Excess Pneumonia and Influenza Associated Hospitalization during Influenza Epidemics in the United States, 1970–78

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Abstract: In this study, excess rates of pneumonia and influenza (P&I) associated hospitalization during influenza A epidemics which occurred in the United States between 1970–78 were computed utilizing unpublished data from the National Hospital Discharge Survey (NHDS). Excesses occurred at rates of 35, 93, and 370 per 100,000 persons per epidemic for age groups 15–44, 45–64, and 65+ years. There was no evidence of a persisting excess or a compensatory decline in P&I hospitalization during post-epidemic months. An average excess of about 172,000 hospitalizations per epidemic at a cost in excess of $300 million was computed. The study quantifies a major impact of epidemic influenza upon health and health services, much of which may be preventable, and illustrates an important use of unpublished data contained in the NHDS. (*Am J Public Health* 1986; 76:761–765.)

Introduction

Reduction in excess pneumonia and influenza (P&I) mortality and morbidity due to influenza epidemics has been identified as a major public health goal for the United States during the present decade.[1] While excess mortality due to epidemics has been measured in a variety of ways from published vital statistics, excess hospitalization, which probably represents the largest cost to the health care system, has not been measured and reported. Various attempts to assess the impact of epidemic influenza on society in recent years have accordingly either used crude indirect estimates of excess hospitalization[2,3] or omitted it altogether from their analyses.[4] In light of evidence that influenza vaccine may substantially reduce the occurrence of excess P&I associated hospitalization during epidemics, particularly among elderly persons, it becomes important for policy-making purposes to measure the size of this excess.[5] This paper reports a method for directly estimating excess P&I hospitalization rates and costs, utilizing data from the National Hospital Discharge Survey (NHDS), and reports findings for influenza A epidemics for the period 1970–78.

The lack of readily available data for computing excess epidemic-related P&I hospitalization rates is inherent in the prevailing practice of focusing upon a single principal diagnosis in most published analyses of national hospital discharge statistics.[6] Since a large proportion of P&I associated hospitalizations present as acute decompensation of underlying cardiac or pulmonary disease, these diseases will commonly be listed as principal discharge diagnosis. The role of precipitating influenza or pneumonia, listed as associated diagnoses, will hence be obscured in the officially reported discharge statistics. An analogous phenomenon has been shown to occur with certification of P&I associated deaths in which the majority are attributed to cardiac or pulmonary cause without mention of P&I.[7] To overcome this problem, it was postulated that excess hospitalizations might be accounted for by searching NHDS files for those hospitalizations in which either influenza or pneumonia appeared among all-listed diagnoses. This approach had previously been found useful in studying impact of influenza epidemics in a large prepaid health plan in which virtually all excess hospitalizations were accounted for by cases in which pneumonia or influenza was included among discharge diagnoses.[8]

Methods

Using national pneumonia and influenza mortality curves published by the Centers for Disease Control, five epidemic periods and three comparable nonepidemic periods were identified between 1970–78. The epidemic periods were concentrated in the first quarters (January–March) of the respective years 1972, 1973, 1975, 1976, 1978 and were caused by variant strains of the H3N2 subtype of influenza A, as shown in Figure 1.[9]

The National Hospital Discharge Survey, conducted by the National Center for Health Statistics (NCHS) since 1964, is comprised of data abstracted from discharges from a stratified sample of acute, non-federal hospitals in the United States. Over 200,000 discharges from approximately 450 hospitals were included in the survey each year during the period of this study.[6] A basic data file was created by the NCHS from NHDS master files for 1970–78, including all first and second quarter hospitalizations, grouped by age, in which one or more of the following morbidities was listed among the discharge diagnoses: influenza or pneumonia (ICDA 470-74, 480-86); other respiratory tract conditions (ICDA 460, 462, 464-66, 490-93); acute cardiac conditions (ICDA 410, 420, 422, 427–28).

These hospitalizations were subgrouped into a hierarchy of mutually exclusive categories as follows:

- All hospitalizations with any listing of influenza or pneumonia;
- All hospitalizations including one of the other respiratory conditions among discharge diagnoses, *without* mention of influenza or pneumonia;
- All hospitalizations including one of the acute cardiac conditions among discharge diagnoses, *without* mention of influenza, pneumonia, or one of the other respiratory conditions.

Annual population estimates for age groups 0–14, 15–44, 45–64, and 65 years and above were obtained from the US Census Bureau. Age-specific hospitalization rates for each of the aforementioned categories were computed for the first and second quarters of each of the five epidemic and three non-epidemic years.

A series of analyses of variance were performed to determine the effects of the influenza epidemics on hospitalization rates during the first and second calendar quarters of the respective years included in the study. No effects were found for any of the three diagnostic categories among all age

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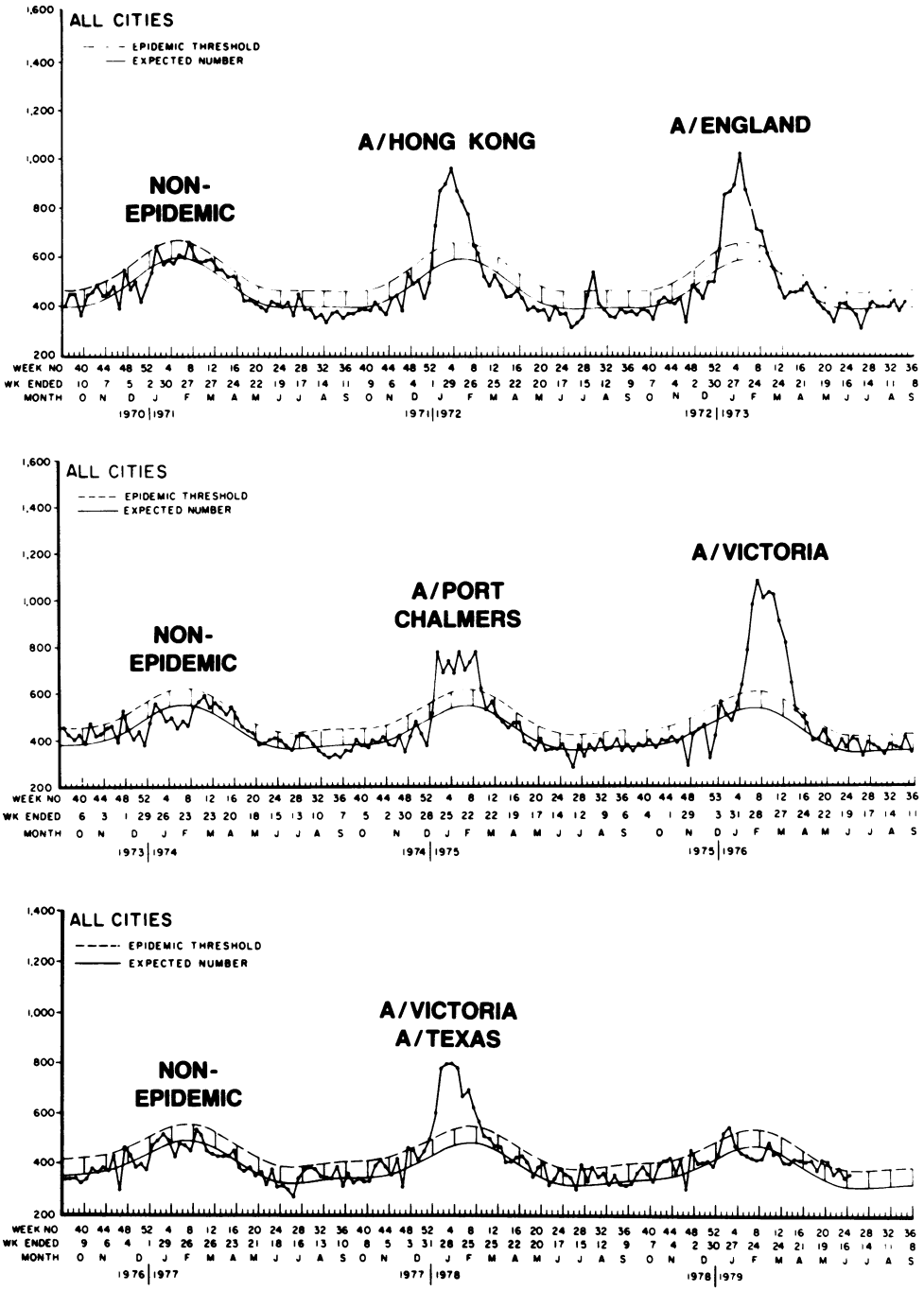

FIGURE 1—Five Epidemics Caused by Strains of the H3N2 Subtype of Influenza A Virus (as labeled) and Three Comparable Non-Epidemic Periods Between 1970–78 in the United States
SOURCE: Ref 9

groups, for the five epidemic and three non-epidemic years. Therefore, analyses of excess hospitalization were performed on aggregated rates averaged over the five epidemic and three non-epidemic years, rather than for individual years.

Excess hospitalization rates attributable to epidemic influenza were computed by subtracting the first quarter averages for the non-epidemic years from first quarter averages for the epidemic years. Similar computations were performed for second quarter rates to determine whether there were residual effects, either increases or decreases in hospitalization rates, in the months immediately following an epidemic.

Cost of excess hospitalization attributable to influenza was estimated utilizing 1978 age-specific length of stay and hospital per diem and physician fee data for pneumonia associated hospitalizations as compiled from secondary sources by the Office of Technology Assessment.[10] Average lengths of stay were 8, 10, and 12 days for age groups 15–44, 45–64, and 65+ years of age, respectively; hospital per diem cost was $150; and physician fees were $40 for an admission examination and $10 for daily follow-up visits. Age-specific

TABLE 1—Average Annual Hospitalizations per 100,000 for Influenza-related Diagnoses by Age Group during January–March of Epidemic and Non-epidemic Years, USA, 1970–78

Diagnoses, Age Groups (years)	Epidemic Years (A)	Non-epidemic years (B)	Excess A–B (95% CL)*
Pneumonia & Influenza (P&I)			
0–14	240	215	25 (0,63)
15–44	106	71	35 (27,43)
45–64	259	166	93 (57,129)
65+	939	569	370 (166,574)
Other Respiratory Conditions in Absence of P&I			
0–14	281	261	20 (0,62)
15–44	92	89	3 (0,11)
45–64	288	273	15 (0,43)
65+	684	644	40 (0,102)
Acute Cardiac Conditions in Absence of P&I, Other Respiratory Conditions			
0–14	10	9	1 (0,3)
15–44	34	33	1 (0,17)
45–64	340	336	4 (0,100)
65+	1322	1313	9 (0,699)

*Approximate 95% confidence interval for Excess.

TABLE 2—Average Annual Hospitalizations per 100,000 for Influenza-related Diagnoses by Age Group during April–June of Epidemic and Non-epidemic Years, USA, 1970–78

Diagnoses, Age Groups (years)	Epidemic Years (A)	Non-epidemic years (B)	Excess A–B (95% CL)*
Pneumonia & Influenza (P&I)			
0–14	129	114	15 (0,51)
15–44	44	45	−1 (−9,0)
45–64	114	123	−9 (−27,0)
65+	469	461	8 (0,226)
Other Respiratory Conditions in Absence of P&I			
0–14	188	185	3 (0,25)
15–44	71	70	1 (0,7)
45–64	239	231	8 (0,38)
65+	589	579	10 (0,52)
Acute Cardiac Conditions in Absence of P&I, Other Respiratory Conditions			
0–14	10	11	1 (0,9)
15–44	35	34	1 (0,7)
45–64	355	315	40 (0,122)
65+	1424	1317	107 (0,791)

*Approximate 95% confidence interval for Excess.

population figures were obtained from the 1980 census for use in estimating total excess amount and cost of hospitalization during a contemporary influenza A epidemic.

Results

Table 1 compares average first quarter hospitalization rates per 100,000 persons by age group for each of the three discharge diagnosis categories during epidemic and non-epidemic years. Rates of hospitalization with pneumonia or influenza listed among discharge diagnoses were higher during epidemics for all age groups, with the magnitude of excess increasing dramatically with age.

The lower part of Table 1 summarizes the hospitalization experience attributed to the diagnostic categories, other respiratory conditions, without mention of pneumonia or influenza, and acute cardiac conditions without mention of either of the above. Hospitalization rates for all age groups were consistently greater for both of these categories during epidemic years; however all of these excesses were very slight and in all cases the excess was closer to the lower bound of zero than to the upper bound of the 95% confidence interval.

Table 2 summarizes the differences in hospitalization rates during the second quarter, April through June, of epidemic versus non-epidemic years. There was no evidence for a persisting impact of influenza epidemics on hospital use once excess mortality has abated. Furthermore, there was no deficit in hospitalization rates during the second quarter of epidemic years, hence no evidence of a post-epidemic compensatory decline in morbidity.

The derivation of estimated total cost of excess P&I associated hospitalizations in the country during an influenza A epidemic is shown in Table 3. Applying the age-specific excess rates to corresponding population figures from the 1980 census yields a total of some 172,000 excess hospitalizations, over half of which involved persons 65 years of age or above. Age-specific costs per P&I associated hospitalization were derived from hospital and physician costs for 1978. The product of total age-specific excess hospitalizations and costs per hospitalization provided estimated total costs of approximately $300 million, as shown in the right-hand column. Utilizing annual per cent increases in the consumer price index for physician services and hospital care, the computed cost of excess hospitalization per epidemic in 1984 dollars is between $600 and $700 million.[11]

Discussion

This study sheds considerable light on the nature and magnitude of hospitalization attributable to influenza A epidemics. The data support the postulate that identification of all hospitalizations in which pneumonia or influenza appears among discharge diagnoses provides a sensitive measure for determining excess rates of hospitalization in epidemic versus non-epidemic years. Rates of hospitalization in which acute cardiac or respiratory diseases were listed among discharge diagnoses in the absence of mention of pneumonia or influenza remained essentially the same between epidemic and non-epidemic years. These observations, based on nationwide probability survey data, are similar to previously published findings from a single large prepaid practice population[7] and strongly suggest that virtually all increased hospitalization during influenza epidemics involves clinically significant lower respiratory tract infection. There is accordingly little reason to suspect an important effect of influenza virus directly on the cardiovascular system as has been pointed out in an earlier discussion dealing with excess mortality.[12]

The lack of any evidence of a compensatory decreased rate of hospitalization for P&I, other respiratory disease, or cardiac disease during the postepidemic second quarter of the year indicates that the excess hospitalizations during the epidemics represent a true net increase in hospitalizations, rather than an acceleration of the expected seasonal occurrence of hospitalization among frail persons. This under-

TABLE 3—Estimated Cost of Excess P&I Associated Hospitalization for Epidemic of Type A Influenza

Age Groups (years)	Excess Hospitalization: Excess per Million[a]	× US Population in Millions[b]	= Total Excess	Cost per Hospitalization (dollars): Hospital Cost[c]	+ Physician Fees[d]	= Total	Total Excess[e] Cost (dollars)
15–44	350	105.2	36820	$1200	$110	$1310	$ 48,234,200
45–64	930	44.5	41385	1500	130	1630	67,457,550
65+	3700	25.6	94720	1800	150	1950	184,704,000
			172,925				$300,395,750

a)Rates per million for those age groups with statistically significant excess (Table 1).
b)From 1980 US Census.
c)At per diem of $150. Average length of stay (days) by age group: 15–44 = 8, 45–64 = 10, ≥65 = 12. (Ref 10).
d)At $40 per initial visit and $10 for per day followup. (Ref 10).
e)Total Excess = Product of Excess hospitalization × Cost per hospitalization.

scores the point that mortality and serious morbidity from influenza epidemics occurs among persons who, though many are afflicted with major chronic disease, are in a state of stable health.[13,14]

For two reasons, this analysis is likely to provide a conservative estimate of the potential full impact of recent influenza epidemics. First, given that a small percentage of elderly and other high-risk persons received influenza vaccine prior to each of the epidemics included in the study,[15] it is reasonable to assume that some potential P&I associated hospitalizations were in fact prevented. Secondly, the fact that only slight epidemic-related increases in hospitalizations were noted among the 0–14 year old age group is likely to be due in part to the regular occurrence of hospitalizing lower respiratory tract infections due to viral agents other than influenza among this younger and more susceptible segment of the population.[16] The frequent epidemic occurrence of such illness during the winter months irrespective of the presence of an influenza epidemic could readily obscure our ability to detect a specific impact of an influenza epidemic in this age group, utilizing national hospitalization statistics.

The relative constancy of the magnitude of excess P&I hospitalization among the five different influenza A epidemics should not be interpreted as a pattern generalizable to all influenza A epidemics. Each of the epidemics between 1970–78 was caused by a drifted mildly altered variant of the basic H3N2 strain, hence might be expected to have roughly equivalent virulence in the population as was observed. However, at times when an epidemic strain represents a major antigenic shift from previously prevalent strains, excess mortality and morbidity (including hospitalization) of unusual magnitude may be anticipated, as occurred with the appearance of the H2N2 ("Asian") strain in 1957–58 and the H3N2 ("Hong Kong") strain in 1968–69.[17]

Well over 50 per cent of excess hospitalization and cost was accounted for by persons over age 65, representing some 10–12 per cent of the population. As this segment of the population grows in absolute numbers and enjoys extended longevity[18] in the near future, the costly occurrence of hospitalization during influenza epidemics may be anticipated to increase correspondingly. This reaffirms the imperative for providing preventive care, including vaccination and judicious use of chemoprophylaxis, to high-risk elderly persons as recommended by the US Public Health Service.[19]

In considering the significance of the findings reported here, it is noteworthy that a recent Institute of Medicine assessment of the quality of NHDS data found the diagnosis of pneumonia to be highly reliable (93–95 per cent), thus providing assurance that the data do not over- or underestimate the occurrence of pneumonia.[20] Among its recommendations, the Institute of Medicine study recognized the potential to use the survey data to identify and quantify the impact on hospitalization ascribable to particular morbidities which commonly occur as one among multiple discharge diagnoses. The present study of the role of pneumonia and influenza confirms this capacity of the NHDS data and may serve as a prototype for future studies of other morbidities.

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