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Seasonal Influenza Infections and Cardiovascular Disease Mortality

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Abstract

IMPORTANCE—Cardiovascular deaths and influenza epidemics peak during winter in temperate regions.

OBJECTIVES—To quantify the temporal association between population increases in seasonal influenza infections and mortality due to cardiovascular causes and to test if influenza incidence indicators are predictive of cardiovascular mortality during the influenza season.

DESIGN, SETTING, AND PARTICIPANTS—Time-series analysis of vital statistics records and emergency department visits in New York City, among cardiovascular deaths that occurred during influenza seasons between January 1, 2006, and December 31, 2012. The 2009 novel influenza A(H1N1) pandemic period was excluded from temporal analyses.

EXPOSURES—Emergency department visits for influenza-like illness, grouped by age (≥0 years and ≥65 years) and scaled by laboratory surveillance data for viral types and subtypes, in the previous 28 days.

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Author Contributions: Dr Nguyen had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Nguyen, Yang, Shaman, Kinney.
Acquisition, analysis, or interpretation of data: Nguyen, Ito, Matte.
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Administrative, technical, or material support: Ito, Matte.
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MAIN OUTCOMES AND MEASURES—Mortality due to cardiovascular disease, ischemic heart disease, and myocardial infarction.

RESULTS—Among adults 65 years and older, who accounted for 83.0% (73 363 deaths) of nonpandemic cardiovascular mortality during influenza seasons, seasonal average influenza incidence was correlated year to year with excess cardiovascular mortality (Pearson correlation coefficients ≥0.75, $P \leq .05$ for 4 different influenza indicators). In daily time-series analyses using 4 different influenza metrics, interquartile range increases in influenza incidence during the previous 21 days were associated with an increase between 2.3% (95% CI, 0.7%–3.9%) and 6.3% (95% CI, 3.7%–8.9%) for cardiovascular disease mortality and between 2.4% (95% CI, 1.1%–3.6%) and 6.9% (95% CI, 4.0%–9.9%) for ischemic heart disease mortality among adults 65 years and older. The associations were most acute and strongest for myocardial infarction mortality, with each interquartile range increase in influenza incidence during the previous 14 days associated with mortality increases between 5.8% (95% CI, 2.5%–9.1%) and 13.1% (95% CI, 5.3%–20.9%). Out-of-sample prediction of cardiovascular mortality among adults 65 years and older during the 2009–2010 influenza season yielded average estimates with 94.0% accuracy using 4 different influenza metrics.

CONCLUSIONS AND RELEVANCE—Emergency department visits for influenza-like illness were associated with and predictive of cardiovascular disease mortality. Retrospective estimation of influenza-attributable cardiovascular mortality burden combined with accurate and reliable influenza forecasts could predict the timing and burden of seasonal increases in cardiovascular mortality.

Cardiovascular disease (CVD) accounts for approximately 25% of the mortality in the United States and 30% globally.[1,2] In addition to the traditional risk factors (eg, hypertension, smoking, diabetes mellitus, obesity, physical inactivity, and abnormal serum lipid levels),[3,4] influenza infection has long been thought to directly contribute to cardiovascular morbidity and mortality.[5] Various infective agents are involved in the development and progression of atherosclerosis,[5] and influenza virus RNA has been found in human atherosclerotic plaques.[6] Experimental and observational reports find that influenza infections can cause direct cardiac changes (ranging in severity from asymptomatic electrocardiogram abnormalities,[7–9] to myopericarditis,[8,10] to acute myocardial infarction[6,8]), can elicit systemic effects via inflammatory cytokines and prothrombotic changes,[3,11] and are associated with population-level increases in cardiovascular hospitalizations[12] and mortality.[13–15]

In temperate regions, influenza epidemics recur annually in winter and coincide with surges in CVD mortality.[13,15] This regular timing can inform proactive public health mitigation and response efforts. Municipal seasonal influenza peak timing can be forecasted many weeks in advance.[16,17] Given the association between seasonal influenza and CVD mortality,[13–15] influenza forecasts (if accurate and reliable) might also inform the timing and burden of wintertime increases in cardiovascular mortality.

In this study, we quantified the temporal association between seasonal influenza infections and CVD mortality using several measures of influenza incidence. We also evaluated whether influenza incidence was predictive of CVD mortality during the 2009–2010

influenza season, an atypical influenza season dominated by the novel influenza A(H1N1) pdm09 virus strain,[18] which first emerged in April 2009.

Methods

Study Period

We restricted this study to influenza seasons (week 40 through week 20 of the following year) between January 1, 2006, and December 31, 2012. Weeks 17 through 20 in 2009 and the 2009–2010 influenza season, corresponding to when the A(H1N1)pdm09 strain first emerged and circulated as a pandemic virus,[19] were excluded from the initial analyses. Instead, the 2009–2010 influenza season was reserved for out-of-sample prediction of CVD mortality using models developed during the initial analyses. This study was approved by the Columbia University Medical Center Institutional Review Board and the New York City Department of Health and Mental Hygiene (NYC DOHMH) Institutional Review Board.

CVD Mortality

We obtained mortality data on date of death, age, and the *International Statistical Classification of Diseases*, *Tenth Revision* (*ICD-10*) codes for underlying cause of death from the New York City Office of Vital Statistics. Daily mortality counts for all deaths in New York City from 2006 to 2012 were aggregated for all cardiovascular causes (*ICD-10* codes I00–I99), which included ischemic heart disease (IHD) (*ICD-10* codes I20–I25), myocardial infarction (*ICD-10* code I21), stroke (*ICD-10* codes I61–I64), and heart failure (*ICD-10* code I50). In secondary analyses, we examined mortality specifically due to IHD and myocardial infarction.

Measures of Influenza Incidence

We used emergency department visit data in combination with respiratory viral surveillance data to estimate our 2 primary exposures of interest—total influenza-like illness (ILI) and ILI+ counts (among persons ≥0 years). As part of the city's surveillance efforts, NYC DOHMH uses a text-scanning algorithm to search free-text descriptions of the patient's reason for seeking emergency care for key text strings assigned to specific syndromes. Descriptions are received daily from 51 of 53 (96.2%) emergency departments in New York City[20] and scanned for key text strings assigned to specific syndromes.[21] To be categorized as ILI, flu, fever, and cough or sore throat must be mentioned in the patient's self-described reason for visiting the emergency department. Daily ILI counts, total and aggregated by age group (≤4, 5–17, 18–64, and ≥65 years), are available from NYC DOHMH's EpiQuery from January 1, 2006, onward.[20]

A more specific measure of influenza incidence than ILI,[17,22] ILI+ is computed by multiplying ILI by the proportion of respiratory specimens testing positive for influenza virus. We used weekly virologic surveillance data collected by US World Health Organization and National Respiratory and Enteric Virus Surveillance System laboratories for US Health and Human Services Region 2, which includes New York City,[23] and converted the data to the daily scale using linear interpolation to calculate daily ILI+. Similarly, we used strain-specific data to generate the following subtype-specific ILI+

measures: A(H1N1)+, A(H1N1)pdm09+, A(H3N2)+, and B+. Some influenza A virus specimens are not or cannot be subtyped. For those samples, we divided them among all circulating subtypes in proportion to their share among the subtyped strains.

Statistical Analysis

We calculated the year-to-year Pearson product moment correlation between the average daily ILI or ILI+ in an influenza season and the average daily excess CVD mortality count, estimated by summing the residuals above the long-term trend in CVD mortality. In time-series analyses, we examined influenza activity in the previous 28 days using individual lags and determined an optimum moving average period for each set of analyses using a 7-day block increment (eg, moving average of 1–14 days or 8–21 days, etc) unless the associations appeared with a clearly shorter span of days. Daily time-series models took the following form:

$$\mathrm{Y}=\beta_0+\beta_1(\mathrm{ILI\ or\ ILI+\ })+\beta_{2-7}(\mathrm{Day\ of\ Week})+ns(\mathrm{Time})+\varepsilon \quad (1)$$

Y represents the cardiovascular mortality count on a particular day, β_0 is the intercept, β_1 is the coefficient associated with the number of emergency department visits for an influenza incidence measure (ILI or ILI+), β_{2-7} accounts for day-of-the-week patterns, *ns* is a natural spline with 4 *df* per influenza season to adjust for seasonal and time trends, and ε is the random error term. We assumed a normally distributed response variable (daily counts were large and allowed a normal approximation). We checked for residual confounding by season and serial correlation through examination of autocorrelation and partial autocorrelation function plots. We tested for confounding and effect modification by outdoor ambient temperature and absolute humidity (a measure of water vapor) in the prior 28 days using the same method as for influenza to identify a moving average. Weather data were obtained from National Climatic Data Center files for New York City's LaGuardia Airport. In sensitivity analyses using the same statistical methods, we examined how age-specific (≥65 years) ILI and ILI+ counts affected CVD mortality. To compare the associations across influenza measures, we standardized effect estimates by the interquartile range (IQR) of the examined influenza measure (eg, IQR is 103.2 for total ILI and 44.3 for total ILI+ for the moving average of lag days 8–21). The results are expressed as the percentage change in the expected daily mortality count per IQR increase for each influenza measure.

To test the effect of different influenza strains on CVD mortality, we compared the coefficients from separate prepandemic and postpandemic strain-specific models of the following form:

$$\mathrm{Y}=\beta_0+\beta_1[\mathrm{A(H1N1)+}]+\beta_2[\mathrm{A(H3N2)+}]+\beta_3(\mathrm{B+})+\beta_{4-9}(\mathrm{Day\ of\ Week})+ns(\mathrm{Time})+\varepsilon \quad (2)$$

β_1, β_2, and β_3 represent coefficients associated with the number of emergency department visits for strain-specific ILI+ among the total population. Because the same A(H1N1) pdm09 strain was in circulation during the postpandemic period as during the pandemic, we

then trained ILI and ILI+ models (of the same form as equation 1) to the postpandemic period to test if influenza incidence was predictive of CVD mortality during the 2009–2010 influenza season using time lags identified in the initial analyses. We assessed prediction accuracy by comparing the absolute and relative difference between the expected and actual mortality count.

Results

A total of 157 648 CVD deaths occurred between 2006 and 2012, of which 88 377 occurred during nonpandemic influenza seasons (daily mean [SD], 64.7 [10.9]) (Table 1). Ischemic heart disease accounted for 72.4% (63 960 deaths) and myocardial infarction accounted for 11.7% (10 301 deaths) of nonpandemic CVD mortality. Cardiovascular disease mortality among persons 65 years and older, who accounted for 83.0% (73 363) of nonpandemic CVD deaths, showed a strong seasonal trend and decline over time (eFigure 1 in the Supplement). During the study period, there were a mean (SD) of 225.7 (83.3) total ILI visits and 31.8 (38.5) total ILI+ visits per day. Emergency department presentation for ILI varied by age. Children 4 years old and younger generally were seen earlier in the influenza season compared with the rest of the population (eFigure 2 in the Supplement).

Cardiovascular disease mortality and influenza incidence peaked at similar times during the study period (Figure 1). Seasonal excess daily average CVD mortality among adults 65 years and older strongly correlated with daily average total ILI ($r = 0.75$, $P = .05$) and ILI+ ($r = 0.82$, $P = .02$) (Figure 2). In contrast, the correlation among the group younger than 65 years was not significant for total ILI ($r = 0.59$, $P = .16$) or total ILI+ ($r = 0.44$, $P = .32$). These results suggested that seasonal influenza infections primarily affected CVD mortality among older individuals. Therefore, we focused the remaining analyses in the study on adults 65 years and older.

Cardiovascular disease mortality was consistently associated with influenza across the 4 examined influenza indicators, but there were differences in the timing and magnitude of the associations depending on the influenza measure and CVD outcome. The associations were strongest for total ILI: each increase of 103.2 emergency department visits for ILI was associated with a 6.3% (95% CI, 3.7%–8.9%) rise in CVD mortality and a 6.9% (95% CI, 4.0%–9.9%) rise in IHD mortality, both at a lag of 8 to 21 days (Figure 3). Total ILI associations were strongest and most acute for myocardial infarction mortality: each IQR increase was associated with a 13.1% (95% CI, 5.3%–20.9%) increase in myocardial infarction mortality at a lag of 1 to 14 days. Using the more specific measure of influenza (ILI+), temporal associations for total ILI+ were the same as for ILI for all 3 CVD outcomes, but the strength of the associations was weaker. Each IQR increase of total ILI+ was associated with 3.1% (95% CI, 0.5%–5.7%), 4.0% (95% CI, 1.1%–6.9%), and 9.4% (95% CI, 1.2%–17.6%) increased mortality from CVD, IHD, and myocardial infarction, respectively.

In sensitivity analyses using age-specific (≥65 years) influenza measures, daily average ILI ($r = 0.80$, $P = .03$) and ILI+ ($r = 0.82$, $P = .02$) remained strongly correlated year to year with seasonal excess CVD mortality. The timing of daily associations was consistent at a lag of 7

to 8 days for all CVD outcomes, and the associations were weaker compared with total ILI and ILI+ but remained statistically significant (Figure 3).

To reduce the number of multiple comparisons and to be conservative, we tested for confounding and effect modification by absolute humidity and temperature only for the age-specific (≥65 years) ILI measure. Absolute humidity in the prior 2 to 4 days significantly modified the effect of age-specific ILI on CVD (interaction $P = .01$) and IHD (interaction $P = .02$) mortality but not myocardial infarction mortality (interaction $P = .80$). An IQR decrease in absolute humidity (of 3.7 g/m^3) combined with an IQR increase in age-specific ILI increased CVD mortality by 3.3% (95% CI, 1.6%–5.0%) and increased IHD mortality by 3.2% (95% CI, 1.2%–5.1%). Temperature was not a confounder or effect modifier of age-specific ILI (interaction $P > .05$ for all CVD outcomes).

Model coefficients trained using prepandemic vs postpandemic strain-specific total ILI+ data sets (equation 2) were not significantly different between the 2 periods ($P > .10$ for tests of the difference between 2 slopes for each influenza strain). The effect of the A(H3) strain was similar and was the only strain significantly predictive of CVD mortality in both periods, with prepandemic $\beta_2 = 1.4 \times 10^{-3}$ ($P = .008$) and postpandemic $\beta_2 = 0.9 \times 10^{-3}$ ($P = .003$). Using a prediction model trained to total ILI during postpandemic influenza seasons, we predicted 11 632 (95% CI, 11 402–11 861) CVD deaths occurring among adults 65 years and older during the 2009–2010 influenza season, which is only 37 (95% CI, −193 to 266) deaths or 0.3% more than the observed CVD mortality (Table 2). Other influenza incidence metrics (total ILI+, age-specific ILI, and age-specific ILI+) predicted average CVD mortality among adults 65 years and older with at least 94.0% accuracy. Prediction models trained to prepandemic influenza seasons, when the old seasonal A(H1N1) strain was in circulation, predicted on average approximately 1700 to 2000 more CVD deaths during the 2009–2010 influenza season than the 11 595 observed.

Discussion

We found that community-level rises in ILI were associated with and predictive of CVD mortality. Annual wintertime increases in influenza infections and excess CVD mortality among individuals 65 years and older were strongly correlated across 4 different measures of population-level influenza infection (r range, 0.75–0.82 for all and $P \leq .05$ for all). Increases in the number of influenza-related emergency department visits from the 25th to 75th percentiles within the previous 21 days were associated with a rise in CVD mortality of approximately 2.3% (95% CI, 0.7%–3.9%) to 6.3% (95% CI, 3.7%–8.9%), IHD mortality of approximately 2.4% (95% CI, 1.1%–3.6%) to 6.9% (95% CI, 4.0%–9.9%), and myocardial infarction mortality of approximately 5.8% (95% CI, 2.5%–9.1%) to 13.1% (95% CI, 5.3%–20.9%). Four different metrics of influenza incidence were consistently predictive of cumulative CVD mortality during the initial year when A(H1N1)pdm09 emerged and dominated, estimating an average mortality within 6.0% of the 11 595 deaths that occurred during the 2009–2010 influenza season.

Age-specific (≥65 years) influenza measures were consistently associated with CVD mortality at a 1-week delay, consistent with an expectation of a 1-week to 2-week delay to

allow time for secondary health effects to occur.[6] Relevant exposure windows were narrower using age-specific measures compared with total population measures (a 2-day window for age-specific ILI and ILI+ vs a 14-day window for total ILI and ILI+). Age-specific indicators likely provide a more precise estimate of timing because emergency department presentation for ILI is highly age dependent. Infants and children comprise the majority of ILI emergency department visits in New York City and generally are seen earlier in the influenza season than other age groups (eFigure 2 in the Supplement). Therefore, using total ILI counts would result in a widening of the relevant exposure windows, consistent with our results. However, total ILI may be a better indicator of severity than age-specific (≥65 years) ILI because age-specific ILI accounts for a small proportion of emergency department visits among older adults, who are likely seeking care for other more serious conditions.

We found the strongest association for mortality from myocardial infarction. Recent respiratory or influenza infection is known to increase the risk of myocardial infarction,[4,24–28] particularly in the first few days after infection and for up to 4 weeks.[6,14] The results of our analysis suggested that lower absolute humidity (ie, drier air) interacts with influenza to synergistically increase the incidence of IHD mortality. Absolute humidity is associated with the onset of seasonal influenza epidemics[29] and has been reported to be consistently predictive of cause-specific mortality.[30] Lower humidity levels might increase the risk of dehydration, resulting in a reduction in circulatory blood volume, hemoconcentration, and hyperviscosity.[31] It is possible that we did not find evidence of effect modification on myocardial infarction mortality due to limited statistical power.

Influenza-associated health effects vary by season and depend on factors like population immunity, vaccine effectiveness, and virulence of the circulating influenza virus types and subtypes.[15,32–34] The 2009 pandemic offered a unique opportunity to investigate the association between a specific influenza subtype and CVD mortality. The novel A(H1N1) pdm09 strain is less likely to infect the elderly due to prior cross-immunity,[35,36] which in turn might mitigate CVD mortality among the elderly should influenza infections contribute to cardiovascular risk. Indeed, we found that mortality among older adults was lower than expected based on historical trends when A(H1N1)pdm09 predominated during the influenza season. We estimated that 1700 to 2000 fewer CVD deaths occurred in New York City during 2009–2010 than expected due to the circulation of this novel A(H1) strain. Mortality estimates were consistent across 4 influenza activity measures, suggesting that the predictions were robust to artificial surges in emergency department visits for ILI that may have arisen from pandemic-related hype.

Processes that transiently alter endothelial function might destabilize vulnerable atherosclerotic plaques and lead to eventual coronary artery occlusion, the major cause of myocardial infarction.[6] Some influenza strains exhibit a high degree of similarity between amino acid sequences involved in viral hemagglutinin cell-site attachment and the corresponding amino acids of apolipoprotein B low-density lipoproteins, providing a potential pathway for lipid dysregulation.[37] Via inflammatory and coagulation pathways, influenza infections can increase the expression of proinflammatory cytokines,[10] promote macrophage infiltration in the artery wall,[38,39] result in the release of endotoxin or lipopolysaccharide into the circulation that damages vascular endothelium or elicits an

immune response, heighten plasma viscosity during fever,[40] or cause changes in circulating clotting factors that increase the tendency for clotting.[41]

In this association study, we focused on seasonal influenza infections, but several other CVD risk factors display seasonal variation. Obesity, increased fat intake, reduced physical activity, and higher blood pressure and serum cholesterol level are more prevalent in winter.[42] Seasonal changes in hemostatic variables (eg, fibrinogen,[41,43] factor VII,[41] and protein S[44]) might contribute to thrombotic risk. In addition to raising cardiac workload after activation of the sympathetic nervous system and coagulation system,[42,45] exposure to cold winter temperatures increases the risk of respiratory infection[46] through suppression of the immune system and direct effects on the tracheobronchial tree.[47–49] In turn, the host acute-phase response to infections could trigger manifestations of chronic diseases through localized and general inflammatory and prothrombotic changes.[11] Due to the similar time dependencies between multiple CVD risk factors, it is difficult to separate the contribution of each factor from the others.[41] One or more seasonally varying risk factors likely contributed to the results reported herein.

Our study has several limitations. Only approximately half of the persons infected with influenza experience clinical symptoms,[50] and individuals with mild or prodromal symptoms usually do not seek medical care in an emergency department.[21,51] Therefore, ILI visit data used herein likely reflect serious cases of ILI and miss mild and asymptomatic cases. Additional influenza cases are missed when persons do not or cannot mount an appropriate immune response and are excluded from ILI counts due to lack of fever. Passive laboratory virus surveillance data are largely based on contributed samples and therefore do not reflect a systematic sampling scheme,[52] and laboratory diagnosis is infrequently performed to confirm clinical diagnosis.[24,32] The NYC DOHMH has estimated that every emergency department visit for respiratory, fever, or influenza syndromes represents approximately 76.5 illnesses among New York City residents 18 to 64 years old and 11.1 illnesses among those 65 years and older.[21] Despite these limitations, surveillance data can identify morbidity and mortality trends, and ILI+ has been shown to be a good estimator of relative influenza infection incidence.[17,22] By incorporating both ILI and laboratory surveillance data, ILI+ reflects the fluctuating number of individuals sampled for influenza and accounts for other microorganisms that simultaneously circulate during influenza epidemics, such as respiratory syncytial viruses, parainfluenza viruses, and adenoviruses.[22,24,52,53]

Age and certain medical conditions (eg, chronic heart, lung, or immune diseases) are known risk factors for influenza-related complications.[50] Vaccination is the primary strategy for preventing influenza-related deaths[54] and can reduce the severity of infection and subsequent complications.[50] Unfortunately, older adults exhibit poor uptake of the influenza vaccine. In 2012, only 62% of adults 65 years and older reported being vaccinated against influenza during the past year in New York City, slightly behind the national average of 66%,[55] highlighting the need to better promote vaccine uptake among high-risk populations. Given this reality, alternative strategies to decrease the health burden of influenza infections should be explored. If influenza epidemics can be reliably and accurately forecasted, such forecasts could also inform the timing of elevated cardiovascular risk and help guide

cardiovascular drug prescriptions for high-risk patients,[14] planning and allocation of antiviral medications,[8,56] and public health information dissemination campaigns.[56]

Conclusions

Seasonal influenza infections may contribute to wintertime increases in CVD mortality. This association suggests that accurate and reliable forecasts of influenza activity could provide health professionals with additional weeks of lead time to plan and respond to seasonal increases in cardiovascular mortality.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Key Points

Question

Are community-level rises in influenza-like illness associated with and predictive of cardiovascular mortality?

Findings

In this time-series analysis of 73 363 nonpandemic cardiovascular deaths during influenza seasons between 2006 and 2012, increases in influenza-related emergency department visits in the previous 21 days were associated with a significant increase in cardiovascular mortality among adults 65 years and older. Out-of-sample prediction of cardiovascular mortality during the 2009–2010 influenza season yielded average estimates with 94.0% accuracy.

Meaning

Retrospective estimation of influenza-attributable cardiovascular mortality in combination with accurate and reliable influenza forecasts could inform the timing of elevated cardiovascular risk.

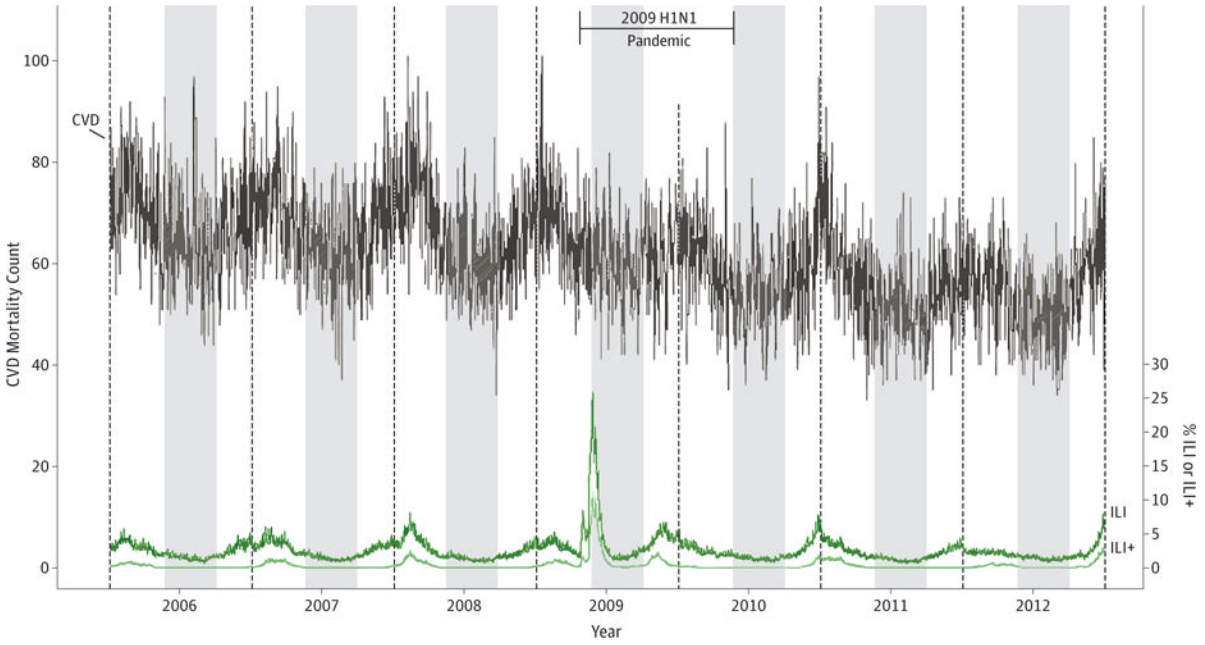

Figure 1. Time Series of Daily Cardiovascular Disease (CVD) Mortality and the Percentage of Emergency Department Visits for Influenza-Like Illness (ILI) and ILI+ in New York City, 2006 to 2012

ILI+ is a scaled measure of ILI that incorporates laboratory surveillance data. Noninfluenza seasons (weeks 21–39 in a calendar year, indicated by gray shading) and the 2009 novel influenza A(H1N1) pandemic were excluded from temporal analyses in this study.

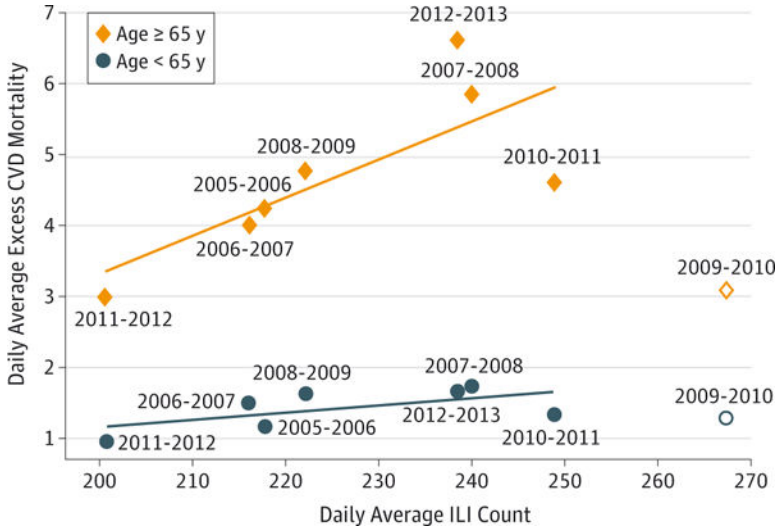

Figure 2. Scatterplot Comparing Seasonal Excess Cardiovascular Disease (CVD) Mortality With Seasonal Average Emergency Department Visits for Influenza-Like Illness (ILI) in New York City, 2006 to 2012

The 2005–2006 season includes only weeks 1 to 20 of calendar year 2006, and the 2012–2013 season includes only weeks 40 to 52 of calendar year 2012. Excluding the 2009–2010 influenza season (hollow symbols), $r = 0.75$ ($P = .05$) for adults 65 years and older and $r = 0.59$ ($P = .16$) for adults younger than 65 years.

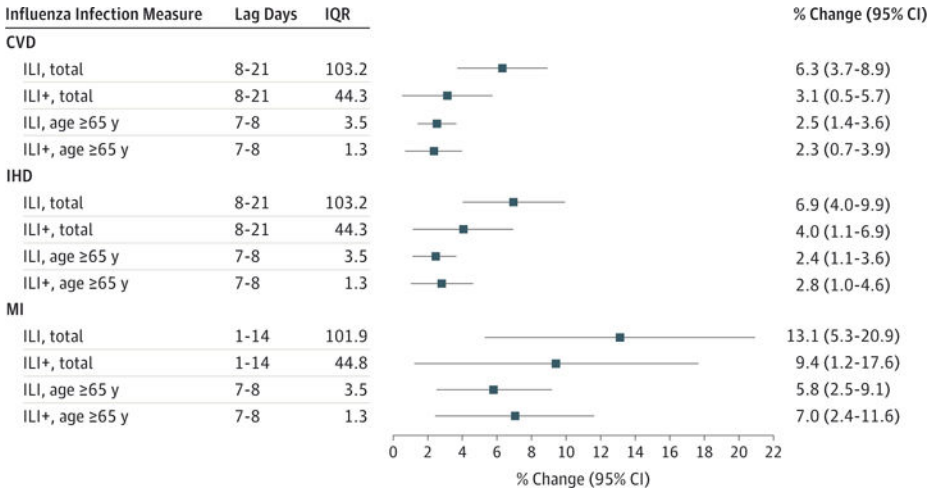

Figure 3. Percentage Change in Daily Mortality From Cardiovascular Disease (CVD), Ischemic Heart Disease (IHD), and Myocardial Infarction (MI) per Interquartile Range (IQR) Increase in an Influenza Infection Measure

Influenza-like illness (ILI), total and for age 65 years and older, represents the number of emergency department visits for ILI among persons 0 years and older and 65 years and older, respectively, while ILI+ measures additionally incorporate virologic surveillance data into the metric.

Table 1

Cardiovascular Disease (CVD) Mortality and Emergency Department (ED) Visits for Influenza-Like Illness (ILI) During the Influenza Season in New York City, 2006 to 2012[a]

	Mean (SD)		
Variable	**Age <65 y[b]**	**Age ≥65 y**	**Total[c]**
CVD mortality[d]	11.0 (3.4)	53.7 (9.7)	64.7 (10.9)
IHD mortality	6.3 (2.6)	40.5 (9.1)	46.8 (10.0)
MI mortality	1.2 (1.1)	6.3 (2.8)	7.5 (3.0)
ILI ED visits	218.9 (80.6)	6.8 (4.2)	225.7 (83.3)
ILI+ ED visits	30.8 (37.2)	1.0 (1.5)	31.8 (38.5)

Abbreviations: IHD, ischemic heart disease; ILI+, scaled measure of ILI that incorporates laboratory surveillance data; MI, myocardial infarction.

[a] Influenza season is week 40 of a calendar year to week 20 of the following calendar year.

[b] For mortality due to cardiovascular causes, this range includes ages 40 to 64 years. For ILI and ILI+ ED visits, this range includes ages 64 years and younger.

[c] For mortality due to cardiovascular causes, this range includes ages 40 years and older. For ILI and ILI+ ED visits, this range includes all ages.

[d] Cardiovascular disease includes IHD, MI, stroke, and heart failure.

Table 2

Cumulative CVD Mortality Predictions for Persons 65 Years and Older for the 2009–2010 Influenza Season in New York City

CVD Mortality During the 2009–2010 Influenza Season	Influenza Activity Measure	Expected (95% CI) CVD Mortality Based on Prepandemic Trends	Absolute Difference (95% CI) From Prepandemic Expectation	Expected (95% CI) CVD Mortality Based on Postpandemic Trends	Absolute Difference (95% CI) From Postpandemic Expectation	Relative %Difference (95% CI) From Postpandemic Expectation
11 595	ILI, total[a]	13 648 (13 394 to 13 902)	2053 (1799 to 2307)	11 632 (11 402 to 11 861)	37 (−193 to 266)	0.3 (−1.7 to 2.3)
11 595	ILI+, total[a]	13 377 (13 227 to 13 527)	1782 (1632 to 1932)	11 059 (10 911 to 11 206)	−536 (−684 to −389)	−4.6 (−5.9 to −3.4)
11 595	ILI, age ≥65 y	13 437 (13 301 to 13 574)	1842 (1706 to 1979)	11 081 (10 932 to 11 230)	−514 (−663 to −365)	−4.4 (−5.7 to −3.1)
11 595	ILI+, age ≥65 y	13 317 (13 190 to 13 443)	1722 (1595 to 1848)	10 938 (10 783 to 11 093)	−657 (−812 to −502)	−6.0 (−7.5 to −4.5)

Abbreviations: CVD, cardiovascular disease; ILI, influenza-like illness; ILI+, scaled measure of ILI that incorporates laboratory surveillance data.

[a]Total includes all ages.