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Persistent and extreme outliers in causes of death by state, 1999-2013

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Persistent and extreme outliers in causes of death by state, 1999-2013

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Abstract

In the United States, state-specific mortality rates that are high relative to national rates can result from legitimate reasons or from variability in coding practices. This paper identifies instances of state-specific mortality rates that were at least twice the national rate in each of three consecutive five-year periods (termed persistent outliers), along with rates that were at least five times the national rate in at least one five-year period (termed extreme outliers). The resulting set of 71 outliers, 12 of which appeared on both lists, illuminates mortality variations within the country, including some that are amenable to improvement either because they represent preventable causes of death or highlight weaknesses in coding practices. Because the approach used here is based on relative rather than absolute mortality, it is not dominated by the most common causes of death such as heart disease and cancer.

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Introduction

This paper builds upon the findings of the paper, "The Most Distinctive Causes of Death by State, 2001–2010", published in the online journal *Preventing Chronic Disease* in May, 2015 (Boscoe and Pradhan, 2015). That paper – formally a "GIS Snapshot", consisting of a single map and accompanying short description – presented the most distinctive cause of death for each state and the District of Columbia for the 2001-2010 period. "Most distinctive" was defined as the highest ratio of state-specific death rate to national death rate for each of the causes of death included in the 113 Selected Causes of Death List published by the National Center for Health Statistics (2002). For example, the age-adjusted death rate due to pneumoconiosis nationwide was 0.3 per 100,000, but in Kentucky, it was 1.0 and in West Virginia it was 3.9. The respective ratios of 3.3 and 12.4 were higher than for any other cause of death in these states, making them the most distinctive. The mapped causes of death can also be understood as those with the highest state-specific relative risks, the highest location quotients (Mayer and Pleeter, 1975), or as the largest outliers. In general, the identification of outliers is useful for assessing the integrity of a data set and to identify genuinely unusual phenomena that can give rise to hypotheses (Osborne and Overbay, 2004).

In the time since the original paper was first submitted for publication, three additional years of data have become available. I incorporate these data into an alternative way of conducting the analysis that identifies what I term persistent outliers and extreme outliers. Persistent outliers were those causes of death with an age-adjusted rate that was at least twice the national rate in each of the five-year time periods 1999-2003, 2004-2008, and 2009-2013. Extreme outliers were defined as those causes of death with an age-adjusted rate that was at least 5 times above the national rate in at least one of the time periods. Identifying all of the outliers in

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this manner instead of identifying exactly one per state, as was done on the original map, is a more inclusive means of summarizing the data.

Methods

National and state-specific age-adjusted death rates for all of the causes of death included in the 113 Selected Causes of Death List for the period 1999-2013 were obtained from CDC's Wide-ranging Online Data for Epidemiologic Research (WONDER) web site (Centers for Disease Control and Prevention, no date). This list was developed for the general analysis of mortality data and for ranking causes of death and is based on International Classification of Diseases version 10 (ICD-10) codes. Data were divided into three 5-year periods: 1999-2003, 2004-2008, and 2009-2013. The ratios of the state rates to the national rates for each cause of death in each period were calculated, and persistent and extreme outliers were identified, as defined above. Counts below 10 were suppressed by WONDER and thus excluded from the analysis. 95% confidence intervals around the ratios were determined using the RELRISK option in the FREQ procedure in SAS version 9.3 (SAS Institute, Cary NC). Results were tabulated for all causes of death in the list, even where the classifications overlapped, as for example with homicide, homicide by firearm, and homicide by other and unspecified means. An exception was made for "other and unspecified events of undetermined intent and their sequelae" and "events of undetermined intent", because these two categories were nearly identical - the first comprised over 99% of the second. Only the second, more inclusive category is reported here.

Results

There were 62 persistent outliers among 28 states plus the District of Columbia (Table 1 and Figure 1a). The District of Columbia had the most persistent outliers, with 9, while there were 22 states without any. There were 38 extreme outliers among 14 states plus the District of Columbia (Table 2 and Figure 1b). The District of Columbia led with 7, while 36 states did not have any. Twelve of the persistent outliers also appeared on the list of extreme outliers: water and air accidents (Alaska), events of undetermined intent (Maryland and Utah), other acute ischemic heart disease (Oklahoma and Virginia), influenza (South Dakota), and pneumoconiosis (West Virginia), plus five in the District of Columbia – HIV, homicide, homicide by firearm, hypertensive heart disease, and atherosclerotic cardiovascular disease. Table 2 also reveals that the number of extreme outliers has decreased over time. Between 1999 and 2003, there were 17; from 2004-2008 there were 13; and from 2009-2013 there were 8.

Discussion

The tables and figures highlight instances where state mortality rates exceeded national rates by substantial margins. These can be understood as either genuine phenomena – where the risk of death due to a certain cause was truly elevated – or as artifacts of state-specific coding practices. The former category includes unambiguous infectious and chronic diseases such as viral hepatitis and pneumoconiosis, and well-specified types of accidents such as accidental drowning and exposure to smoke, fire and flames. The latter category includes causes of death containing the words “other”, “unspecified” and “unknown”, where a state, for whatever reason, was unable to code deaths to the same level of specificity as other states.

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There are a number of possible explanations for this lack of specificity. The information could have truly been absent –a physician or coroner might have only indicated something like "cardiac arrest" on the death certificate, for example, and there were insufficient resources to follow up and obtain something more precise. It is also possible that coding guidelines may have been interpreted overly strictly or literally, or may have been perceived as unclear. There could have also been instances of "motivated misreporting", in which the person filling out the death certificate may have had an incentive to be vague (Osborne and Overbay, 2004). An example of this has occurred in Maryland, where the state's chief medical examiner is on record that many "events of undetermined intent" - which include unresolved homicides, suicides, and accidents - cannot be coded more specifically without input from the legal system, even though the medical determination of intent is distinct from the legal determination (Fenton, 2012). Critics have argued that this practice substantially suppresses the official homicide rate. Indeed, Maryland's rate of "events of undetermined intent" was 6 to 7 times above the national average in each of the 3 time periods.

For some of the reported outliers, it is not obvious whether the findings were genuine, an artifact, or some combination of the two. For example, influenza, which appeared as an outlier in 9 different states (Iowa, Maine, Minnesota, Montana, Nebraska, North Dakota, South Dakota, Vermont, and Wyoming), would seem to be a clearly defined cause of death. Yet the national influenza mortality data have been described as "a mess" (Doshi, 2005). Deaths due to influenza are much less common than generally believed – it is perceived as common because it is typically either lumped with deaths from pneumonia or reported in terms of "influenza-related" deaths, which derive not from death certificates but from mathematical models (Doshi, 2008; Thompson et al., 2009). Of the comparatively small number of deaths officially ascribed to

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influenza, a minority were confirmed with a lab test (these receive ICD-10 codes J09 and J10), while the remainder were based on observation (these receive code J11). The nine states with unusually high influenza death rates may simply have been more aggressive in ordering lab tests, or more willing to have called influenza-like illness influenza, than to have had a true excess risk.

Note that this analysis was only able to identify likely examples of substantial overreporting in certain causes of death. There have also been well-documented examples of substantial underreporting, such as with suicide (Klugman, Condran and Wray, 2013), pregnancy-related deaths (Deneux-Tharaux et al., 2005), and injuries from falls (Betz, Kelly and Fisher, 2008). In some cases, such as with "events of undetermined intent", the overreported category can imply which categories were likely underreported, but a separate analysis would be required to identify properly these negative outliers; such an analysis would be complicated by the suppression of counts less than 10.

Each one of the causes of death highlighted in the tables and figures suggests a story about mortality disparities, mortality coding disparities, or some combination of the two that demands further investigation. In the interest of brevity, I will comment only on the dozen entries which appeared in both tables. The District of Columbia, with 5 of the 12, revealed itself as an outlier among outliers. Though not a state, its data are typically reported with the 50 states, as was done here. It is unique among "states" in having an African-American majority and being entirely urban. It also has the highest poverty rate and income inequality of any "state", making it an outlier by numerous measures. The high rates of HIV-related deaths and homicide seen here reflect the urban pathologies of intravenous drug use and crime, while hypertensive heart disease and atherosclerotic cardiovascular disease reflect DC's racial composition, even while the

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precise reasons for greater hypertension among black Americans remain elusive (Fuchs, 2011).

Moving to Alaska, the classification "water, air and space, and other and unspecified transport accidents and their sequelae" has a straightforward explanation: travel by water and air is vastly more common here than in other states, and is the only way to reach many settlements within the state. Pneumoconioses, more commonly known as black lung disease, has a similarly obvious association with West Virginia, the state most closely associated with coal mining. "Events of undetermined intent", with high rates in Maryland and Utah, has already been discussed, as has influenza, with particularly high rates in South Dakota.

That leaves "other acute ischemic heart disease", which appeared in both Oklahoma and Virginia. From 1995 to 1999, the rate for this cause of death was over 25 times the national average in Oklahoma, making it the most extreme outlier in this entire analysis. The rate subsequently dropped to 9 times the national average in 2008-2013, still one of the more extreme values. This is a clear example of coding imprecision, reflecting an inability to distinguish among chronic heart disease, heart attack (myocardial infarction), and a few other less common conditions in a manner not shared by other states. For any studies which distinguish among types of ischemic heart disease (see, for example, Ibfelt, Bonde and Hanson, 2010), care would have to be taken to make sure that the results were not biased by the data from these two states.

The need for uniform standards for cause of death coding, and for public health data generally, is obvious – in order to compare conditions in different places and times, the measurement of those conditions must be done in as similar a manner as possible. The drop in the number of extreme outliers over time suggests that standardization has been improving. Massachusetts and Rhode Island represent good examples of this trend. Both of these states had very high rates of "events of undetermined intent" in 1999-2003, but by 2009-2013 were below

the national average. Public health agencies are continuously trying to improve standards and data quality; for example, since 2012, the National Center for Health Statistics has been flagging rare causes of death such as those caused by vaccine preventable diseases and requesting that states follow up and attempt to verify them (Centers for Disease Control and Prevention, 2014). Findings such as those reported here can also serve to motivate improvements, as no state wants to be identified as an outlier for a preventable cause of death or an indicator of low data quality.

Cause of death coding based on the International Classification of Diseases is the most widely used system in the world and enables comparisons between countries and across decades. While no such system can ever be perfect or tell us everything we would like to know, it is in our collective interest to strive for the highest data quality possible.

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References

Betz ME, Kelly SP, Fisher J. Death certificate inaccuracy and underreporting of injury in elderly people. *Journal of the American Geriatrics Society* 2008; 56: 2267-2272.

Boscoe FP, Pradhan E. The most distinctive causes of death by state. *Preventing Chronic Disease* 2015, 12: 140395.

Centers for Disease Control and Prevention. 2014. *Improvements to the National Vital Statistics System*. On line: http://www.cdc.gov/nchs/data/factsheets/factsheet_nvss_improvements.htm. Accessed July 20, 2015.

Centers for Disease Control and Prevention. No date. *About Underlying Cause of Death, 1999-2010*. On line: http://wonder.cdc.gov/ucd-icd10.html. Accessed July 20, 2015.

Deneux-Tharaux C, Berg C, Bouvier-Colle M-H, Gissler M, Harper M, Nannini A, Alexander S, Wildman K, Breart G, Buekens P. Underreporting of Pregnancy-Related Mortality in the United States and Europe. *Obstetrics & Gynecology* 2005; 106: 684-692.

Doshi P. Are US flu death figures more PR than science? *BMJ* 2005; 331: 1412.

Doshi P. Trends in recorded influenza mortality: United States, 1900-2004. *American Journal of Public Health* 2008; 98: 939-945.

Fenton J. Raising doubt on homicide count: unusual ruling in city heroin overdoes throws spotlight on many deaths of 'undetermined' cause. *Baltimore Sun* 2012; June 11, A1.

Fuchs FD. Why do black Americans have higher prevalence of hypertension? An enigma still unsolved. *Hypertension* 2011; 57: 383-389.

Galea S, Tracy M, Hoggatt KJ, DiMaggio C, Karpati A. Estimated deaths attributable to social factors in the United States. *American Journal of Public Health* 2011; 101: 1456-1465.

Ibfelt E, Bonde JP, Hansen J. Exposure to metal welding fume particles and risk for cardiovascular disease in Denmark: a prospective cohort study. *Occupational and Environmental Medicine* 2010; 67: 772-777.

Klugman J, Condran G, Wray M. The role of medicological systems in producing geographic variation in suicide rates. *Social Science Quarterly* 2013; 94(2): 462-489.

Mayer W, Pleeter S. A theoretical justification for the use of location quotients. *Regional Science and Urban Economics* 1975; 5: 343-355.

National Center for Health Statistics. 2002. Instruction manual, part 9: ICD-10 cause-of-death lists for tabulating mortality statistics. On line: http://www.cdc.gov/nchs/data/dvs/im9_2002.pdf.pdf. Accessed July 20, 2015.

Osborne JW, Overbay A. The power of outliers (and why researchers should always check for them). *Practical Assessment, Research and Evaluation* 2004; 9(6).

Thompson WW, Moore MR, Weintraub E, Cheng PY, Jin X, Bridges CB, Bresee JS, Shay DK. Estimating influenza-associated deaths in the United States. *American Journal of Public Health* 2009; 99: S225-S230.

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Table 1. Persistent outliers, by state, 1999-2013.

		1999-2003		2004-2008		2009-2013	
State	Cause of Death	Deaths	RR	Deaths	RR	Deaths	RR
Alabama	Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (R00-R99)	5550	2.31 (2.25-2.37)	6829	2.69 (2.63-2.76)	7882	2.88 (2.81-2.94)
Alabama	Accidental discharge of firearms (W32-W34)	209	3.81 (3.31-4.38)	161	3.27 (2.79-3.83)	127	2.47 (2.07-2.95)
Alabama	Other heart diseases (I26-I51)	28255	2.11 (2.09-2.14)	30196	2.28 (2.26-2.31)	30702	2.12 (2.10-2.14)
Alabama	Heart failure (I50)	10894	2.44 (2.39-2.48)	10225	2.31 (2.27-2.36)	9981	2.05 (2.01-2.09)
Alaska	Water, air and space, and other and unspecified transport accidents and their sequelae (V90-V99, Y85)	186	9.19 (7.95-10.63)	124	6.09 (5.10-7.27)	129	6.09 (5.12-7.25)
Alaska	Tuberculosis (A16-A19)	13	2.81 (1.63-4.85)	13	4.17 (2.42-7.19)	18	3.70 (2.33-5.88)
Alaska	Accidental drowning and submersion (W65-W74)	119	3.11 (2.60-3.73)	134	3.44 (2.90-4.08)	118	2.95 (2.46-3.54)
Alaska	Intentional self-harm (suicide) by discharge of firearms (X72-X74)	387	2.16 (1.96-2.39)	470	2.53 (2.31-2.77)	503	2.49 (2.28-2.72)
Alaska	Other and unspecified nontransport accidents and their sequelae (W20-W31, W35-W64, W75-W99, X10-X39, X50-X59, Y86)	301	2.18 (1.95-2.44)	292	2.04 (1.82-2.29)	320	2.07 (1.86-2.31)
Arizona	Discharge of firearms, undetermined intent (Y22-Y24)	62	2.52 (1.95-3.25)	80	3.02 (2.41-3.79)	63	2.24 (1.74-2.88)
Arkansas	Discharge of firearms, undetermined intent (Y22-Y24)	37	3.10 (2.24-4.30)	40	3.46 (2.53-4.74)	27	2.04 (1.40-2.99)
District of Columbia	Hypertensive heart and renal disease (I13)	144	4.82 (4.09-5.68)	140	5.16 (4.37-6.09)	131	4.47 (3.76-5.31)
District of Columbia	Human immunodeficiency virus (HIV) disease (B20-B24)	1221	8.49 (8.02-8.99)	1015	8.97 (8.43-9.55)	536	4.41 (4.05-4.81)
District of Columbia	Atherosclerotic cardiovascular disease, so described (I25.0)	2794	4.06 (3.91-4.21)	2797	5.06 (4.88-5.25)	2338	3.96 (3.80-4.13)
District of Columbia	Hypertensive heart disease (I11)	1375	5.44 (5.16-5.73)	936	3.38 (3.17-3.60)	852	2.87 (2.69-3.07)
District of Columbia	Assault (homicide) by discharge of firearms (U01.4, X93-X95)	756	5.92 (5.51-6.36)	650	4.75 (4.39-5.13)	381	2.50 (2.26-2.77)
District of Columbia	Assault (homicide) U01-U02, X85-Y09, Y87.1)	990	5.01 (4.71-5.34)	827	4.24 (3.96-4.54)	535	2.49 (2.29-2.72)

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District of Columbia	Assault (homicide) by other and unspecified means and their sequelae (U01.0-U01.3, U01.5-U01.9, U02, X85-X92, X96-Y09, Y87.1)	234	3.49 (3.07-3.97)	177	3.16 (2.72-3.66)	154	2.48 (2.12-2.91)
District of Columbia	Viral hepatitis (B15-B19)	111	2.09 (1.74-2.52)	157	2.63 (2.24-3.07)	168	2.47 (2.12-2.87)
District of Columbia	Pregnancy, childbirth and the puerperium (O00-O99)	10	2.52 (1.35-4.69)	28	3.65 (2.51-5.29)	21	2.37 (1.54-3.63)
Hawaii	Accidental drowning and submersion (W65-W74)	153	2.06 (1.75-2.41)	169	2.18 (1.87-2.54)	227	2.77 (2.43-3.16)
Idaho	Water, air and space, and other and unspecified transport accidents and their sequelae (V90-V99, Y85)	99	2.35 (1.93-2.86)	113	2.63 (2.19-3.17)	115	2.41 (2.01-2.90)
Iowa	Influenza (J09-J11)	196	2.46 (2.13-2.83)	178	2.39 (2.06-2.78)	190	2.59 (2.24-2.99)
Kansas	Atherosclerosis (I70)	1706	2.16 (2.06-2.27)	1700	3.32 (3.16-3.48)	1941	3.56 (3.40-3.73)
Kentucky	Pneumoconioses and chemical effects (J60-J66, J68)	240	3.01 (2.65-3.43)	216	3.27 (2.86-3.75)	211	2.88 (2.51-3.31)
Louisiana	Accidental discharge of firearms (W32-W34)	179	3.15 (2.72-3.66)	195	3.99 (3.45-4.61)	169	3.41 (2.92-3.98)
Louisiana	Assault (homicide) by discharge of firearms (U01.4, X93-X95)	2109	2.35 (2.25-2.45)	2298	2.47 (2.37-2.58)	2186	2.34 (2.24-2.44)
Louisiana	Meningococcal infection (A39)	27	2.91 (1.99-4.27)	21	3.51 (2.27-5.43)	10	2.05 (1.10-3.83)
Louisiana	Assault (homicide) (U01-U02, X85-Y09, Y87.1)	2834	2.00 (1.93-2.08)	2916	2.14 (2.07-2.22)	2765	2.03 (1.95-2.10)
Maine	Influenza (J09-J11)	67	2.15 (1.69-2.73)	105	3.50 (2.89-4.25)	90	2.72 (2.21-3.35)
Maryland	Events of undetermined intent (Y10-Y34, Y87.2, Y89.9)	3144	7.37 (7.10-7.65)	3405	6.99 (6.74-7.24)	2990	5.88 (5.66-6.11)
Minnesota	Influenza (J09-J11)	293	2.57 (2.28-2.89)	281	2.62 (2.33-2.95)	272	2.41 (2.14-2.73)
Mississippi	Discharge of firearms, undetermined intent (Y22-Y24)	37	2.77 (2.00-3.84)	34	2.53 (1.80-3.55)	34	2.73 (1.94-3.84)
Mississippi	Hypertensive heart and renal disease (I13)	317	2.18 (1.95-2.43)	324	2.37 (2.12-2.64)	378	2.55 (2.31-2.83)
Mississippi	Accidental discharge of firearms (W32-W34)	133	3.75 (3.15-4.45)	108	3.30 (2.72-4.00)	83	2.53 (2.03-3.14)
Mississippi	Accidental exposure to smoke, fire and flames (X00-X09)	452	2.80 (2.55-3.07)	398	2.66 (2.41-2.94)	377	2.39 (2.16-2.65)
Mississippi	Hypertensive heart disease (I11)	2624	2.16 (2.08-2.25)	3416	2.46 (2.38-2.55)	3349	2.24 (2.17-2.32)
Mississippi	Heart failure (I50)	6566	2.42 (2.36-2.28)	6879	2.62 (2.56-2.68)	6339	2.24 (2.18-2.29)
Montana	Influenza (J09-J11)	72	3.47 (2.75-4.38)	43	2.08 (1.54-2.80)	72	3.21 (2.54-4.05)

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Montana	Intentional self-harm (suicide) by discharge of firearms (X72-X74)	571	2.11 (1.94-2.29)	594	2.14 (1.97-2.32)	729	2.44 (2.26-2.62)
Montana	Water, air and space, and other and unspecified transport accidents and their sequelae (V90-V99, Y85)	64	2.07 (1.62-2.65)	79	2.64 (2.12-3.30)	76	2.43 (1.94-3.05)
Montana	Accidental discharge of firearms (W32-W34)	25	2.18 (1.47-3.23)	22	2.02 (1.33-3.08)	24	2.34 (1.57-3.50)
Nebraska	Influenza (J09-J11)	115	2.72 (2.26-3.27)	86	2.10 (1.70-2.60)	96	2.31 (1.89-2.83)
Nebraska	Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (R00-R99)	2391	2.33 (2.23-2.42)	2228	2.05 (1.97-2.14)	2398	2.03 (1.95-2.11)
Nevada	Legal intervention (Y35, Y89.0)	35	2.46 (1.76-3.44)	42	2.72 (2.01-3.69)	38	2.36 (1.71-3.25)
New Mexico	Legal intervention (Y35, Y89.0)	36	2.99 (2.15-4.15)	34	2.84 (2.02-3.98)	50	4.33 (3.27-5.73)
New Mexico	Alcoholic liver disease (K70)	932	2.41 (2.26-2.57)	969	2.24 (2.10-2.39)	1275	2.72 (2.57-2.87)
New Mexico	Accidental poisoning and exposure to noxious substances (X40-X49)	1268	2.65 (2.51-2.80)	1823	2.16 (2.06-2.26)	2261	2.56 (2.45-2.67)
North Dakota	Influenza (J09-J11)	42	2.37 (1.75-3.21)	47	2.95 (2.21-3.93)	38	2.34 (1.70-3.22)
Oklahoma	Other acute ischemic heart diseases (I24)	5324	25.20 (24.44-25.99)	4130	18.52 (17.90-19.15)	2156	8.95 (8.56-9.35)
Oregon	Meningococcal infection (A39)	16	2.37 (1.45-3.88)	12	3.12 (1.76-5.52)	12	2.80 (1.58-4.96)
South Carolina	Other acute ischemic heart diseases (I24)	796	3.43 (3.20-3.69)	998	3.67 (3.44-3.91)	1356	4.37 (4.13-4.62)
South Dakota	Influenza (J09-J11)	102	5.07 (4.17-6.17)	78	4.18 (3.35-5.23)	91	4.57 (3.72-5.63)
Utah	Events of undetermined intent (Y10-Y34, Y87.2, Y89.9)	889	5.65 (5.28-6.04)	1472	7.44 (7.06-7.84)	875	4.00 (3.74-4.28)
Utah	Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (R00-R99)	2275	2.60 (2.49-2.71)	3645	3.72 (3.60-3.84)	3427	2.97 (2.87-3.07)
Vermont	Hyperplasia of prostate (N40)	12	2.78 (1.57-4.90)	15	2.94 (1.77-4.89)	19	3.24 (2.06-5.08)
Vermont	Influenza (J09-J11)	38	2.80 (2.03-3.85)	36	2.86 (2.06-3.97)	33	2.28 (1.62-3.21)
Virginia	Other acute ischemic heart diseases (I24)	2419	6.21 (5.95-6.48)	2699	6.14 (5.89-6.39)	2592	5.19 (4.98-5.41)
Virginia	Pneumoconioses and chemical effects (J60-J66, J68)	332	2.62 (2.35-2.93)	271	2.51 (2.22-2.84)	286	2.31 (2.05-2.60)

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West Virginia	Pneumoconioses and chemical effects (J60-J66, J68)	557	12.90 (11.82-14.07)	414	12.08 (10.93-13.35)	338	9.36 (8.38-10.45)
Wyoming	Influenza (J09-J11)	34	3.45 (2.46-4.83)	19	2.13 (1.36-3.34)	38	3.52 (2.56-4.84)
Wyoming	Intentional self-harm (suicide) by discharge of firearms (X72-X74)	331	2.24 (2.01-2.49)	330	2.19 (1.97-2.44)	440	2.65 (2.42-2.91)

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Table 2. Extreme outliers, by state, 1999-2013.

		1999-2003		2004-2008		2009-2013	
State	Cause of Death	Deaths	RR	Deaths	RR	Deaths	RR
Alaska	Water, air and space, and other and unspecified transport accidents and their sequelae (V90-V99, Y85)	186	**9.19 (7.95-10.63)**	124	**6.09 (5.10-7.27)**	129	**6.09 (5.12-7.25)**
Alaska	Discharge of firearms, undetermined intent (Y22-Y24)	19	**6.68 (4.25-10.51)**	<10		27	**8.30 (5.67-12.15)**
District of Columbia	Human immunodeficiency virus (HIV) disease (B20-B24)	1221	**8.49 (8.02-8.99)**	1015	**8.97 (8.43-9.55)**	536	4.41 (4.05-4.80)
District of Columbia	Assault (homicide) by discharge of firearms (U01.4, X93-X95)	756	**5.92 (5.51-6.36)**	650	4.24 (3.96-4.54)	381	2.50 (2.26-2.77)
District of Columbia	Assault (homicide) (U01-U02, X85-Y09, Y87.1)	990	**5.01 (4.71-5.34)**	827	4.74 (4.39-5.13)	535	2.49 (2.29-2.72)
District of Columbia	Hypertensive heart disease (I11)	1375	**5.44 (5.16-5.73)**	140	**5.16 (4.37-6.09)**	852	2.87 (2.69-3.07)
District of Columbia	Atherosclerotic cardiovascular disease, so described (I25.0)	2794	4.06 (3.91-4.21)	2797	**5.06 (4.88-5.25)**	2338	3.96 (3.80-4.13)
Iowa	Other and unspecified acute lower respiratory infections (J22, U04)	17	2.76 (1.70-4.46)	16	**5.32 (3.23-8.77)**	<10	
Kansas	Other and unspecified acute lower respiratory infections (J22, U04)	58	**10.87 (8.30-14.23)**	17	**6.09 (3.74-9.89)**	<10	
Louisiana	Syphilis (A50-A53)	13	**9.23 (5.26-16.19)**	<10		16	**9.29 (5.58-15.45)**
Maryland	Events of undetermined intent (Y10-Y34, Y87.2, Y89.9)	3144	**7.37 (7.10-7.65)**	3405	**6.99 (6.74-7.24)**	2990	**5.88 (5.66-6.11)**
Maryland	Syphilis (A50-A53)	<10		10	**5.65 (2.99-10.65)**	<10	
Massachusetts	Events of undetermined intent (Y10-Y34, Y87.2, Y89.9)	2762	**5.54 (5.33-5.77)**	950	1.71 (1.61-1.83)	429	0.75
Nebraska	Other and unspecified acute lower respiratory infections (J22, U04)	24	**6.72 (4.47-10.11)**	20	**9.92 (6.33-15.54)**	<10	
Oklahoma	Other acute ischemic heart diseases (I24)	5324	**25.20 (24.44-25.99)**	4130	**18.52 (17.90-19.15)**	2156	**8.95 (8.56-9.35)**
Rhode Island	Events of undetermined intent (Y10-Y34, Y87.2, Y89.9)	425	**5.24 (4.76-5.77)**	271	3.01 (2.67-3.40)	60	0.65
South Dakota	Influenza (J09-J11)	102	**5.07 (4.17-6.17)**	78	4.18 (3.35-5.23)	91	4.57 (3.72-5.62)

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Utah	Events of undetermined intent (Y10-Y34, Y87.2, Y89.9)	889	**5.65 (5.28-6.04)**	1472	**7.44 (7.06-7.84)**	875	4.00 (3.74-4.28)
Vermont	Other nutritional deficiencies (E50-E64)	11	4.77 (2.63-8.63)	<10		27	**12.59 (8.59-18.46)**
Virginia	Other acute ischemic heart diseases (I24)	2419	**6.21 (5.95-6.48)**	2699	**6.14 (5.89-6.39)**	2592	**5.19 (4.98-5.41)**
West Virginia	Pneumoconioses and chemical effects (J60-J66, J68)	557	**12.90 (11.82-14.07)**	414	**12.08 (10.93-13.35)**	338	**9.36 (8.38-10.45)**

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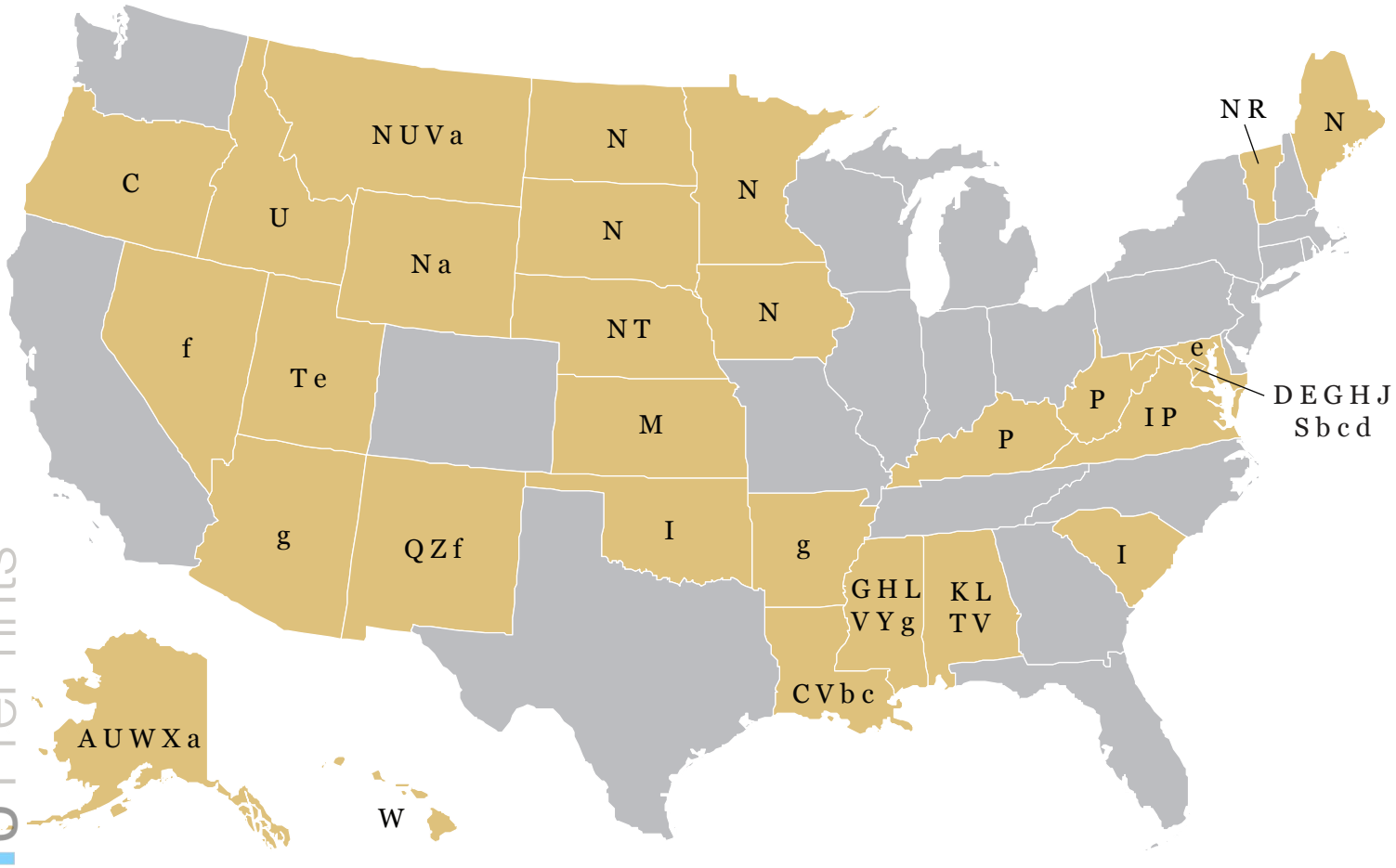
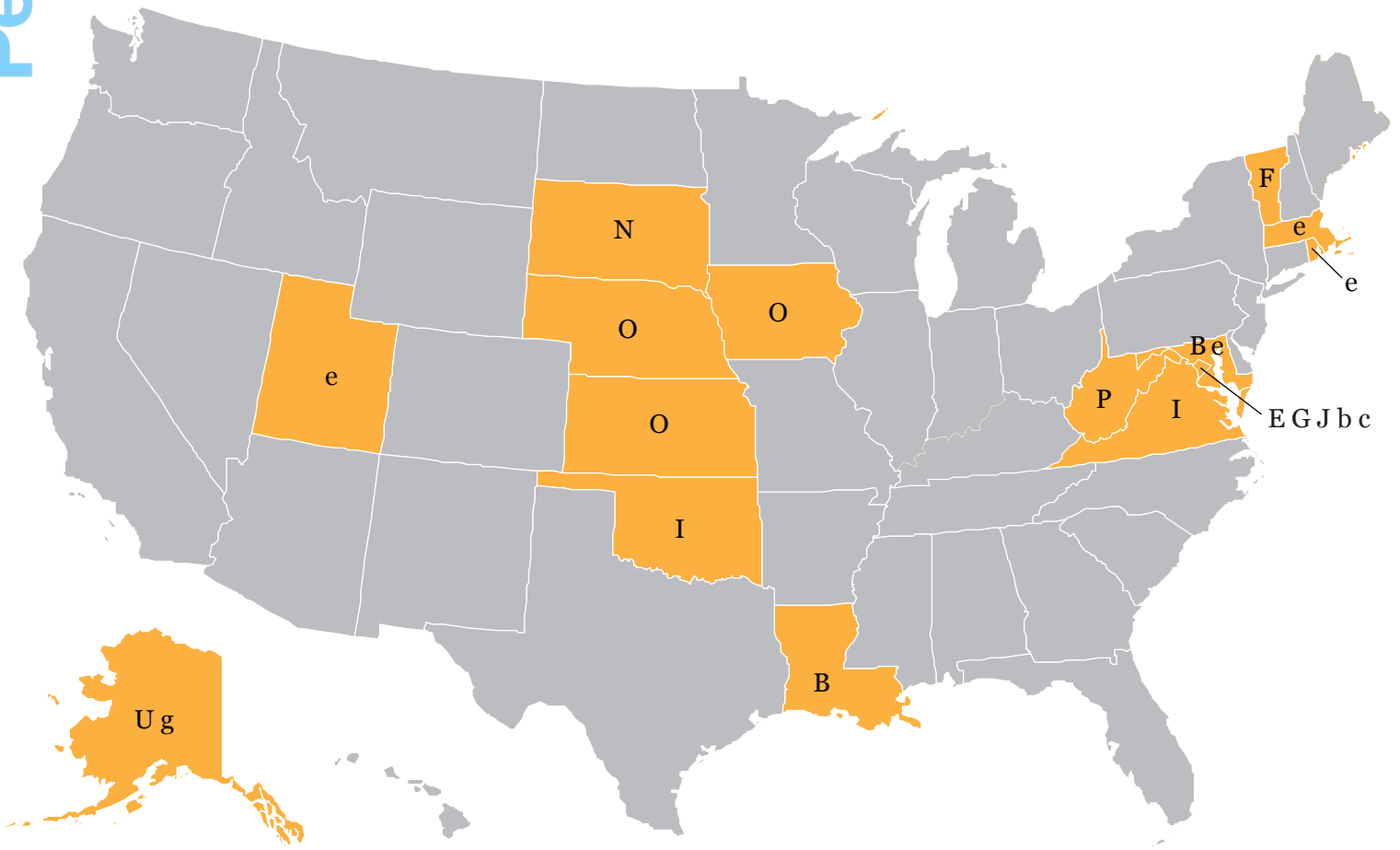


(a)



(b)

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A. Tuberculosis (A16-A19)
B. Syphilis (A50-A53)
C. Meningococcal infection (A39)
D. Viral hepatitis (B15-B19)
E. Human immunodeficiency virus (HIV) disease (B20-B24)
F. Other nutritional deficiences (E50-E64)
G. Hypertensive heart disease (I11)
H. Hypertensive heart and renal disease (I13)
I. Other acute ischemic heart diseases (I24)
J. Atherosclerotic cardiovascular disease, so described (I25.0)
K. Other heart diseases (I26-I51)
L. Heart failure (I50)
M. Atherosclerosis (I70)
N. Influenza (J09-J11)
O. Other and unspecified acute lower respiratory infections (J22, U04)
P. Pneumoconioses and chemical effects (J60-J66, J68)
Q. Alcoholic liver disease (K70)
R. Hyperplasia of prostate (N40)
S. Pregnancy, childbirth and the puerperium (O00-O99)
T. Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (R00-R99)
U. Water, air and space, and other and unspecified transport accidents and their sequelae (V90-V99, Y85)
V. Accidental discharge of firearms (W32-W34)
W. Accidental drowning and submersion (W65-W74)
X. Other and unspecified nontransport accidents and their sequelae (W20-W31,W35-W64,W75-W99,X10-X39,X50-X59,Y86)
Y. Accidental exposure to smoke, fire and flames (X00-X09)
Z. Accidental poisoning and exposure to noxious substances (X40-X49)
a. Intentional self-harm (suicide) by discharge of firearms (X72-X74)
b. Assault (homicide) (U01-U02,X85-Y09,Y87.1)
c. Assault (homicide) by discharge of firearms (U01.4,X93-X95)
d. Assault (homicide) by other and unspecified means and their sequelae (U01.0-U01.3,U01.5-U01.9,U02,X85-X92,X96-Y09,Y87.1)
e. Events of undetermined intent (Y10-Y34,Y87.2,Y89.9)
f. Legal intervention (Y35,Y89.0)
g. Discharge of firearms, undetermined intent (Y22-Y24)

Figure 1 (a). Persistent outliers among causes of death, by state, 1999-2013. These are the causes of death from the CDC 113 Cause List with at least double the national rate in each of the periods 1999-2003, 2004-2008, and 2009-2013. (b) Extreme outliers among causes of death, by state, 1999-2013. These are the causes of death with at least five times the national rate in at least one of the same periods.