Age Distribution of Influenza and Pneumonia Mortality in the United States, 1960-2002

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1 Introduction

Influenza is a major cause of mortality in the United States, killing an estimated average of 21,000[7] to 34,470[8]people each year. Recent discovery of new influenza strains in humans have spurred concerns around another influenza pandemic. Influenza pandemics occur when a new strain of influenza virus emerges in the human population and spreads rapidly across the world. The twentieth century has witnessed three influenza pandemics in 1918, 1957, and 1968. The 1918 pandemic, coined the 'Spanish flu', was particularly severe and estimated to have killed 20 million people.[4]

While in epidemic years, flu mortality disproportionately affects the elderly[8], Simonsen, et al.[6] has suggested that during pandemic years, the age distribution shifts down. They showed that persons under 65 years of age accounted for a high proportion of influenza-related deaths during pandemic years and their proportion leveled off during subsequent epidemic years. Reichert, et al.[5] had a similar finding for the 1968/69 pandemic year. This shift in age distribution is a well-known characteristic of the 1918 pandemic where the mortality curve took on an unusual 'W' shaped curve. [4]

This paper examines the demography of influenza and pneumonia mortality. It seeks to further investigate the trends and shifting age distribution of influenza and pneumonia mortality. The following research questions are explored:

1) What are the changes in the age distribution of mortality during flu epidemics and pandemics over time?

Given that life expectancy in the U.S. has been steadily increasing over the past decades, how has the age distribution of flu mortality changed? Also, is there a drop in age distribution of flu mortality during the pandemic year of 1968-1969?

2) What are the differences in age distribution of flu mortality between flu and non-flu seasons?

Influenza deaths in temperate climates have been shown to be seasonal in nature and peak during winter months.[2][3] Does flu mortality take on different age distribution characteristics during flu season and non-flu seasons?

3) What is the sex differential?

A gap in life expectancy has been observed between men and women. Considering women on average live longer than men, what is the difference in flu mortality between men and women? How does the age distribution of flu mortality differ by sex? Does this change during the pandemic year?

2 Methodology

The Multiple Cause-of-Death Mortality Data for years 1959-2003 from the U.S. National Vital Statistics System, National Center for Health Statistics, Centers for Disease Control and Prevention were used as numerators for the calculation of mortality rates. Pneumonia and Influenza as the underlying cause of death was used to classify influenza-related deaths. The population size from the Human Mortality Database was used as the denominators.

Data from 1960 to 2002 were used. A flu season was defined as December to March of the following year. Adjustments were made for changes in International Classification Diseases in 1968, 1979, and 1999 from ICD-7, ICDA-8, ICD-9, to ICD-10 were made using published comparability ratios (NCHS, 2006. http://www.cdc.gov/nchs/data/dvs/comp2.pdf)

The Brass Relational Logit Model[1] was used to examine the changes in age distribution of mortality from flu related deaths. The Brass model states that:

$Y_x = 0.5ln(l_x/(1 - l_x))$

where l_x is equal to the proportion surviving to age x. The logits of l_x has a linear relationship with the logits of a Brass standard such that:

$Y_x = \alpha + \beta Y'_x$

where Y'_x is the logits of the Brass standard, α is the level parameter and β is the shape parameter.

To investigate the changing age distribution in mortality using the Brass model, the changes in α and β over time were examined. A positive α means higher survivorship and weaker mortality. Therefore, an increasing α means improving survivorship and decreasing mortality and vice versa. The β parameter determines the balance between childhood and old-age mortality. β greater than one means better early survivorship compared to later adult survivorship. An increasing β means shifting of mortality into older ages.

The Brass α and β were calculated for deaths from pneumonia and influenza in the absence of other causes and the trends in α and β parameters were observed. Age-specific death rates were calculated for 5 year age groups except for age groups 0-1, 1-4, 5-14, and 85 and up. These were then used to calculate the probability of death ($_nq_x$) and the proportion surviving l_x. The l_x from 2002 was used as the standard in calculating the α and β parameters.

3 Results

The results showed that Brass β parameters associated with flu mortality has been increasing during both flu and non-flu seasons in both sexes. (Figure 1) This suggests that mortality from flu and pneumonia has been shifting to older ages over the past few decades. The expected drop in β for a pandemic year was not observed as expected during the flu season. However, a drop in β was observed during the non-flu season, although the initial drop occurred the year before the pandemic rather than in the pandemic year. The β parameters for females was lower than that for males.

A declining trend in the Brass α parameter was observed over time in both sexes and for flu and non-flu seasons. The declining trend in the α parameter suggests lower survivorship and stronger mortality. The male α values were lower than those for females. This is consistent with the age-adjusted rates where higher rates were observed among males than females. A drop in α was observed during the pandemic year, but only during the flu season.

A sex differential was observed birth in the Brass parameters and in the age-adjusted mortality rates.(Figure 2) Female age-adjusted mortality rates from flu and pneumonia was found to be lower than for males.

4 Conclusion

The use of the Brass relational logit model to examine the changing age distribution of mortality is an important demographic tool. We have applied this method to study the shifts in age distribution during flu epidemics and pandemics over the course of four decades. We stratified by sex to examine the differences between men and women. Our findings showed that flu mortality is shifting to older ages, though no drop in age distribution was observed during the pandemic year. These findings could have implication for public health prevention and intervention strategies.

References

[1] W. Brass. *Biological Aspects of Demogrpahy*. Taylor and Francis, Ltd., third edition, 1979.

[2] N.J. Cox and K. Subbarao. Global epidemiology of influenza: Past and present. *Annu. Rev. Med.*, 51:407–421, 2000.

[3] J.S. Nguyen-Van-Tam and A.W. Hampson. The epidemiology and clinical impact of pandemic influenza. *Vaccine*, 21:1762–1768, 2003.

[4] A. Noymer and M. Garenne. The 1918 influenza epidemic's effects on sex differentials in mortality in the united states. *Population and Development Review*, 26:565–581, 2000.

[5] T.A. Reichert, L. Simonsen, A. Sharma, S.A. Pardo, D.S. Fedson, and M.A. Miller. Influenza and the winter increase in mortality in the united states, 1959-1999. *American Journal of Epidemiology*, 160(5):492–502, 2004.

[6] L. Simonsen, M.J. Clarke, L.B. Schonberger, N.H. Arden, N.J. Cox, and K. Fukuda. Pandemic versus epidemic influenza mortality: A pattern of changing age distribution. *The Journal of Infectious Diseases*, 98(178):53–60, 1998.

[7] L. Simonsen, M.J. Clarke, G.D. Williamson, D.F. Stroup, N.H. Arden, and L.B. Schonberger. The impact of influenza epidemics on mortality: Introducing a severity index. *American Journal of Public Health*, 87(12):1944–1950, 1997.

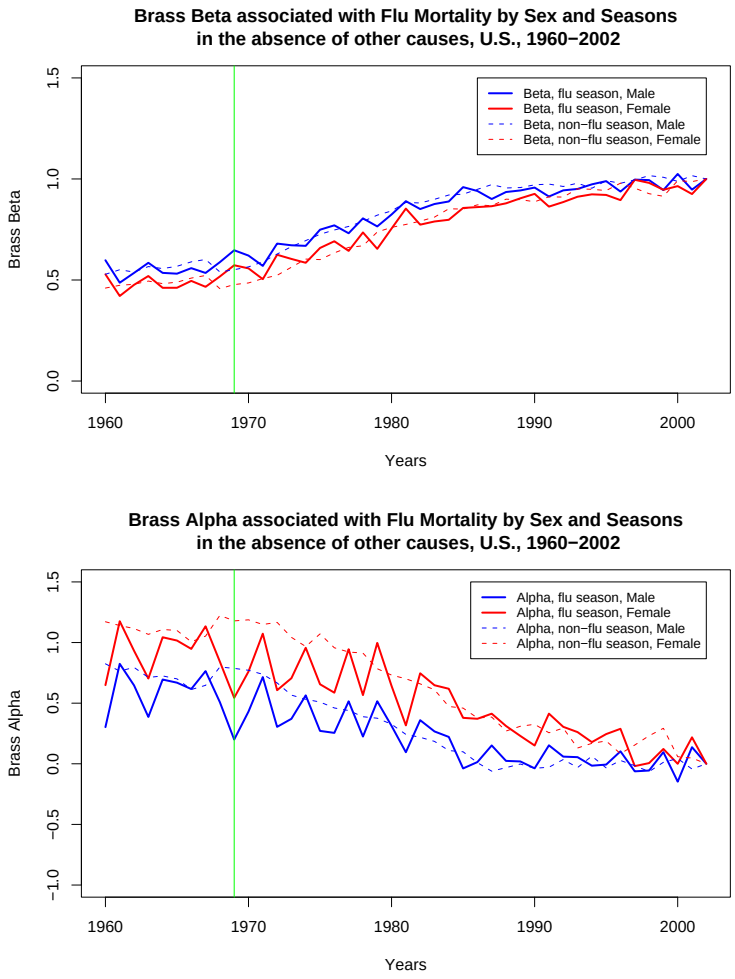

Figure 1: Brass Beta and Alpha Parameters Associated with Pneumonia and Influenza Deaths by Sex and Flu Season, 1960-2002, United States

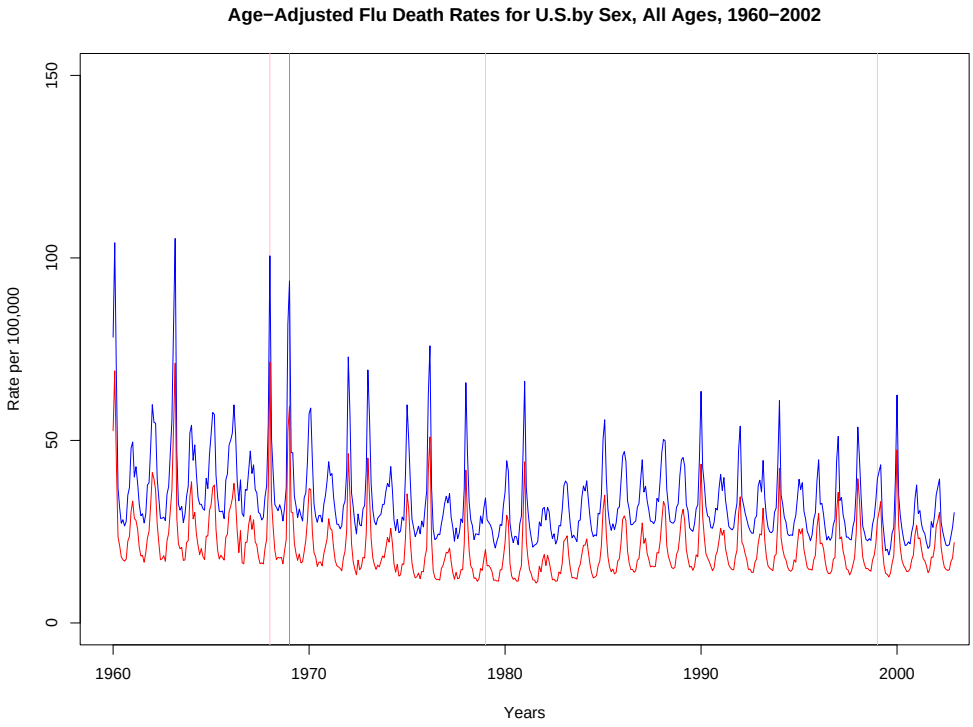

Figure 2: Age Adjusted Pneumonia and Influenza Death Rates by Sex, 1960-2002, United States

[8] W.W. Thompson, D.K. Shay, E. Weinbraub, L Brammer, N. Cox, L.J. Anderson, and K. Fukuda. Mortality associated with influenza and respiratory syncytial virus in the united states. *JAMA*, 289(2):179–186, 2003.