05	0.08	-0.04	-0.02
3	-2.45	-0.85	-0.48	-0.00	0.14	0.28
4	-2.55	-0.69	-0.25	0.30	0.49	0.66
Kulkarni et al.	-	2.18	2.05	1.84	1.54	1.35
Wang et al.	-	3.28	4.31	5.79	4.39	1.86

eTable 5: Mean absolute relative error (%) for age-standardized mortality rates derived from the SAE model.

	Population Size					
Model	1,000	3,000	5,000	10,000	25,000	100,000
1	6.53	4.71	4.00	3.23	2.50	1.83
2	7.17	4.86	4.05	3.27	2.54	1.94
3	6.73	5.22	4.75	4.28	3.99	3.77
4	6.81	5.19	4.70	4.24	3.95	3.75
Kulkarni et al.	-	5.97	5.72	5.21	4.33	2.86
Wang et al.	-	6.82	6.98	7.01	5.09	2.43

eTable 6: Coverage (%) for age-standardized mortality rates derived from the SAE model.

	Population Size					
Model	1,000	3,000	5,000	10,000	25,000	100,000
1	95.43	95.15	94.75	95.20	95.63	96.68
2	93.58	92.00	90.29	87.56	80.72	64.08
3	86.30	81.10	76.24	67.61	52.20	30.91
4	85.96	81.53	76.91	68.22	52.53	30.99
Kulkarni et al.	-	63.37	64.02	65.30	68.26	73.31
Wang et al.	-	66.66	72.89	78.21	80.15	81.45