Influenza mortality in the United States, 2009: Burden and timing

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150-word abstract

In April 2009, the most recent pandemic of influenza A began. We present the first estimates of pandemic mortality based on the newly-released final data on deaths in 2009. In the aggregate, 2009 was not an unusual year for pneumonia and influenza mortality. Compared to the typical pattern of seasonal flu deaths, pneumonia and influenza age-specific mortality in 2009, as well as influenza-attributable (excess) mortality, skewed much younger. In many age groups, pneumonia and influenza mortality in October and November 2009 broke month-specific records since 1959 when the current series of detail US mortality data began. Mortality in influenza pandemics skews younger than seasonal influenza. This can be explained in part by a protective effect due to antigenic cycling. If older cohorts have been previously exposed to a similar antigen, immune memory can result in lower death rates at older ages.

Abstract

Background

In April 2009, the most recent pandemic of influenza A began. We present the first estimates of pandemic mortality based on the newly-released final data on deaths in 2009 and 2010 in the United States.

Methods

We obtained data on influenza and pneumonia deaths from the National Center for Health Statistics (NCHS). Age- and sex-specific death rates, and age-standardized death rates, were calculated. Using standard Serfling-type methods, excess mortality was calculated separately by age groups.

Results

In the aggregate, 2009 was not an unusual year for pneumonia and influenza mortality. Compared to the typical pattern of seasonal flu deaths, pneumonia and influenza age-specific mortality in 2009, as well as influenza-attributable (excess) mortality, skewed much younger. In many age groups, pneumonia and influenza mortality rates in October and November 2009 broke month-specific records since 1959 when the current series of detail US mortality data began.

Conclusions

Mortality in influenza pandemics skews younger than seasonal influenza. This can be explained in part by a protective effect due to antigenic cycling. When older cohorts have been previously exposed to a similar antigen, immune memory results in lower death rates at older ages. Age-targeted vaccination should be considered in future pandemics.

Introduction

In April 2009, a novel strain of influenza A/H1N1 emerged in Mexico and rapidly spread to the United States [1] and then worldwide. On 11 June 2009, the World Health Organization declared a pandemic [2]. The pandemic would eventually cause an estimated 284,500 deaths, worldwide [3]. Approximately 20% of the US population contracted influenza during the pandemic [4, 5]. Overall, the pandemic case fatality rate was low, and attack rates were higher among children and young adults [6]. The sparing of adults 65 and older is thought to be due to immunity from previous exposure to antigenically-similar H1N1 strains [7–12].

In this article, we analyze final mortality data for the United States which were released in August 2012. This is the first analysis of the complete mortality record of influenza for 2009. Our age- and sex-specific analysis incorporates data from 1959–2010. Pneumonia and influenza deaths are commonly analyzed together [13], and in 2009, there were 53,692 pneumonia and influenza deaths, making this combination the eighth leading cause of death [14]. Age-specific mortality burden estimates, like those presented here, can aid pandemic planning.

Results

Figure 1 plots the age-standardized death rate (ASDR) for pneumonia and influenza for the United States from January 1959 to December 2010. This figure presents the most complete monthly record of pneumonia and influenza ASDR in the US. Considering death rates weighted over all ages, recent influenza pandemics are not especially severe. This is seen clearly in figure 1 for 2009, as well as for the H3N2 "Hong Kong" influenza pandemic of 1968–69. Due to the fall wave of the 2009 H1N1 pandemic, the mortality of the winter 2009–10 influenza season began unusually early [15], creating an atypical wide-and-broad pattern. Calendar year 2003 is the only other recent year with pneumonia and influenza mortality rising so strongly in the fall (in this case, December), which was associated with the emergence of the Fujian strain of influenza A/H3N2 [16]. Other remarkable features of figure 1 are the secular decline of the ASDR for pneumonia and influenza, and the consistency with which male death rates exceed those of females.

Figure 2 presents the distribution of pneumonia and influenza deaths by age group (0, 1–4, 5–9, . . . , 95–99, $\geq$100) and by sex. The solid bars represent calendar year 2009,

and, for comparison, the cross-hatched bars are for the average of 1999–2008. Mortality skewed younger in 2009 compared to the previous 10-year average: the solid bars exceed the hatched bars for all ages 0–69 (to 74 for females). The female histograms skew older than those for males. Although females consistently have lower pneumonia and influenza death rates than males, their longer life expectancy [14] means more females at older ages, and therefore more deaths at older ages.

Figure 3 plots pneumonia and influenza death rates versus age for each month of 2009, separately by sex. This illustrates combined aspects of figure 1 (unusual timing) and figure 2 (younger age distribution). As table 1 details, October–November 2009 is one of the most remarkable periods in the history of pneumonia and influenza mortality since 1959, especially for females. Out of all Octobers, 1959–2010, October 2009 recorded the highest pneumonia and influenza death rate for females in the age span 25–59. This month was less notable for males, although in ages 25–29 and 35-39 they also had a record mortality rate. Likewise, November 2009 recorded record-high pneumonia and influenza death rates: for females, in the age spans 20–34 and 40–59, and for males, 25–29. December 2009, on the other hand, did not experience unusually high mortality rates (figure 1). For Decembers, of the 44 age groups (22 age groups $\times$ 2 sexes), 31 have their record high in 1968, coinciding with the H3N2 "Hong Kong" pandemic [17]. Note that these comparisons refer to mortality rates, not death counts; the latter rise with population growth. Prior to 1959, age $\times$ sex $\times$ cause-of-death monthly data are unavailable, so the October–November record-high death rates are at least 52-year records.

Figure 4 displays the age distribution of influenza-attributable excess mortality as calculated by a Serfling-type regression model of pneumonia and influenza death rates. The age groups and shading follow that of figure 2. Even more so than age-specific mortality (i.e., figure 2), 2009 pandemic excess mortality skews young. Thus, the youngness of the distributions in 2009 (solid) versus 1999–2008 (cross-hatched) reflects the pandemic, and is not an artifact of switching the metric from raw mortality (figure 2) to excess mortality (figure 4).

Table 2 provides calendar year 2009 excess pneumonia and influenza mortality estimates by age group and sex, with the corresponding 95% confidence bounds. Negative excess mortality values indicate that the observed pneumonia and influenza deaths in the age group were less than the age group-specific Serfling baseline. Where the lower bound is negative, it may be interpreted as non-statistically-significant excess mortality. Excess mortality is highest in the age group 55–59 for males and 50–54 for females. For both sexes, there is no significant excess mortality at age 80 and above. Below age 80, two age groups for males (1–4, 60–64), and three for females (0, 70–74, 75–79), were not significant. The ratio of excess mortality to all pneumonia and influenza mortality is comparable to similar ratios in prior work [18].

Discussion

Overall, 2009 had about 2,010 pneumonia and influenza excess deaths. It was not an unusually lethal flu year; the confidence bounds on the total excess deaths include zero (cf. table 2). This should not be taken to mean that the pandemic was not deadly, especially below age 60. The bulk of pneumonia and influenza mortality occurs above age 60, and when the pandemic strain of influenza H1N1 displaced other circulating strains [19], the accompanying rise in pneumonia and influenza mortality took place in age groups with generally low mortality rates. Indeed, the unusual mortality at young ages is a remarkable indication of the specific impact of the pandemic. Moreover, this number should not be regarded as contradicting other estimates of mortality burden [4] since multiplier models (see also [20]) and Serfling-type models represent different approaches.

The public health concern about influenza pandemics stems, above all else, from their potential to kill millions, as in the 1918–19 pandemic [21]. The mortality of the 2009 pandemic was unusual not for its severity but for its timing and age distribution. In terms of the ASDR and overall excess mortality, the 2009 pandemic was not distinguishable from a typical influenza season. The H3N2 ("Hong Kong") pandemic of 1968–69 was, similarly, comparable in ASDR to the previous winter (figure 1). However, in October and November 2009, pneumonia and influenza mortality rates in a number of age groups were the highest for those months since at least 1959. This phenomenon, which occurred exclusively below age 60, was more pronounced for females; the reasons for this are unclear.

Seasonal influenza typically kills with an old-age mortality pattern: the cross-hatched bars (1999–2008 average) of figures 2 and 4 peak at age 80 and above. There were three influenza pandemics in the twentieth century (1918–19, 1957, 1968–69) [22], all of which skewed young [23–28]. The 2009 data confirm this pattern. There is a limited sample from which to draw conclusions, but influenza pandemic mortality consistently skews young. The younger pattern is seen in both 2009 excess mortality (figure 4 and table 2) and age-specific mortality (figure 2, figure 3, and table 1). Our finding is also consistent with earlier work [29]. Excess mortality is calculated relative to a baseline model [30, 31]. Thus, excess mortality estimates may be influenced by timing (phase) as well as severity (amplitude). The age-specific mortality data are not model-based, so the qualitative agreement of younger skew in both modes of analysis suggests that the skew is not an artifact.

After reemergence in 1977, influenza A/H1N1 spread in children and young adults because of its remarkable antigenic similarity to the pre-1957 H1N1 strains [32, 33]. The protective effect of older cohorts having seen this strain before was clear-cut. In the case of 2009, an analogous phenomenon is likely [7, 8]. The relative peak at age 25–29 in 2009 (figure 4) may be an example of original antigenic sin [34–39]. Specifically, persons who were first exposed to influenza during the H1N1-dominant flu seasons of 1978–79, 1983–84, 1986–87, or 1988–89 [40] may have reacted differently than surrounding cohorts. This is somewhat speculative and merits further investigation. The local maximum, for example,

is more pronounced for females, which is not accounted for by the original antigenic sin explanation. Our data do not record prior infection status, so more in-depth exploration would require additional data.

One of the biggest challenges of pandemic preparedness is rapid formulation and manufacture of a strain-specific vaccine [41]. Our analysis suggests that younger ages (30–60, see figure 4) should be prioritized in the event of a pandemic. Excess pneumonia and influenza mortality in 2009 peaked below age 60 for both sexes. The mortality data for 2009 do not provide the last word, but do suggest that age-targeted vaccination is a strategy well worth considering.

Materials and Methods

We obtained data on number of deaths, by cause, from the mortality detail files of the National Center for Health Statistics (NCHS) [42]. Deaths were stratified by age, sex, month, and underlying cause. We extracted data on influenza and pneumonia deaths from January 1959 to December 2010. As shown in table 3, this period spans four revisions of the International Classification of Diseases (ICD 7–10). To ensure comparability, all data were converted to ICD-10 using the published crossover tables [43–45]. Prior to 1959, no detailed mortality data (i.e., simultaneously disaggregated by age, sex, month, and cause) are available. Final mortality data for 2009 and 2010 were released in 2012.

Rates (per 100,000) were calculated using these death counts in the numerator, and exposure data (person-years at risk) from the Human Mortality Database [46] in the denominator. The age-specific exposure data were interpolated to monthly units to match the death counts. Variable days per month (including leap years) were used in the monthly exposure interpolation.

Excess mortality was calculated using standard Serfling-type methods [30, 31] on the monthly death rates described above. Our excess mortality calculation was done separately by age groups, which permits full use of the data, while being collapsible to all-ages in a robust way [47]. We used a Serfling approach similar to that of [18], running regressions of the type:

$$\log\left(\frac{\text{deaths}_{a,s,t}}{\text{exposure}_{a,s,t}}\right) = \beta_0 + \beta_1 t + \beta_2 t^2 + \beta_3 t^3 + \beta_4 t^4 + \beta_5 t^5 + \beta_6 \cos\left(\frac{2\pi t}{12}\right) + \beta_7 \sin\left(\frac{2\pi t}{12}\right)$$

where subscripts a, s, t denote age- and sex-specific models, with monthly time (t) resolution. The model de-trends by a quintic polynomial in time ($t..t^5$), and includes two harmonic (sin, cos) terms; $\beta_0..\beta_7$ are coefficients to be estimated. Ordinary least squares was used; this technique produces comparable results to other approaches [48]. The models establish a baseline by estimating a waveform from the summer troughs (May–October) of pneumonia and influenza mortality. September and October 2009 were excluded from the baseline calculations due to the atypically early circulation of influenza virus during this time period.

Once the coefficients are estimated, a baseline is calculated from the regression equation, exponentiating to restore correct scale. Upper and lower bounds were calculated from the standard error of the prediction equation and the tails of the t-distribution (probability 0.025 in each tail), to create a 95% confidence bound. Excess mortality rates are the observed rates minus the baseline. Excess mortality is calculated as the excess mortality rate multiplied by the exposure. An analogous approach to excess mortality calculation is to use all-cause mortality in lieu of pneumonia and influenza (both as input to the baseline estimation, and as the rates from which the baseline is subtracted), but we chose to emphasize specificity over sensitivity [40]. Analysis was done using IDL version 8.2 (Exelis Visual Information Solutions, Inc., Boulder CO, USA) and Stata version 10.1 (StataCorp LP, College Station TX, USA).

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References

1. Dawood FS, Jain S, Finelli L, Shaw MW, Lindstrom S, et al. (2009) Emergence of a novel swine-origin influenza A (H1N1) virus in humans. New England Journal of Medicine 360: 2605-2615.

2. Chan M (2009). World now at the start of 2009 influenza pandemic: Statement to the press by who director-general. `http://www.who.int/mediacentre/news/statements/2009/h1n1_pandemic_phase6_20090611/`.

3. Dawood FS, Iuliano AD, Reed C, Meltzer MI, Shay DK, et al. (2012) Estimated global mortality associated with the first 12 months of 2009 pandemic influenza A H1N1 virus circulation: A modelling study. Lancet Infectious Diseases 12: 687-695.

4. Shrestha SS, Swerdlow DL, Borse RH, Prabhu VS, Finelli L, et al. (2011) Estimating the burden of 2009 pandemic influenza A (H1N1) in the United States (April 2009–April 2010). Clinical Infectious Diseases 52: S75-S82.

5. Cox CM, Goodin K, Fisher E, Dawood FS, Hamilton JJ, et al. (2011) Prevalence of 2009 pandemic influenza A (H1N1) virus antibodies, Tampa Bay Florida — November–December, 2009. PLoS One 6: e29301.

6. Bautista E, Chotpitayasunondh T, Gao Z, Harper SA, Shaw M, et al. (2010) Clinical aspects of pandemic 2009 influenza A (H1N1) virus infection. New England Journal of Medicine 362: 1708-1719.

7. Hancock K, Veguilla V, Lu X, Zhong W, Butler EN, et al. (2009) Cross-reactive antibody responses to the 2009 pandemic H1N1 influenza virus. New England Journal of Medicine 361: 1945-1952.

8. Xu R, Ekiert DC, Krause JC, Hai R, Crowe JE, et al. (2010) Structural basis of preexisting immunity to the 2009 H1N1 pandemic influenza virus. Science 328: 357-360.

9. Jacobs JH, Archer BN, Baker MG, Cowling BJ, Heffernan RT, et al. (2012) Searching for sharp drops in the incidence of pandemic A/H1N1 influenza by single year of age. PLoS One 7: e42328.

10. Hsu JP, Phoon MC, Koh GCH, Chen MIC, Lee VJ, et al. (2012) Comparison of neutralizing antibody and cell-mediated immune responses to pandemic H1N1 2009 influenza virus before and after H1N1 2009 influenza vaccination of elderly subjects and healthcare workers. International Journal of Infectious Diseases 16: e621-e627.

11. Iorio AM, Bistoni O, Galdiero M, Lepri E, Camilloni B, et al. (2012) Influenza viruses and cross-reactivity in healthy adults: Humoral and cellular immunity induced by seasonal 2007/2008 influenza vaccination against vaccine antigens and 2009 A(H1N1) pandemic influenza virus. Vaccine 30: 1617-1623.

12. O'Donnell CD, Wright A, Vogel LN, Wei CJ, Nabel GJ, et al. (2012) Effect of priming with H1N1 influenza viruses of variable antigenic distances on challenge with 2009 pandemic H1N1 virus. Journal of Virology 86: 8625-8633.

13. Thompson WW, Moore MR, Weintraub E, Cheng PY, Jin X, et al. (2009) Estimating influenza-associated deaths in the United States. American Journal of Public Health 99: S225-S230.

14. Kochanek KD, Xu J, Murphy SL, Miniño AM, Kung HC (2011) Deaths: Final data for 2009. National Vital Statistics Reports 60.

15. Centers for Disease Control and Prevention (2010) Update: Influenza activity — United States, August 30, 2009–January 9, 2010. Morbidity and Mortality Weekly Report 59: 38-43.

16. Centers for Disease Control and Prevention (2010) Experiences with influenza-like illness and attitudes regarding influenza prevention — United States, 2003–04 influenza season. Morbidity and Mortality Weekly Report 53: 1156-1158.

17. Cockburn WC, Delon PJ, Ferreira W (1969) Origin and progress of the 1968–69 Hong Kong influenza epidemic. Bulletin of the World Health Organization 41: 345-348.

18. Simonsen L, Reichert TA, Viboud C, Blackwelder WC, Taylor RJ, et al. (2005) Impact of influenza vaccination on seasonal mortality in the us elderly population. Archives of Internal Medicine 165: 265-272.

19. Palese P, Wang TT (2011) Why do influenza virus subtypes die out? a hypothesis. mBio 2: e00150.

20. Reed C, Angulo FJ, Swerdlow DL, Lipsitch M, Meltzer MI, et al. (2009) Estimates of the prevalence of pandemic (H1N1) 2009, United States, April–July 2009. Emerging Infectious Diseases 15: 2004-2007.

21. Johnson NPAS, Mueller J (2002) Updating the accounts: Global mortality of the 1918–1920 'Spanish' influenza pandemic. Bulletin of the History of Medicine 76: 105-115.

22. Laver WG, Bischofberger N, Webster RG (2000) The origin and control of pandemic influenza. Perspectives in Biology and Medicine 43: 173-192.

23. Palese P (2004) Influenza: Old and new threats. Nature Medicine Supplement 10: S82-S87.

24. Henderson DA, Courtney B, Inglesby TV, Toner E, Nuzzo JB (2009) Public health and medical responses to the 1957–58 influenza pandemic. Biosecurity and Bioterrorism 7: 265-273.

25. Eickhoff TC, editor (1960) The epidemiology of Asian influenza: 1957–1960. Communicable Disease Center, Atlanta: U.S. Department of Health, Education, and Welfare.

26. Viboud C, Grais RF, Lafont BAP, Miller MA, Simonsen L (2005) Multinational impact of the 1968 Hong Kong influenza pandemic: Evidence for a smoldering pandemic. Journal of Infectious Diseases 192: 233-248.

27. Simonsen L, Reichert TA, Miller MA (2004) The virtues of antigenic sin: consequences of pandemic recycling on influenza-associated mortality. International Congress Series 1263: 791-794.

28. Simonsen L, Clarke MJ, Schonberger LB, Arden NH, Cox NJ, et al. (1998) Pandemic versus epidemic influenza mortality: A pattern of changing age distribution. Journal of Infectious Diseases 178: 53-60.

29. Presanis AM, De Angelis D, Hagy A, Reed C, Riley S, et al. (2009) The severity of pandemic H1N1 influenza in the United States, from April to July 2009: A Bayesian analysis. PLoS Medicine 6: e1000207.

30. Eickhoff T, Sherman I, Serfling R (1961) Observations on excess mortality associated with epidemic influenza. Journal of the American Medical Association 176: 776-782.

31. Serfling RE (1963) Methods for current statistical analysis of excess pneumonia-influenza deaths. Public Health Reports 78: 494-506.

32. Nakajima K, Desselberger U, Palese P (1978) Recent human influenza-A (H1N1) viruses are closely related genetically to strains isolated in 1950. Nature 274: 334-339.

33. Webster RG, Bean WJ, Gorman OT, Chambers TM, Kawaoka Y (1992) Evolution and ecology of influenza A viruses. Microbiological Reviews 56: 152-179.

34. Francis T Jr (1960) On the doctrine of original antigenic sin. Proceedings of the American Philosophical Society 104: 572-578.

35. de StGroth SF, Webster RG (1966) Disquisitions on original antigenic sin, i: Evidence in man. Journal of Experimental Medicine 124: 331-345.

36. Welsh RM, Selin LK, Szomolanyi-Tsuda E (2004) Immunological memory to viral infections. Annual Review of Immunology 22: 711-743.

37. Muñoz ET, Deem MW (2005) Epitope analysis for influenza vaccine design. Vaccine 23: 1144-1148.

38. Reichert T, Chowell G, Nishiura H, Christensen R, McCullers J (2010) Does glycosylation as a modifier of original antigenic sin explain the case age distribution and unusual toxicity in pandemic novel H1N1 influenza? BMC Infectious Diseases 10: 5.

39. Pan K (2011) Understanding original antigenic sin in influenza with a dynamical system. PLoS One 6: e23910.

40. Thompson WW, Shay DK, Weintraub E, Brammer L, Cox N, et al. (2003) Mortality associated with influenza and respiratory syncytial virus in the United States. Journal of the American Medical Association 289: 179-186.

41. Robertson JS, Inglis SC (2011) Prospects for controlling future pandemics of influenza. Virus Research 162: 39-46.

42. National Center for Health Statistics (2012) Mortality multiple cause-of-death data files, http://www.cdc.gov/nchs/nvss/mortality_public_use_data.htm. National Center for Health Statistics.

43. Klebba AJ, Dolman AB (1975) Comparability of mortality statistics for the seventh and eighth revisions of the International Classification of Diseases, United States. Vital and Health Statistics 2.

44. Klebba AJ (1980) Estimates of selected comparability ratios based on dual coding of 1976 death certificates by the eighth and ninth revisions of the International Classification of Diseases. Monthly Vital Statistics Report 28.

45. Anderson RN, Miniño AM, Hoyert DL, Rosenberg HM (2001) Comparability of cause of death between ICD–9 and ICD–10: Preliminary estimates. National Vital Statistics Reports 49.

46. Human Mortality Database (accessed October 2012) U.S.A. Complete Data Series: Exposure-to-risk. http://www.mortality.org/.

47. Viboud C, Grais RF, Lafont BAP, Miller MA, Sugaya N, et al. (2005) Reply to Reichert and Christensen. Journal of Infectious Diseases 192: 1860-1862.

48. Thompson WW, Weintraub E, Dhankhar P, Cheng PY, Brammer L, et al. (2009) Estimates of US influenza-associated deaths made using four different methods. Influenza and Other Respiratory Viruses 3: 37-49.

Figure Legends

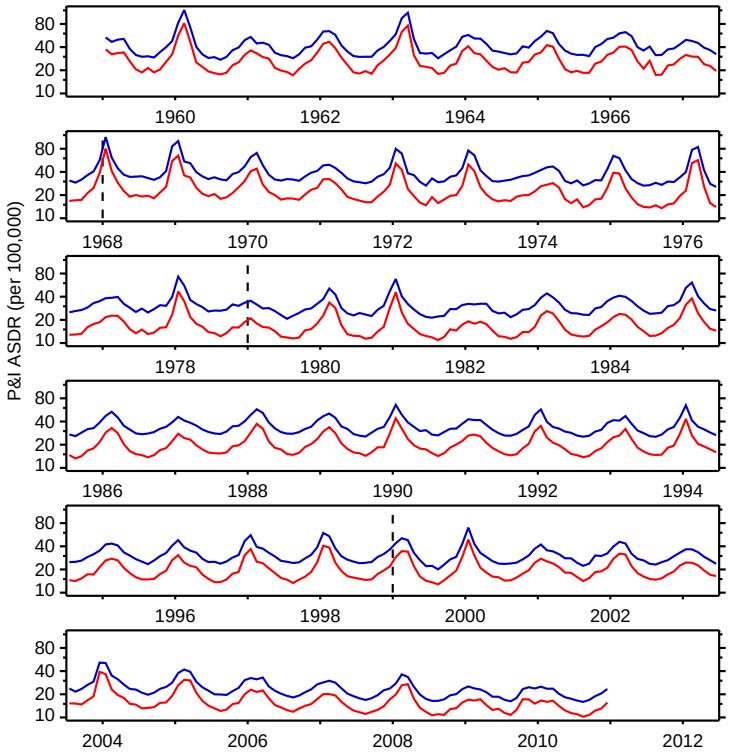

Figure 1. Monthly age-standardized death rate (ASDR) for pneumonia and influenza, United States, 1959–2010. Males blue, females red. Dashed lines denote boundaries of ICD regimes, but data are adjusted for ICD changes.

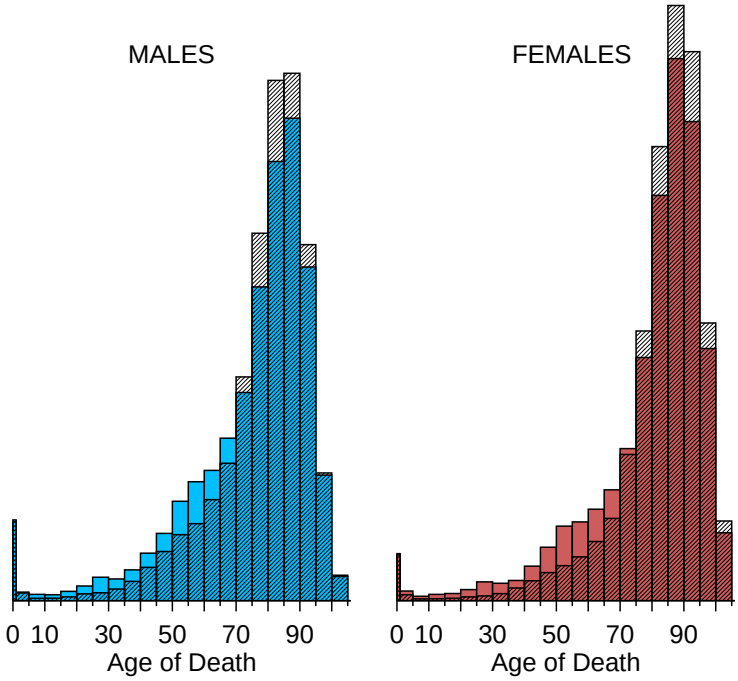

Figure 2. Histograms of deaths by age, pneumonia and influenza (ICD10 J10–J18), United States. 2009 is solid; 1999–2008 average, cross-hatched.

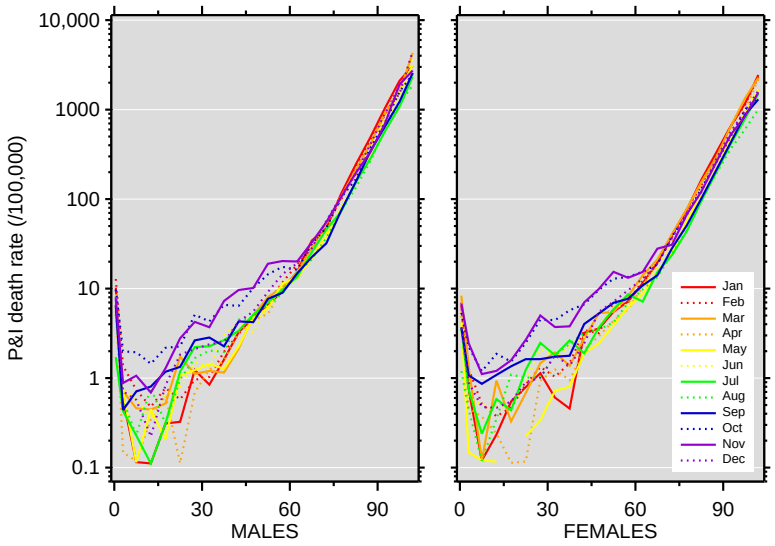

Figure 3. Pneumonia and influenza (P&I) age-mortality profiles by month. Vertical axis: P&I death rate per 100,000; horizontal axis: age. The gap in May for females reflects that there were no deaths in the 15–19 age group.

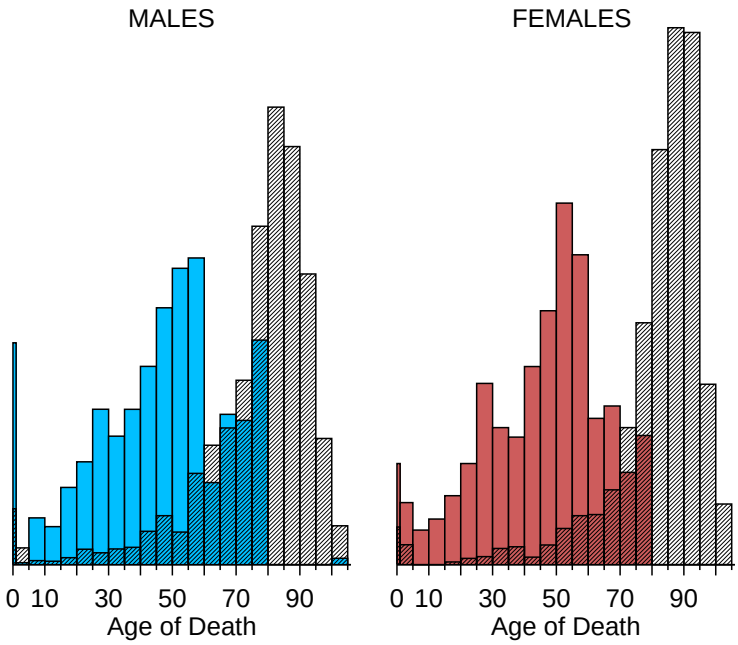

Figure 4. Histograms of excess deaths by age, pneumonia and influenza, United States. 2009 is solid; 1999–2008 average, cross-hatched.

Tables

Table 1. October and November record-high P&I mortality rates

	Males				Females			
Age	Octobers		Novembers		Octobers		Novembers	
Group	Rate	Year	Rate	Year	Rate	Year	Rate	Year
0	175.98	1968	217.28	1959	145.57	1960	175.27	1968
1–4	12.56	1959	14.53	1960	12.18	1959	12.90	1960
5–9	2.44	1964	2.45	1969	2.78	1959	2.90	1964
10–14	1.53	1965	2.21	1962	1.88	1965	2.50	1962
15–19	2.27	1970	2.49	1959	2.19	1967	1.95	1969
20–24	2.60	1966	3.61	1961	3.20	1959	2.67	2009
25–29	5.11	2009	4.25	2009	4.51	2009	5.01	2009
30–34	4.42	1969	5.00	1965	4.44	2009	3.72	2009
35–39	6.58	2009	7.30	1968	5.73	2009	4.21	1959
40–44	9.05	1964	9.77	1968	6.67	2009	7.01	2009
45–49	13.69	1964	13.79	1969	9.69	2009	9.91	2009
50–54	18.23	1965	19.74	1968	12.91	2009	15.40	2009
55–59	24.71	1965	26.54	1968	13.49	2009	13.21	2009
60–64	37.55	1963	43.56	1968	21.00	1961	20.35	1960
65–69	62.33	1961	65.43	1964	28.07	1962	30.58	1959
70–74	108.52	1964	113.23	1968	50.47	1965	51.30	1965
75–79	206.63	1965	212.16	1965	111.15	1962	118.76	1961
80–84	371.10	1965	378.92	1972	226.37	1964	244.23	1961
85–89	780.87	1987	800.08	1991	458.96	1961	497.82	1961
90–94	1431.85	2001	1520.08	1995	891.89	1988	1032.25	1962
95–99	2588.80	1989	2926.11	2003	1763.49	1961	1755.16	1991
≥100	5638.09	2002	5232.87	2001	3380.34	2001	3406.07	1966

Record-high mortality rates (per 100,000) for 22 age groups in Octobers and Novembers, 1959–2010. Out of 88 age × sex × month combinations, 17 record highs occur in 2009, all below age 60.

Table 2. Excess mortality estimates

	Males		Females	
Age Group	Excess Mortality	(lower bound, upper bound)	Excess Mortality	(lower bound, upper bound)
0	38.8	(19.5, 55.2)	16.3	(−0.3, 30.2)
1–4	5.3	(−9.8, 17.2)	40.5	(27.7, 50.1)
5–9	39.5	(32.1, 44.8)	29.0	(22.6, 33.7)
10–14	32.3	(23.9, 38.4)	39.5	(29.2, 46.9)
15–19	61.9	(52.6, 68.6)	53.1	(44.7, 59.2)
20–24	81.6	(63.6, 95.0)	77.5	(64.2, 87.5)
25–29	126.0	(103.8, 143.8)	136.3	(116.4, 151.2)
30–34	106.1	(85.9, 122.7)	105.6	(85.5, 121.5)
35–39	129.0	(102.6, 151.5)	102.2	(80.8, 120.0)
40–44	165.2	(127.5, 198.2)	162.6	(121.5, 196.5)
45–49	214.2	(167.9, 255.7)	213.5	(161.5, 258.7)
50–54	258.3	(192.7, 317.7)	296.3	(225.8, 357.8)
55–59	254.1	(186.9, 316.3)	254.1	(185.9, 314.8)
60–64	70.9	(−11.6, 147.6)	133.8	(62.5, 199.4)
65–69	130.8	(44.7, 211.6)	120.3	(39.1, 195.6)
70–74	101.1	(−4.5, 200.8)	93.5	(−5.4, 186.2)
75–79	197.1	(48.2, 337.9)	117.7	(−30.9, 257.5)
80–84	−10.7	(−211.2, 180.2)	−8.6	(−244.3, 214.5)
85–89	−229.2	(−481.6, 10.0)	−242.4	(−581.8, 78.1)
90–94	−259.1	(−485.2, −47.6)	−210.9	(−531.6, 90.8)
95–99	−8.0	(−134.0, 105.4)	−290.2	(−544.2, −56.8)
≥100	2.9	(−52.5, 47.0)	−78.1	(−207.1, 32.4)
Total	1508.1	(−138.5, 3018)	1161.6	(−878.2, 3025.8)

Excess pneumonia and influenza mortality estimates (deaths) and 95% confidence bounds for calendar year 2009.

Table 3. ICD codes for Pneumonia & Influenza

Years	Causes used as Pneumonia & Influenza
1959–1967 (ICD 7)	480–483, 490–493
1968–1978 (ICD 8)	470–474 , 480–486
1979–1998 (ICD 9)	480–487
1999–2010 (ICD 10)	J10–J18

Codes from the four revisions of the ICD (International Classification of Diseases) merged to the combined cause "pneumonia and influenza."