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Christmas and New Year as risk factors for death

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ABSTRACT

This paper poses three questions: (1) Does mortality from natural causes spike around Christmas and New Year? (2) If so, does this spike exist for all major disease groups or only specialized groups? (3) If twin holiday spikes exist, need this imply that Christmas and New Year are risk factors for death? To answer these questions, we used all official U.S. death certificates, 1979–2004 ($n = 57{,}451{,}944$) in various hospital settings to examine daily mortality levels around Christmas and New Year. We measured the Christmas increase by comparing observed deaths with expected deaths in the week starting on Christmas. The New Year increase was measured similarly. The expected number of deaths was determined by locally weighted regression, given the null hypothesis that mortality is affected by seasons and trend but not by holidays. On Christmas and New Year, mortality from natural causes spikes in dead-on-arrival (DOA) and emergency department (ED) settings. There are more DOA/ED deaths on 12/25, 12/26, and 1/1 than on any other day. In contrast, deaths in non-DOA/ED settings display no holiday spikes. For DOA/ED settings, there are holiday spikes for each of the top five disease groups (circulatory diseases; neoplasms; respiratory diseases; endocrine/nutritional/metabolic diseases; digestive diseases). For all settings combined, there are holiday spikes for most major disease groups and for all demographic groups, except children. In the two weeks starting with Christmas, there is an excess of 42,325 deaths from natural causes above and beyond the normal winter increase. Christmas and New Year appear to be risk factors for deaths from many diseases. We tested nine possible explanations for these risk factors, but further research is needed.

Introduction

A recent study in this journal found that the level of deliberate self harm fluctuated significantly around Christmas and New Year (Bergen & Hawton, 2007). Similarly, other studies have found significant fluctuations in the number of homicides (Bridges, 2004) and motor vehicle accidents (National Highway Traffic Safety Administration, 2009) around these holidays. However, although many studies have examined the effect of Christmas and New Year on *external* causes of death (like suicide, homicide, and accidents), few have examined the effect of these holidays on *natural* causes of death (Phillips, Jarvinen, Abramson, & Phillips, 2004). This omission seems significant because natural causes account for 93% of all mortality, while external causes account for only 7% (National Center for Health Statistics, 1994).

These considerations raise several important questions: (1) Is there a spike in deaths from natural causes around Christmas and New Year? (2) If so, does this spike exist for all major disease groups, or just for some specialized groups? (3) If there are twin holiday spikes, does this imply that Christmas and New Year are risk factors for death?

There are reasons to suspect the existence of these holiday spikes in deaths from natural causes because medical care may worsen around the holidays. First, the number of physicians (as well as nurses and other health care professionals) may *decrease* at this time because many want to suspend work during the holidays (Keatinge & Donaldson, 2005; Sachs, 2002). Second, the number of patients may *increase* at this time, especially in the Emergency Department (ED) (Salazar, Corbella, Sánchez, Argimón, & Escarrabill, 2002; Zheng, Muscatello, & Chan, 2007).

These medical concerns have been assessed with non-comprehensive studies that focused on cardiac diseases and/or small, geographically non-representative samples (Keatinge & Donaldson, 2005; Kloner, Poole, & Perritt, 1999; Milne, 2005; Rouse, 1999; Zheng et al., 2007). An earlier study of cardiac diseases (Phillips et al., 2004) found a double spike in deaths at Christmas and at New Year. As Phillips et al. were the first to note, there are more cardiac deaths on and around these two holidays

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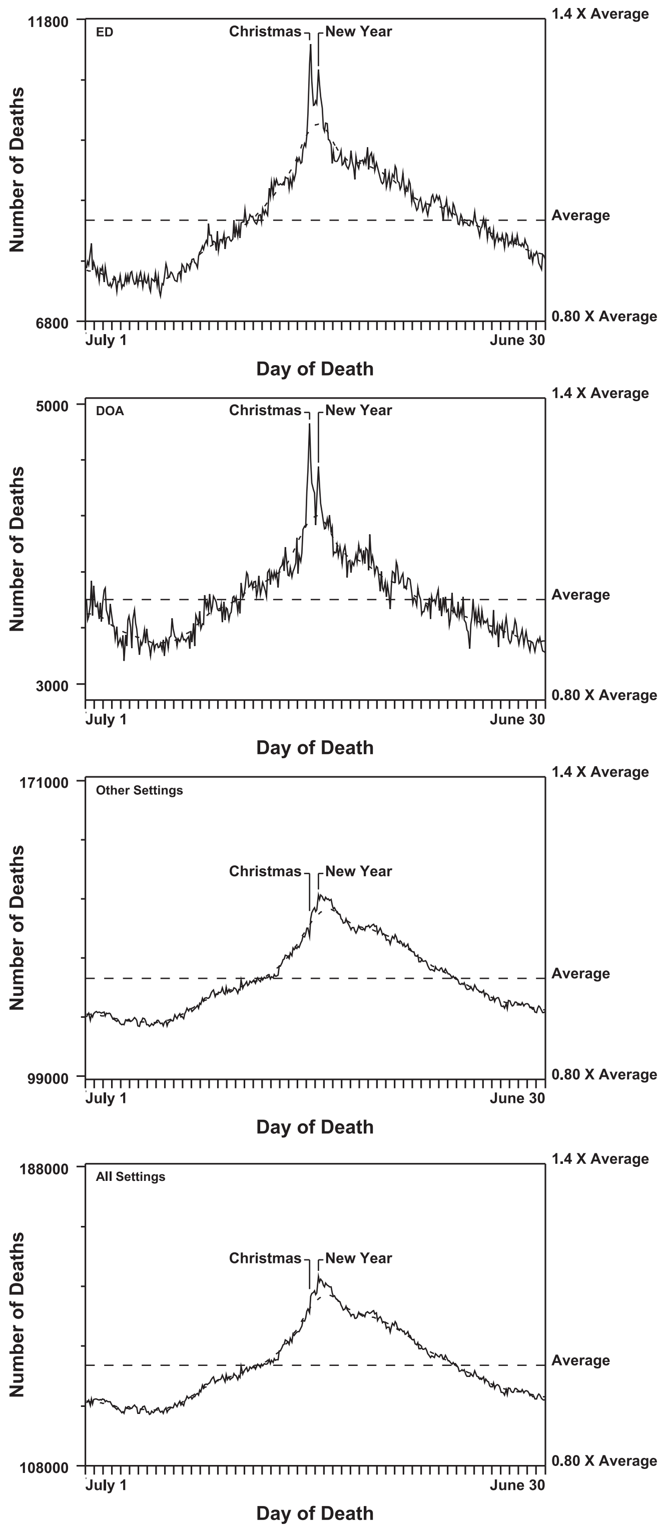

Fig. 1. U.S. Deaths from Natural Causes in Various Settings, for Each Day of the Year, 1979–2004. To facilitate comparison, all panels are plotted to the same ratio scale; e.g., the highest value on the *y*-axis is 1.4 times the average mortality level for the panel. For each Panel, the solid line indicates the observed number of deaths for each day of the year, summed over the study period (e.g., there were 11,602 ED deaths on Christmas for 1979 + 1980 + … + 2004). The dotted LOESS regression line (Dataplot, 2001; Ruckstuhl et al., 2001; Simonoff, 1996) indicates the expected number of deaths for each day, given trend, seasonal fluctuations and the null hypothesis that mortality is unaffected by the holidays. Because so many deaths are examined, the standard error (Altman, Machin, Bryant, & Gardner, 2000) for each daily count is small. Consequently, the number of deaths during Christmas week and during New Year week is many standard errors above the number expected under the null hypothesis.

The computerized death certificate does not distinguish between deaths in the ED and deaths in hospital outpatient settings. However, federal probability surveys of ED and outpatient departments (NCHS, 2007) indicate that death in outpatient departments is exceptionally rare. Therefore, because almost all deaths in ED/outpatient settings occur in the ED, we term these "ED deaths." The ICD codes for natural causes are 001–800 (ICD-9), A00–R99 (ICD-10) (ICD9, 1995; ICD10, 2006).

Number of Excess Deaths Observed for Each Holiday Spike and for Each Setting		
	Christmas holiday effect	New Year holiday effect
ED	4890.1	2638.9
DOA	1809.5	671.3
All Other Settings	8480	22562

than at any other time of the year. The cause of these cardiac holiday spikes is under debate and is sometimes ascribed to psychological stress, patients' delay in seeking treatment, and/or reduced quality of medical care (Kloner, 2004; Kloner et al., 1999; Milne, 2005; Phillips et al., 2004).

In this paper, we sought to determine whether there are holiday mortality spikes for (1) every major disease group and/or (2) every demographic group. Following earlier research, we focused initially on ED deaths but also examined deaths in other settings.

Methods

We examined all official computerized death certificates for the United States ($n = 57{,}451{,}944$) (Mortality detail file, 1979–2004). Our dataset starts on 1/1/1979 (when the 9th Revision of the International Classification of Diseases (ICD) began) and ends on 12/31/2004 (the latest date for which exact date of death is available).

We initially examined deaths from all natural causes combined, and then examined separately the five most common disease groups, i.e., diseases of the circulatory system; neoplasms; diseases of the respiratory system; endocrine, nutritional, and metabolic diseases; and diseases of the digestive system (National Center for Health Statistics). Each cause group examined, together with its ICD codes, is listed in the Figure and Table legends. In some analyses, we examined not only the primary cause of death but also secondary causes; this information is available from 1983 onwards. Hence, analyses examining secondary causes of death cover 1983–2004.

We focused initially on mortality in the emergency department (ED) because earlier studies found that this site is unusually crowded during the holidays (Hoot & Aronsky, 2008; Salazar et al., 2002; Zheng et al., 2007). Overcrowded EDs can result in ambulance diversion (Hoot & Aronsky, 2008) and can delay arrival at the ED. These delays can increase the number of patients who are "dead-on-arrival" (DOA). Therefore, in addition to examining ED deaths, we also examined those which are DOA.

In one analysis, we examined non-injury-related conditions requiring immediate attention: cardiac arrest, respiratory arrest, and coma. Henceforth, we term these "triage level 1" conditions (CAEP, 2002; McCaig & Burt, 2004). We assumed that these conditions would show particularly large holiday spikes if ED crowding and ambulance diversion were associated with these spikes.

Following Phillips et al. we fitted a locally weighted polynomial regression (LOESS) line to daily mortality, from 1/1/1979 through 12/31/2004 (Dataplot, 2001; Ruckstuhl, Jacobson, Field, & Dodd, 2001; Simonoff, 1996). Phillips et al. determined that a six-week "bandwidth" was appropriate for this LOESS analysis; we used the same bandwidth in our analysis. This standard non-parametric procedure makes minimal distributional assumptions and allowed us to correct for seasonality and trend (e.g., winter increases in mortality and downward secular trends). Thus, the LOESS procedure enabled us to determine whether deaths increase around the holidays, after correction for seasonality and trend.

We defined the Christmas effect as:

$$C = \frac{\text{Observed number of deaths in the week starting on Christmas } (12/25 - 12/31)}{\text{Expected number of deaths in the week starting on Christmas } (12/25 - 12/31)}$$

where the expected number was determined by the LOESS procedure.

Similarly, we defined the New Year effect as:

$$N = \frac{\text{Observed number of deaths in the week starting on New Year } (1/1 - 1/7)}{\text{Expected number of deaths in the week starting on New Year } (1/1 - 1/7)}$$

Thus, e.g., a New Year effect of 1.05 indicates there are 5% more deaths during New Year week than would be expected after correction for seasonality and trend.

We calculated the holiday effects for all Christmas and New Year periods between July 1, 1979 and June 30, 2004, with one exception. ICD codes were revised on 1/1/1999 (when ICD10 replaced ICD9). To avoid distortions arising from this change, we did not examine holiday mortality during the ICD transition period: July 1, 1998 to June 30, 1999.

Following official recommendations (NCHS) and previous practice (Phillips & Carstensen, 1986; Phillips, Christenfeld, & Glynn, 1998; Phillips, Christenfeld, & Ryan, 1999) we calculated standard errors (Altman, Machin, Bryant, & Gardner, 2000) and significance levels, even though we examined complete counts, not samples. As in previous work, the study design allowed examination of numbers of deaths, rather than rates.

Results

Fig. 1A displays daily observed and expected ED mortality levels from all natural causes combined. ED mortality displays distinct spikes around Christmas and New Year: there are more ED deaths on Christmas, the day after Christmas, and New Year's Day than on any other day of the year. In the week starting with Christmas (henceforth "Christmas week"), 78,441 deaths are observed versus 73,550.9 expected [$C = 78{,}441/73{,}550.9 = 1.066$ (1.059–1.074)]. Similarly, in the week starting with New Year (henceforth "New Year week"), 73,973 deaths are observed versus 71,334.1 expected [$N = 73{,}973/71{,}334.1 = 1.037$ (1.030–1.045)]. Thus, ED deaths from natural causes spike around Christmas and New Year, above and beyond the general winter increase in mortality.

These findings also hold for DOA deaths (Fig. 1B). Once again there are two holiday spikes, with the largest associated with Christmas [$C = 31{,}520/29{,}710.5 = 1.061$ (1.049–1.073); $N = 32{,}159/31{,}487.7 = 1.021$ (1.010–1.033)].

In contrast, deaths in all other settings do not display two distinct holiday spikes (Fig. 1C). Instead, these deaths display a small, broadly diffused excess that starts just after Christmas and extends for more than a week past New Year [$C = 1{,}010{,}343/1001{,}863 = 1.008$ (1.007–1.010); $N = 1{,}028{,}618/1006{,}056 = 1.022$ (1.020–1.024)]. The sharp DOA/ED spike around Christmas is partially counterbalanced by a Christmas drop in mortality in non-DOA/ED settings. However, for all settings combined, there are excess deaths during the Christmas–New Year season (Fig. 1D).

Fig. 2 provides a magnified view of mortality levels during the Christmas–New Year season. DOA and ED mortality display distinct holiday spikes, while mortality in other settings shows a small, long-lasting, diffused spike. Because the double holiday spike is mainly evident for DOA/ED settings, we focus on these settings in the remainder of this paper.

Figs. 1 and 2 reveal holiday spikes for all years combined. These spikes are also evident when one examines each year separately: there is a DOA/ED Christmas spike in every year ($P < .000001$; $x = 25$; $n = 25$; binomial test), and a New Year spike in all years except one ($P < .000001$; $x = 24$; $n = 25$; binomial test).

The preceding Figures examined all natural causes of death combined. Fig. 3 focuses instead on two minor causes of death known to spike at New Year — substance abuse and external causes of death (e.g., accidents, homicides, and suicides) (Ahrens, 2007; CDC, 1991; CDC, 2004). Both causes of death display visually distinct and statistically significant DOA/ED mortality spikes during New Year week. These causes also display visually distinct, although statistically insignificant, DOA/ED mortality spikes during Christmas week. In addition, these causes display statistically significant spikes in other settings for both Christmas week and New Year week (Fig. 3C and D; see Figure legend for data).

To investigate the influence of substance abuse and external causes of death, we considered two categories of DOA/ED decedents whose primary cause of death was natural: (A) Those with death certificates that listed substance abuse and/or external causes as *secondary* causes of death; (B) those with death certificates that did *not* list substance abuse and/or external causes as *secondary*. The holiday spikes for "group A" are not significantly larger than the holiday spikes for "group B": For group A, $C = 1.015$ (0.975–1.057) versus $C = 1.068$ (1.061–1.075) for group B; for group A, $N = 1.076$ (1.033–1.119) versus $N = 1.035$ (1.028–1.041) for group B. We return to these findings when examining alternative explanations for the holiday spikes.

Fig. 4 displays DOA/ED mortality levels for each major disease group during the holiday season. For every disease group, DOA/ED mortality is significantly elevated in Christmas week. For every disease group except neoplasms, DOA/ED mortality is significantly elevated in New Year week (see Table 2 for data). For many disease groups, two distinct holiday spikes are evident.

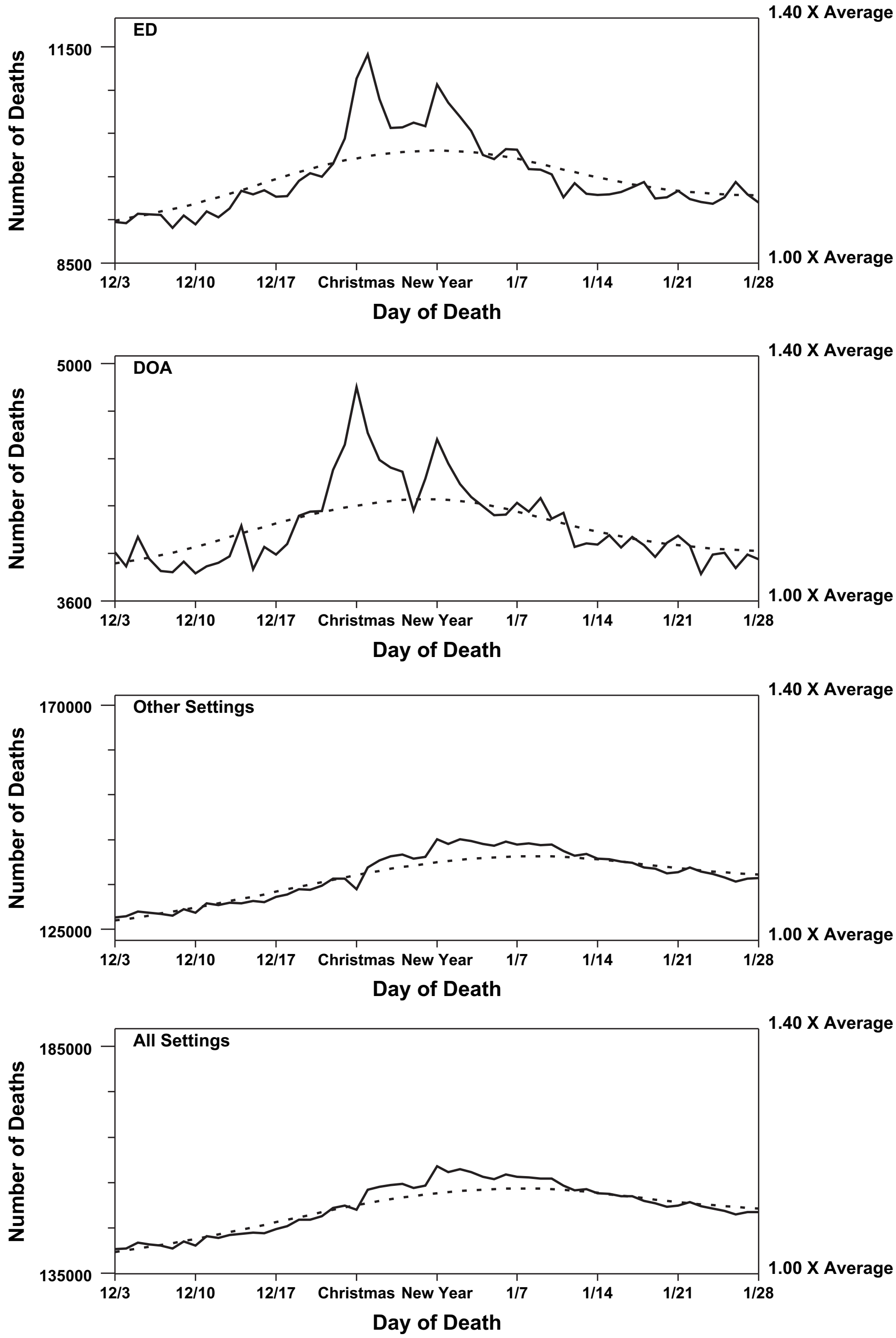

Fig. 2. Daily U.S. Deaths from Natural Causes in Various Settings, for the Winter Holiday Period, 1979–2004. To facilitate comparison, all panels are plotted to the same ratio scale; e.g., the highest value on the *y*-axis is 1.4 times the average mortality level for the panel. In this Figure, the term "average" used to designate limits to the *y*-axis refers to the yearly average, rather than to the average for the winter holiday period. See Fig. 1 legend and Methods section for further details.

Trzeciak and Rivers found that ED overcrowding has worsened over time (2003). We assumed that the holidays spikes would increase over time if these spikes were associated with overcrowded EDs. Table 1 shows that the size of the New Year effect increases over time for each of the five major disease groups analyzed: $P = (1/2)^5 = 0.03$. Similar but slightly weaker results hold for Christmas.

We also examined DOA/ED decedents whose conditions required immediate attention (triage level 1). We assumed that these conditions would show particularly large holiday spikes if these spikes were associated with ED overcrowding. Fig. 5 shows that the spike is larger for triage level 1 conditions on Christmas day: 18.5% (9.3–28.2%) for Panel A versus 12.5% (10.7–14.3%) for Panel B. More strikingly, the spike is significantly larger for triage level 1 conditions on the day after Christmas: 29.2% (19.6–39.4%) for Panel A versus 12.2% (10.5–14.0%) for Panel B. Finally, the spike is larger for triage level 1 conditions on New Year's day: 12.2% (3.3–21.6%) for Panel A versus 8.7% (7.0–10.5%) for Panel B.

Table 2 examines the major disease groups in DOA/ED settings, in other settings, and in all settings combined. For each of the five disease groups, the Christmas spike is larger in DOA/ED settings than in other settings ($P = .03 = 1/32$; $x = 5$; $n = 5$; binomial test). Similarly, for each of the five disease groups, the

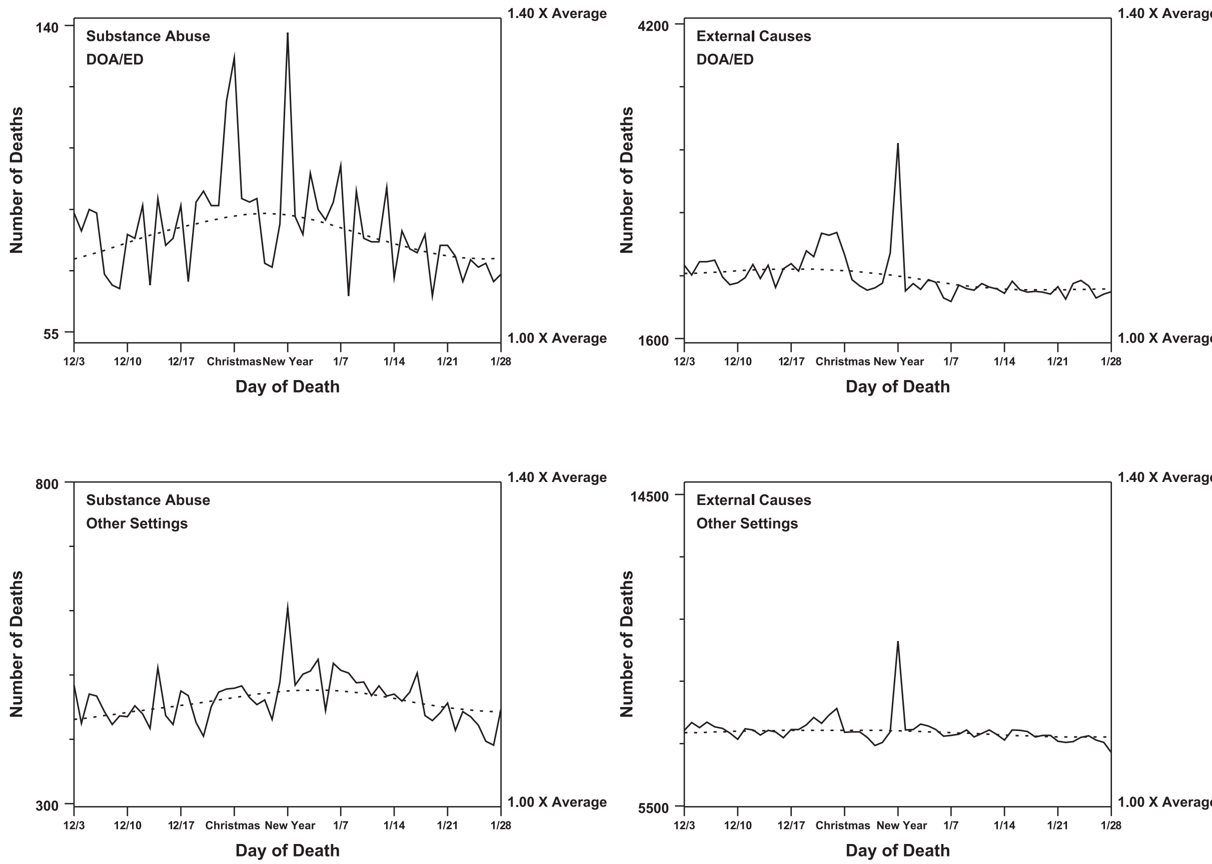

Fig. 3. Daily U.S. Deaths from Substance Abuse and from External Causes in Various Settings, for the Winter Holiday Period, 1979–2004. For substance abuse, ICD codes are 291,303–304,305.0,305.2–305.9 (ICD-9),F10–F16,F18–F19 (ICD-10) (ICD9, 1995; ICD10, 2006). Thus, the term "substance abuse" here excludes the abuse of tobacco (305.1; F17). For external causes (e.g., accidents, homicides, suicides) ICD codes are E800–E999 (ICD-9), V01–Y98 (ICD-10).

	DOA/ED	Other Settings
Christmas Spike		
Substance Abuse	1.045 (0.967–1.129)	0.994 (0.961–1.028)
External Causes	0.984 (0.969–1.000)	0.978 (0.970–0.986)
New Year Spike		
Substance Abuse	1.114 (1.031–1.201)	1.070 (1.035–1.105)
External Causes	1.046 (1.030–1.063)	1.054 (1.046–1.063)

New Year spike is larger in DOA/ED settings than in other settings.

The holiday excess for DOA/ED cancer, evident in Fig. 4, is not evident for cancer in all settings combined (Table 2). In fact, in Christmas week, for all settings combined, cancer deaths *decline* slightly but significantly [$C = 0.992$ (0.988–0.996)] and do not differ significantly from expected in New Year week [$N = 1.001$ (0.997–1.005)]. Similarly, for digestive diseases, the Christmas excess for DOA/ED settings, evident in Fig. 4, is not evident for all settings combined [$C = 1.001$ (0.992–1.011)]. However, for most major disease groups, there are excess deaths during the Christmas and New Year weeks, for all settings combined.

Table 3 examines all diseases combined in DOA/ED settings, in other settings, and in all settings combined, for Christmas, New Year, and other federal holidays. Only Christmas and New Year display a mortality spike in both DOA/ED settings and in all settings combined.

We sought to determine whether the Christmas–New Year spikes pervaded all major demographic groups or were concentrated in a few. As in Figs. 1 and 2, Table 4 examines all natural causes combined. This table displays the holiday spikes for 13 major demographic groups, for DOA/ED settings, for other settings, and for all settings combined. For 12 of the 13 demographic groups, the Christmas spike is significantly larger in DOA/ED than in other settings. For 12 of the 13 groups, the New Year spike is larger in DOA/ED than in other settings. For 10 of the 13 groups, there are excess deaths during Christmas week in all settings combined. For 13 of the 13 groups, there are excess deaths during New Year week in all settings combined.

Discussion

DOA and ED mortality from natural causes display distinct spikes around Christmas and New Year. There are more DOA and ED deaths on Christmas, the day after Christmas, and New Year than on any other day of the year. In contrast, deaths in non-DOA/ED settings do not display two, distinct holiday spikes. Instead, these deaths display a small, diffused spike that starts just after Christmas and extends for more than a week past New Year. For each of the top five disease groups, there are excess holiday deaths in DOA/ED settings (although this excess is not statistically significant for neoplasms). For most disease groups, there are excess holiday deaths in all settings combined. For DOA/ED settings, nearly all demographic groups examined display holiday mortality spikes. During our study period, there was an excess of 42,325 deaths from natural causes in the two weeks starting with Christmas.

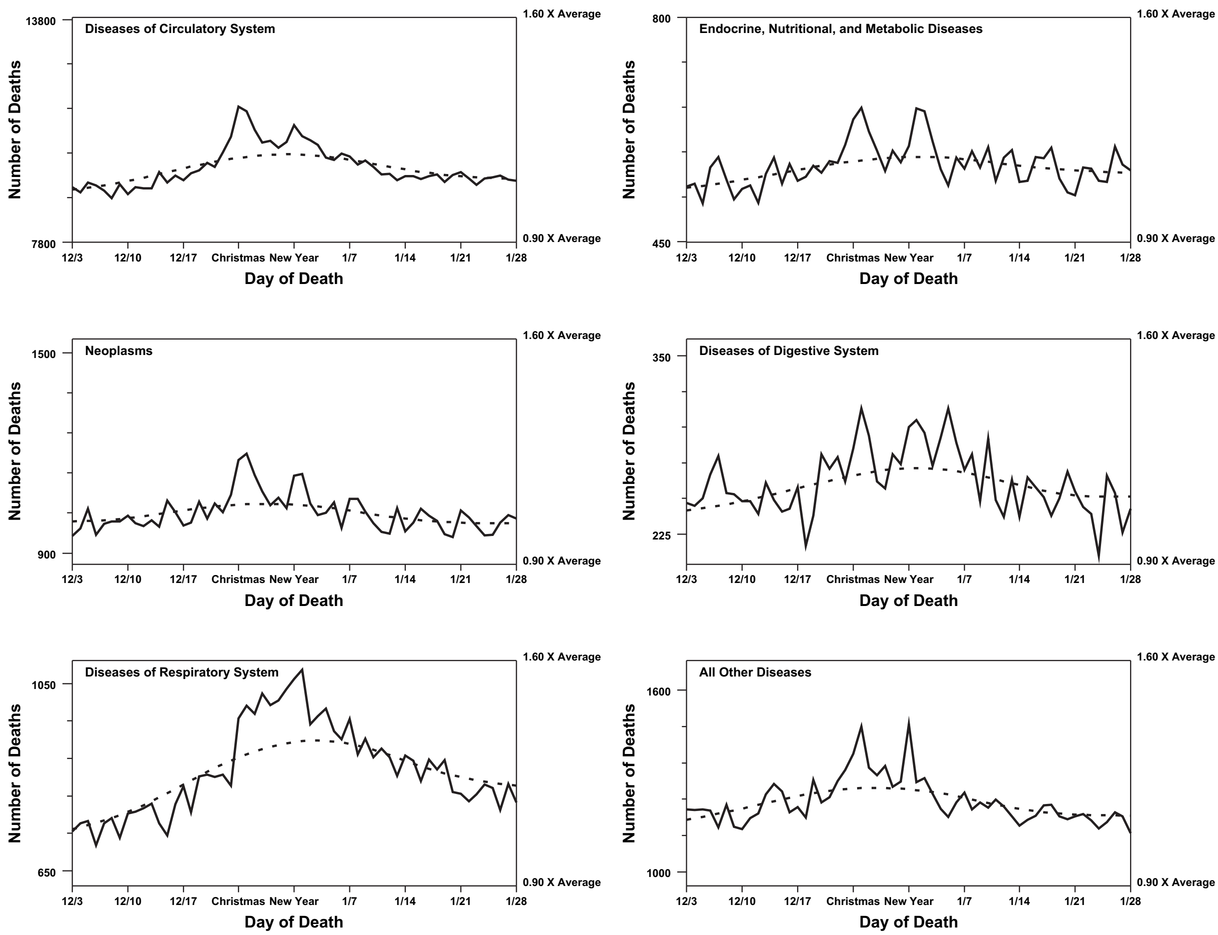

Fig. 4. Daily U.S. Deaths in the Five Most Common Disease Groups, and from all Remaining Diseases, in DOA/ED Settings, for the Winter Holiday Period, 1979–2004. ICD codes for these disease groups are: Diseases of circulatory system: 390–459 (ICD-9), I00–I99 (ICD-10); Neoplasms: 140–199,200–239 (ICD-9), C00–D48 (ICD-10); Diseases of respiratory system: 460–519 (ICD-9), J00–J99 (ICD-10); Endocrine, nutritional, and metabolic diseases: 240–279 (ICD-9), E00–E90 (ICD-10); Diseases of digestive system: 520–579 (ICD-9), K00–K93 (ICD-10); All remaining diseases: 001–139, 280–389, 580–676,680–799 (ICD-9), A00–B99, D50–D89, F00–H95, L00–R99 (ICD-10) (ICD9, 1995; ICD10, 2006).

Alternative explanations

Several potential explanations for these findings are described below.

Some explanations seem plausible but cannot be empirically assessed with our data:

Table 1
The Yearly Trend for the Christmas and the New Year Mortality Spikes, for the Most Common Disease Groups, in DOA/ED Settings, 1979–2004.

	b	*t*
Christmas Spike		
Diseases of Circulatory System	−0.0001	−0.0791
Neoplasms	0.0022	1.5291
Diseases of Respiratory System	0.0014	0.7181
Endocrine, Nutritional, and Metabolic Diseases	0.0019	0.7955
Diseases of Digestive System	0.0032	1.1327
All Other Diseases	0.0003	0.2849
New Year Spike		
Diseases of Circulatory System	0	1.1882
Neoplasms	0.0012	0.8218
Diseases of Respiratory System	0.0036	1.8162
Endocrine, Nutritional, and Metabolic Diseases	0.0028	1.1943
Diseases of Digestive System	0.0001	0.05
All Other Diseases	0.0002	0.1251

(1) Psychological stress levels may change around Christmas and New Year. However, we have no nationwide, detailed, rigorous measures of the size, nature, and timing of these putative changes. In addition, we know of no unambiguous evidence that heightened psychological stresses can cause abrupt, sharp increases in mortality from a wide range of diseases and for a wide range of demographic groups.

Three explanations seem plausible and supported by the data, but can explain only some of our findings:

(2) There are holiday spikes for many causes of death and for many demographic groups. Thus, it is plausible that overcrowded EDs during the holidays, which would affect a wide range of diseases and people, may help to generate our findings. We tested this "overcrowding hypothesis" in two ways:
  (A) ED crowding has increased over time (Trzeciak & Rivers, 2003). Similarly, we found that the size of the Christmas–New Year effects have also increased over time (Table 1). Thus, the evidence in Table 1 is consistent with the "overcrowded ED" hypothesis.
  (B) If the holiday spikes are associated with ED overcrowding, DOA/ED decedents with conditions requiring immediate attention (triage level 1) should show particularly large holiday spikes. The evidence in Fig. 5 is consistent with this

Table 2
The Size of the Christmas and the New Year Mortality Spikes, for the Most Common Disease Groups, in Various Settings, United States, 1979–2004.

	DOA/ED	Other Settings	All Settings
Christmas Spike			
Diseases of Circulatory System	1.063 (1.055–1.070)	1.023 (1.021–1.026)	1.023 (1.021–1.026)
Neoplasms	1.055 (1.032–1.079)	0.992 (0.988–0.996)	0.992 (0.988–0.996)
Diseases of Respiratory System	1.105 (1.080–1.131)	1.023 (1.017–1.029)	1.023 (1.017–1.029)
Endocrine, Nutritional, and Metabolic Diseases	1.049 (1.019–1.080)	1.014 (1.004–1.024)	1.014 (1.004–1.024)
Diseases of Digestive System	1.046 (1.001–1.092)	1.001 (0.992–1.011)	1.001 (0.992–1.011)
All Other Diseases	1.058 (1.037–1.079)	1.008 (1.003–1.013)	1.012 (1.006–1.017)
New Year Spike			
Diseases of Circulatory System	1.030 (1.023–1.038)	1.026 (1.023–1.029)	1.026 (1.023–1.029)
Neoplasms	1.021 (0.998–1.044)	1.001 (0.997–1.005)	1.001 (0.997–1.005)
Diseases of Respiratory System	1.075 (1.050–1.101)	1.068 (1.062–1.074)	1.068 (1.062–1.074)
Endocrine, Nutritional, and Metabolic Diseases	1.033 (1.002–1.065)	1.023 (1.013–1.034)	1.023 (1.013–1.034)
Diseases of Digestive System	1.103 (1.054–1.152)	1.018 (1.008–1.028)	1.019 (1.009–1.029)
All Other Diseases	1.017 (0.996–1.038)	1.019 (1.014–1.025)	1.020 (1.014–1.025)

expectation and thus provides additional support for the "overcrowded ED" hypothesis.

However, this evidence may also be consistent with other possible holiday-related changes in medical care. For example, medical professionals may increasingly suspend work during the holidays and/or patients may increasingly avoid hospital visits during the holidays. Thus, the evidence in Table 1 and in Fig. 5 provides only inconclusive support for the "overcrowded ED" hypothesis.

(3) Some terminally ill patients may prefer to be home for the holidays so they can be with family, rather than in the hospital as inpatients. Given this "displacement" hypothesis, there should be no net change in deaths around the holidays: the *increase* in DOA/ED deaths should be accompanied by a significant *decrease* in inpatient deaths (Phillips et al., 2004). This hypothesis seems plausible for cancer patients: As noted earlier (Table 2), DOA/ED cancer deaths spike around Christmas and New Year; however, for all settings combined, there is no holiday spike for cancer. This "displacement" hypothesis, while plausible for cancer, is not plausible for most other major causes, because these other causes of death display holiday spikes in all settings combined, not only in DOA/ED settings.

(4) Perhaps the holiday spikes result from increased travel around winter holidays. However, most decedents die in their home counties (92.6% in our dataset), and these non-travelers produce significant holiday spikes: $C = 1.057$ (1.050–1.064); $N = 1.041$ (1.034–1.048).

Two explanations may be plausible, but we have found no evidence to support them.

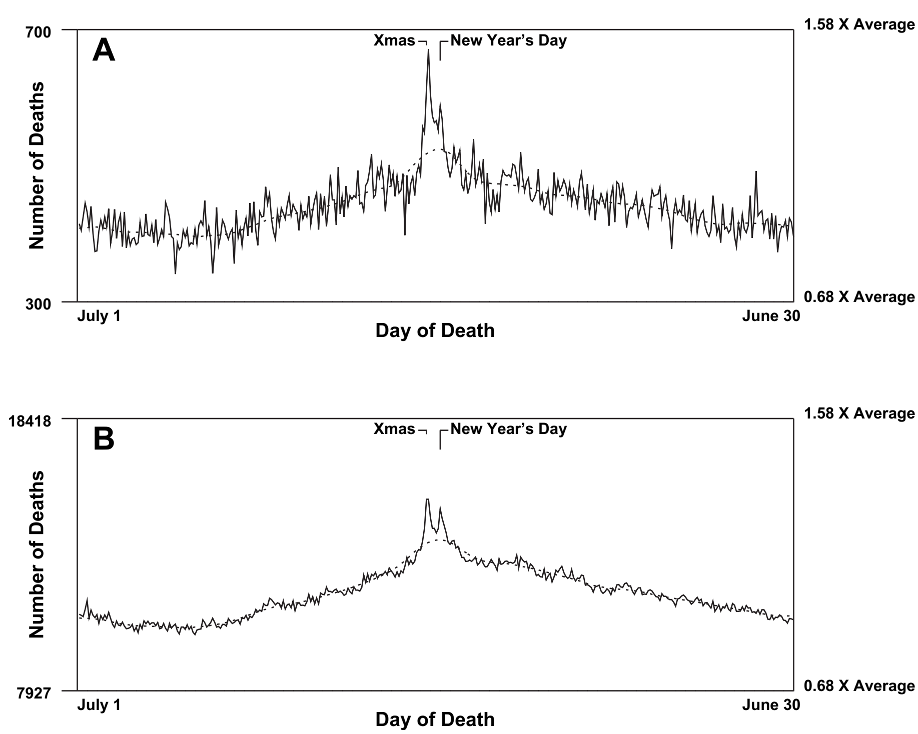

Fig. 5. Daily U.S. Deaths from Triage Level 1 Conditions (Panel A) and Daily U.S. Deaths from all Remaining Diseases (Panel B), in DOA/ED Settings, 1979–2004. To facilitate comparison, Panels A and B are plotted to the same ratio scale; e.g., the highest value on the *y*-axis is 1.58 times the average mortality level for the panel. ICD codes for conditions in Panel A are: Cardiac Arrest: 427.5 (ICD-9), I46.0 (ICD-10); Respiratory Arrest: 799.1 (ICD-9), R09.2 (ICD-10); Coma: 070.0, 070.2, 070.3, 070.4, 070.6, 250.2, 251.0, 572.2, 779.2, (ICD-9), B15.0, B16.0, B16.2, B19.0, E03.5, E10.0, E11.0, E12.0, E13.0, E14.0, E15.0 (ICD-10) (ICD9, 1995; ICD10, 2006).

Table 3
The Size of Mortality Spikes for Federal Holidays, in Various Settings, United States, 1979–2004.

All Natural Causes of Death Combined			
Federal Holidays	DOA/ED	Other Settings	All Settings
New Year's Day	1.032 (1.026–1.038)	1.024 (1.022–1.026)	1.025 (1.023–1.027)
Presidents Day	1.000 (0.994–1.006)	1.004 (1.002–1.006)	1.004 (1.002–1.006)
Memorial Day	1.008 (1.001–1.014)	0.994 (0.992–0.996)	0.995 (0.993–0.997)
Independence Day	1.021 (1.014–1.028)	0.999 (0.997–1.001)	1.001 (0.999–1.003)
Labor Day	1.010 (1.003–1.017)	0.996 (0.994–0.998)	0.997 (0.995–0.999)
Thanksgiving	1.025 (1.018–1.031)	0.990 (0.988–0.992)	0.993 (0.991–0.995)
Christmas	1.063 (1.057–1.070)	1.008 (1.006–1.010)	1.013 (1.011–1.015)

We calculated the above holiday effects in the same way as the Christmas and New Year effects. We restricted attention to federal holidays that have been nationally recognized and celebrated annually during our study period (1979–2004). Thus, e.g., we excluded Martin Luther King Jr. Day because this holiday did not begin until 1983 and was not celebrated by all 50 states until 2000 (Romero, 2010).

(5) Perhaps some persons are able to postpone death briefly in order to reach symbolic occasions(Phillips & Feldman, 1973; Young & Hade, 2004). Given this "postponement hypothesis," the Christmas–New Year spikes should be preceded by a compensatory drop in deaths. However, no such drops are evident.
(6) Perhaps decedents with unknown death dates are preferentially coded as dying on January 1. However, this putative process cannot account for excess deaths around Christmas, nor for elevated mortality on the days following New Year.

At present, three additional explanations seem implausible:

(7) Influenza and pneumonia are risk factors for deaths from other diseases (Crighton, Elliott, Moineddin, Kanaroglou, & Upshur, 2007; Fleming, Cross, & Pannell, 2005; Madjid, Naghavi, Litovsky, & Casscells, 2003). Thus, holiday spikes in influenza/pneumonia might produce holiday spikes in other diseases. However, the yearly size of the influenza/pneumonia holiday spike is not significantly correlated with the yearly size of the holiday spike for other diseases [for Christmas, $r = 0.326$ ($t = 1.655$; $P = .112$, two-tailed test); for New Year, $r = 0.140$ ($t = 0.678$; $P = .505$, two-tailed test)]. Furthermore, it is difficult to understand how the "influenza/pneumonia" hypothesis could explain two distinct, holiday spikes.
(8) It is hard to understand how cold weather could produce two distinct spikes, one at Christmas and one at New Year. In addition, seasonal fluctuations in mortality have been corrected for in our statistical design.
(9) It is unlikely that holiday spikes in substance abuse or external causes produce the holiday spikes from natural causes. The mortality spikes for diseases do not diminish significantly when one restricts analysis to death certificates with no mention of substance abuse or external causes (see comparison of "group A" and "group B" in Results). It is true that substance abuse and external causes may not always be documented on the death certificate. However, we have no evidence that correcting for this failed documentation would alter our findings.

In sum, a combination of processes could produce the holiday mortality spikes uncovered in our study. Some of these processes are plausible but undocumented; some are empirically supported but this support is inconclusive; finally, some are empirically supported but can explain only a portion of the findings. Thus, at present, only preliminary conclusions are appropriate: Christmas and New Year seem to be risk factors for death, but the mechanisms underlying these risk factors are currently unknown.

Table 4
The Size of the Christmas and the New Year Mortality Spikes, for Major Demographic Groups, in Various Settings, United States, 1979–2004.

	DOA/ED	Other Settings	All Settings
Christmas Spike			
Male	1.052 (1.044–1.060)	1.002 (0.999–1.005)	1.008 (1.005–1.011)
Female	1.082 (1.072–1.092)	1.014 (1.011–1.016)	1.018 (1.016–1.021)
Black	1.057 (1.042–1.072)	1.007 (1.001–1.013)	1.014 (1.008–1.019)
White	1.065 (1.058–1.072)	1.009 (1.007–1.011)	1.014 (1.012–1.016)
Age 0–19 years	1.003 (0.970–1.036)	0.977 (0.963–0.992)	0.981 (0.968–0.994)
Age 20–39 years	1.071 (1.039–1.104)	1.008 (0.995–1.022)	1.017 (1.005–1.029)
Age 40–59 years	1.047 (1.033–1.061)	0.996 (0.990–1.002)	1.005 (0.999–1.010)
Age 60–79 years	1.066 (1.057–1.076)	1.003 (1.000–1.007)	1.010 (1.007–1.013)
Age 80 years and up	1.072 (1.060–1.085)	1.016 (1.013–1.019)	1.019 (1.016–1.022)
<12 years of education	1.065 (1.052–1.079)	1.010 (1.005–1.014)	1.015 (1.011–1.019)
12 years of education	1.064 (1.052–1.077)	1.005 (1.001–1.009)	1.011 (1.007–1.015)
13–16 years of education	1.058 (1.040–1.077)	0.999 (0.994–1.005)	1.005 (1.000–1.011)
17 + years of education	1.034 (1.000–1.074)	0.992 (0.980–1.004)	0.995 (0.984–1.007)
New Year Spike			
Male	1.034 (1.026–1.042)	1.020 (1.017–1.023)	1.022 (1.019–1.025)
Female	1.029 (1.019–1.039)	1.023 (1.021–1.026)	1.024 (1.021–1.026)
Black	1.034 (1.019–1.050)	1.014 (1.008–1.020)	1.017 (1.011–1.022)
White	1.031 (1.024–1.038)	1.023 (1.021–1.025)	1.024 (1.022–1.026)
Age 0–19 years	1.031 (0.998–1.064)	1.010 (0.996–1.025)	1.013 (1.000–1.026)
Age 20–39 years	1.051 (1.020–1.084)	1.015 (1.002–1.028)	1.020 (1.008–1.032)
Age 40–59 years	1.031 (1.017–1.045)	1.019 (1.013–1.025)	1.022 (1.016–1.027)
Age 60–79 years	1.030 (1.021–1.039)	1.017 (1.014–1.020)	1.018 (1.016–1.021)
Age 80 years and up	1.031 (1.019–1.044)	1.027 (1.024–1.031)	1.028 (1.025–1.031)
<12 years of education	1.043 (1.030–1.056)	1.032 (1.028–1.036)	1.034 (1.030–1.038)
12 years of education	1.027 (1.014–1.040)	1.030 (1.026–1.034)	1.030 (1.026–1.034)
13–16 years of education	1.041 (1.023–1.060)	1.030 (1.024–1.036)	1.031 (1.026–1.037)
17 + years of education	1.035 (0.996–1.075)	1.028 (1.015–1.040)	1.027 (1.015–1.039)

Advantages and limitations

Our nationwide, multi-decadal dataset was well-suited to discover these risk factors but cannot provide much detail per case and thus cannot easily explain them. Thus, to explicate these risk factors, different types of datasets are needed, e.g., datasets comprising fewer cases and providing more detail per case.

Future research

This paper has uncovered previously unknown phenomena but has left numerous questions unanswered: (1) Our paper has discovered mortality peaks; are there mortality troughs as well? If so, can the mechanisms generating these troughs also help to explain the peaks? (2) We found peaks for all age groups except for children; does this exception help to illuminate the mechanisms generating the holiday peaks? (3) The holiday effects for cancer and digestive diseases differ from the holiday effects for other disease groups; do these exceptions help to illuminate the mechanisms generating the holiday peaks? (4) Christmas and New Year are the only holidays to show a mortality spike in both DOA/ED settings and in all settings combined; do the unique characteristics of these holidays offer insight into the mechanisms generating the holiday peaks? (5) We have found some evidence suggesting that ED overcrowding is associated with holiday spikes; are there other *non*-holiday occasions when EDs are overcrowded and are these occasions also associated with mortality spikes?

Conclusion

The two weeks starting with Christmas are associated with an excess of 42,325 natural deaths over a 25 year period. This nontrivial loss of life is an important public health concern and warrants further research.

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