A COMPARISON OF THE EFFECTS OF AN INFLUENZA EPIDEMIC
ON URBAN AND RURAL POPULATIONS IN OHIO UTILIZING
THE CONCEPT OF EXCESS MORTALITY

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by
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CHAPTER I
INTRODUCTION

Differences in the amount of activity of influenza between rural and urban areas in Ohio are not currently established. Influenza activity in urban areas is well recorded via mortality data from eight large cities in Ohio which are incorporated in the Center for Disease Control's (CDC) weekly mortality report from 121 cities in the United States. This report compiles weekly total deaths and influenza-pneumonia deaths by age groups. These tabulations are published weekly in the "Morbidity and Mortality Weekly Report" issued by the Center for Disease Control (CDC). Statewide surveillance is also maintained by screening death certificates for cause of death due to influenza either as the primary cause of death or as a contributing factor to the cause of death. Surveillance is maintained through the time period between November 1 and March 31 of any year. Although there is a "lag-time" inherent to mortality reporting, it is a much more reliable system than morbidity reporting for showing activity of influenza during a particular time period.

Absentee data is used extensively as a form of morbidity reporting of influenza. However, this type of data suffers from poor or erratic reporting. This may be caused by many factors. In the case of school reporting, breaks in attendance patterns due to weather, vacations, or non-cooperation in reporting may occur. Industrial
absentee data can suffer similar problems from weather, labor trouble, lay-offs, etc. This makes for a sometimes unwieldy system of changing population bases and reasons for absenteeism.

Morbidity reporting of the disease itself suffers from lack of reporting of cases. This causes substantial under-reporting of cases of disease.\(^1\) Diagnosis of the disease is another problem with morbidity reporting because of the difficulty in diagnosing without serologic tests. Therefore, accuracy of reported diagnoses of influenza cases is suspect.

Because of the vagaries in reporting morbidity and because no suitable method for defining the occurrence of influenza in rural areas has been established this thesis examined differences in mortality resulting primarily or secondarily from influenza between rural and metropolitan areas of the State of Ohio. The concept of excess mortality was used to study these differences. Total excess deaths and excess deaths from specific causes were examined. Little has been known about influenza activity in rural populations. Most of the knowledge of influenza activity and recommendations concerning prevention of influenza has come from studies done on urban populations or statewide data. The author broke down the population in Ohio by urban and rural areas and examined differences between the two. Statistical methods such as those developed by Serfling\(^2\) and McDonald\(^3\) were examined to determine their usefulness in examining state mortality data presented in this format.
CHAPTER II
REVIEW OF THE LITERATURE

Surveillance of Influenza

An essential part of any disease program is the surveillance of that disease. Surveillance aids in showing need for a control program and also serves as a continuing evaluation of the effectiveness of a control program. The evaluation of such programs is essential in order to maintain a proper perspective of the usefulness of these programs. What benefits are derived from information obtained by surveillance systems? Dr. David L. Miller⁴ has supplied some answers. Surveillance, in his view, provides immediate and reliable information about how epidemics are progressing. This is important administratively for hospitals and clinics so that they can be prepared to adapt to situations as they happen. Surveillance also enables investigators to measure the size and impact of epidemics as they occur in defined populations. The behavior of diseases can be studied and various field studies can be planned using information obtained from surveillance programs.

The oldest form of disease surveillance is that of the recording of deaths. Current utilization of mortality data is the measurement of excess deaths due to influenza-pneumonia as typified by the weekly listing of such data in the MMWR published by CDC. Horstmann¹ stated that this information has proved to be valuable and accurate in
forewarning the approach of an epidemic of influenza. This author also pointed out that mortality data is useful in uncovering epidemics in areas where reporting of disease morbidity is very low or non-existent. This may be especially true in rural areas where population is sparse and access to medical facilities limited by distance. Horstmann also stated that morbidity reporting surveillance systems suffer disadvantages that mortality data based systems do not. These disadvantages are lack of reporting of morbidity by physicians and inaccuracy of diagnosis of influenza. Dauer and Serfling stated that due to systematic collection of mortality data in epidemic and endemic periods, these provide the only base for a numerical estimate of the relative intensity of influenza epidemics.

Davis stated that except for influenza, epidemics of infectious diseases are no longer a great concern to the Western World. Mortality due to infectious diseases has decreased dramatically this century with the exception of deaths due to influenza-pneumonia. In terms of social cost of influenza, Davis pointed out that in 1971, 206,241,000 bed days of illness were caused by influenza-pneumonia. Economic cost of influenza was reflected by $2,770,406,000 earnings lost in 1972. Influenza and pneumonia ranked fourth in the United States as a cause of death from disease in 1970 and contributed to 62,739 deaths. Davis stated that if influenza and pneumonia were eliminated, a gain of 0.53 years in expectation of life at birth for the total population would occur. Kilbourn stated that influenza is the only human disease that can occur simultaneously in populations throughout the world to cause morbidity and mortality of pandemic extent.
Epidemiology of Influenza

The epidemiology of influenza is well established. Descriptions of outbreaks of influenza were found as early as the tenth century. Langmuyr noted that the recurrent theme in both modern and historical descriptions of influenza is its high morbidity and accompanying rise in mortality. Also commonly expressed in historical accounts is the unpredictability of outbreaks of the disease. This is still somewhat of a problem today. We know that influenza occurs in three distinct patterns: 1) pandemics, 2) epidemics, and 3) sporadic outbreaks. Attack rates during pandemics are high and tend to affect all age groups. Mortality is usually markedly increased. Epidemics are milder than pandemics with somewhat lower attack rates and variable mortality.

The two major types of influenza affecting the human population are types A and B. Influenza A tends to be severe and widespread and affects all age groups. Influenza B tends to be somewhat milder and adults may be spared from illness in an epidemic. Mortality is usually much lower in influenza B epidemics than in influenza A epidemics.

Kilbourne stated that since the first isolation of influenza A from humans in 1933, there have been three well studied pandemics of influenza occurring in 1947, 1957 (Asian), and 1968-69 (Hong Kong). It appears that only influenza A is associated with pandemics although this has been proven only for the 1957 pandemic by virus isolation. Influenza A seems to occur in epidemics in two to three year intervals. Influenza B appears to also occur in cyclical epidemics at longer
intervals of four to six years. The cyclical effect has been discerned from national data.

Experiences in other countries have shown little variation from information gathered in the United States, McDonald\(^3\) stated that Canada experienced little mortality in 1947, but had a severe outbreak in 1951 due to A-1 virus. Six quiet years followed until the pandemic of 1957. Morbidity in Canada was similar to that in the United States. Mortality was somewhat lower than the United States, due to the fact that Canada missed the second wave of mortality in January through March 1968. Britain, however, has had a mortality rate almost five times higher than the United States and almost seven times higher than Canada.\(^3\) Sex, age, and race differences have all been studied in regards to different aspects of influenza and much is known in these areas. However, little has been done to compare the effects of influenza on rural versus urban groups of people. Were the effects of the disease the same on rural populations as on urban populations as reflected in mortality statistics?

**Excess Mortality**

To compare the effects of influenza on urban and rural populations the author proposed to utilize the concept of excess mortality. William Farr first introduced the concept of "excess mortality" in his description of the London influenza epidemic of 1847. He defined this concept as, "the number of deaths exceeding a given norm for the given time and place in which an epidemic occurs."\(^8\) This phenomenon has been and still is used extensively in epidemiologic studies of influenza-pneumonia activity.
Collins has done extensive study of the concept of excess mortality measurement. He stated that the excess mortality rate from influenza-pneumonia in excess of the usual seasonal expected rate is the most commonly used statistical measure of the extent of an epidemic. The usual seasonal expected rates represent a base expectancy in weekly rates that are exclusive of epidemic increases. He also stated that weekly death rates are essential to provide a realistic picture of true excess mortality occurring during an epidemic and true duration of the event. Forty-one epidemics were recorded in the United States between the years 1887-1956. This information was obtained from death data. The best death data available prior to the great pandemic of 1917-18 was from monthly data on deaths by influenza-pneumonia in Massachusetts. Following this pandemic weekly reporting of deaths from major cities in the United States provided data for excess mortality statistics. Treatment of weekly death rates from all causes are done in approximately the same way as those from influenza-pneumonia in order to obtain death rates from all causes in excess of normal expectancy.

Total excess death rates can be obtained by adding the weekly excess rates for the weeks above seasonal expectancy. However, these weekly rates are computed on an annual basis so they must be reduced to actual basis by dividing their sum by the factor by which weekly rates are multiplied to put them on an annual basis.

Trotter, Dunn, et al., studied the A-2 influenza epidemic of 1957-58. During this epidemic they found that approximately 4,000 excess deaths occurred during the first wave of illness (October
through December, 1957), and approximately 3,200 excess deaths occurred during the second wave (January through March, 1958). These figures were obtained from death data of 108 cities in the United States. This biphasic mortality curve was the first related to influenza since the pandemic of 1918.

Eickhoff, Sherman, and Serfling\textsuperscript{10} studied two epidemics of influenza occurring in 1957-58 and 1960. The first epidemic was part of the pandemic caused by the introduction of the A-2 virus strain into the human population. Approximately 60,000 excess deaths occurred in the United States in the first epidemic and 27,000 excess deaths occurred in the second epidemic. Sources of data for this study were collected from the National Office of Vital Statistics (NOVS), and consisted of three types: 1) weekly reports of deaths due to influenza-pneumonia from 108 cities in the United States as was used by Trotter,\textsuperscript{10} 2) final mortality data for specific causes of death for years up to and including 1958, and 3) the 10 percent sample of death certificates taken by the NOVS to obtain estimated death rates for major causes of death for years 1959 and 1960. The use of the 10 percent sample was necessary because of the lag in publication of final mortality figures.

It was also found that deaths due to influenza-pneumonia reached a maximum several weeks after the peak of influenza incidence.\textsuperscript{10} This lag of mortality peaking is felt to be due to the interval required for the epidemic to reach the older and more debilitated group in the population. Although the majority of deaths due to influenza-pneumonia occur in this age group the disease tends to reach this group later
than younger, healthier sub-population groups due to the former's semi-isolation from the community. Did rural excess deaths lag behind urban deaths in time due to their further isolation causes by rural living conditions? The author examined this question.

Housworth and Langmiur suggested that excess deaths from all respiratory causes rather than those due only to influenza-pneumonia are the most suitable index for global comparisons of the severity of influenza epidemics. This conclusion was based on their studies of excess deaths from respiratory causes in the United States, England, and Wales during 1957-1966.\textsuperscript{12}

Eickhoff, et al.,\textsuperscript{11} also stated that a better measure of the impact of an epidemic is in measuring mortality due to all causes rather than those deaths due only to influenza-pneumonia. While the latter may be a more sensitive measurement of influenza activity, the total community involvement can best be examined by the former method. Almost 85 percent of the excess deaths occurring in these two epidemic periods were attributed to two broad categories: influenza-pneumonia and cardiovascular-renal (CV-renal) disease. CV-renal disease alone accounted for over one-half of the 87,000 excess deaths during these periods studied.

It has been found that in general, the smaller the total excess death rates from all causes in an epidemic, the higher the proportion of that excess is credited to causes other than influenza-pneumonia. A fairly consistent lowering in total excess death rates since the pandemic of 1918-19 has been shown and the general trend of annual
death rates from influenza-pneumonia in the death registration states has been declining except for 1918-19.\textsuperscript{9}

Collins\textsuperscript{9} also noted that characteristics of epidemics tend to be similar in different places in the United States. One such characteristic is that peaks of excess influenza-pneumonia deaths appear to be accompanied by small peaks of death credited to other causes. To obtain death rates for these other causes, weekly excess death rates from influenza-pneumonia can be subtracted from the excess death rates from all causes for the same weeks. Data from 1918-1956 showed small peaks for other causes of death corresponding with peaks for influenza-pneumonia. However, when the population is divided into rural and urban sub-populations, did these corresponding peaks for other causes of death occur within each sub-group?

In the time period from 1968 through 1973 deaths from respiratory diseases were studied. There occurred a very high number of deaths from respiratory diseases in 1968-69 in the United States. Other countries experienced only mild to moderate amounts of excess deaths for the same time period. In 1969-70, other countries experienced a high number of excess deaths while the United States had only a moderate amount. Low excess mortality was experienced worldwide in 1970-71 and moderate levels of excess mortality were experienced in 1971-72 and 1972-73.

Housworth and Langmiur\textsuperscript{12} were of the viewpoint that although total excess mortality provides the most accurate measure of the impact of an influenza epidemic on a population in mild and moderate epidemics, the deviations above a baseline of expected deaths are proportionately
small and hence statistical procedures become complex. Excess mortality from total respiratory causes has been found to be a more useful and practical index of influenza activity in the United States. This index of excess deaths from respiratory causes has also been found to be the most practical index for international comparisons of monthly mortality statistics over a period of years.

The authors found a tendency of influenza A epidemics to occur two to three years apart. England and Wales appear to be in a two year cycle and the United States in a three year cycle. During a three month period in January through March, 1963, bronchitis was the most frequently listed cause of death in England and Wales, while pulmonary emphysema was frequently recorded in the United States, but not in England and Wales.

Farr\textsuperscript{12} in his study of the influenza epidemic of London in 1847 showed that an excess of deaths ascribed not only to influenza, but also to pneumonia, bronchitis, and other respiratory disease as well as many non-respiratory diseases.

Pearl\textsuperscript{13} was one of the first to utilize the concept of excess mortality to study influenza epidemics in the United States. He showed that ailments of the heart, lungs, and kidneys were associated with increased mortality during influenza epidemics.

Housworth and Langmuir\textsuperscript{13} studied seven epidemic periods in the time period 1957-66. Their results showed that excess mortality rates for these epidemic periods were higher for diseases of the heart, circulatory, and nervous systems, than for diseases of the respiratory system. The highest percentage of excess deaths credited to disease
of these three non-respiratory systems was associated with the influenza B epidemic of 1962. At the same time the lowest percentage of deaths credited to all other causes was during this same epidemic. Interest was also shown by these authors in the change in percent distribution from the first wave of illness in October through December, 1957, to the second wave of illness in January through March, 1958, where the proportion of excess deaths from respiratory disease decreased from 37 to 27 percent of the total. Housworth and Langmiur also found that deaths credited to respiratory diseases constituted consistently less than 50 percent of the total excess deaths. Actual proportions were approximately 30-38 percent in severe epidemics to less than 25 percent in milder epidemics. Excess deaths due to diseases of the heart, circulation, and nervous systems were greater than 50 percent of the total excess deaths in all epidemics except the first wave in October through December, 1957. Excess mortality from tuberculosis, asthma, and chronic rheumatic heart disease was significant only during the more intense A-2 influenza epidemics. Arteriosclerotic heart disease was the only sub-classification other than influenza-pneumonia which showed a significant excess number of deaths during all seven epidemic periods. Infant deaths showed no excess number of deaths synchronous with major influenza epidemics.

In studying the effects of chronic disease on mortality rates Eickhoff, et al., \(^{10}\) obtained a crude index of seasonal expectancy by computing a two year average for each disease category from data of comparable months of the non-epidemic years September, 1956 through August, 1957, and September, 1958, through August, 1959. CV-renal
disease death rates were markedly higher during epidemic periods than in corresponding months of non-epidemic periods. Proportionate increases in death rates during epidemic periods were found in four components of CV-renal disease. These four components were heart disease, vascular lesions of the CNS, hypertensive heart disease, and generalized arteriosclerosis. No definite influenza-associated increase in death rates due to malignant neoplasia was found.

It was also found that a small but consistent deficit of observed deaths below the expected deaths occurred several months after the 1957-58 epidemic. This was observed in death rates due to all causes—major CV-renal disease and its four components. These deficits may represent a "compensatory" phenomenon in which those persons who might have died within six to twelve months of their primary disease alone died a premature death due to epidemic influenza. It should be noted however, that this deficit amount was small in every case. This suggests that those who died might have lived considerably longer rather than those severely debilitated persons in whom influenza is a terminal event. 10

In their study, Mortality from Influenza, Dauer and Serfling, 5 found that a ten percent sample of death certificates submitted each month by each state showed a well defined rise in mortality from influenza-pneumonia in the period October, 1957 through March, 1958, with an apparent coincident rise in mortality from other causes. These other causes were mainly cardiovascular diseases. The peak of mortality in the 1957 through 1958 epidemic in the United States was approximately the same level as the peak in March, 1950 and 1951, and
slightly below the peak in February, 1953. However, the length of time of the increased level of mortality period was much longer in 1957-58 than in previous years. This long period of increased mortality resembled the 1918-19 pandemic, because it too was characterized by biphasic mortality lasting a long period of time.

Since 1918-19 when 92 percent of excess deaths were due to influenza-pneumonia, a gradual decrease in this percentage has occurred. Simultaneously, a corresponding increase in excess deaths due to other causes, primarily cardiovascular diseases, has occurred. Excess mortality due to influenza-pneumonia has not been greater than 20-25 percent of the total excess in epidemics in the past ten to fifteen years. CV-renal disease accounted for slightly less than 50 percent of excess mortality during October-December, 1957, and January-March, 1960. However, in January-March, 1958, the second wave of excess mortality of the 1957-58 epidemic showed that CV-renal disease had accounted for 65 percent of the excess.5

A Pennsylvania study of the A2/Hong Kong/68 influenza virus epidemic in the winter of 1968-69 yielded information that six disease categories showed significant correlation with influenza activity. These were heart disease (30.3 percent of the total excess deaths in the 1968-69 epidemic), influenza-pneumonia, CVD, diabetes, bronchitis, and asthma.14

Eickhoff, Sherman, and Serfling found that the most sensitive statistical measure of the extent of an influenza epidemic used data obtained from weekly mortality reports from 108 cities.11 Using methods developed by Serfling,2 expected mortality curves were
constructed. Average seasonal expectancies for the baselines were figured and an epidemic threshold line was constructed 1.65 standard deviations above the expected mortality baseline curves.

Rubin and Gregg\textsuperscript{15} stated that observation of influenza epidemics for many years supported the fact that of all infectious diseases, only epidemic influenza produces excess mortality above that which would be expected. Charts were prepared to graphically show the reported number of deaths. These charts consisted of lines representing a significant deviation from expected numbers of deaths. This method was developed by Robert E. Serfling,\textsuperscript{2} and uses a computer for determining the curves for expected deaths and the epidemic threshold. This procedure was briefly outlined by Serfling, Sherman, and Housworth as follows:

1) Months included in epidemic periods were deleted from the observed rates.

2) A function was then fitted to the remaining monthly data for non-epidemic periods.

3) The expected (or non-epidemic) rate was obtained from the fitted curve.

4) Excess mortality rates were calculated by subtracting the expected rate from the observed rate for each month included in the epidemic periods.\textsuperscript{16}

One form of influenza surveillance used by CDC is the tabulating of weekly reports of mortality due to influenza-pneumonia from 121 cities throughout the United States and using the method developed by Serfling to graphically represent this data. This weekly
tabulation of deaths reflects the extent and impact of influenza, but suffers from a three to four week lag behind the actual clinical symptoms.\textsuperscript{15} Another problem with this system is that data obtained from it represents an urban population. The rural population is missed and little has been known about excess mortality in these areas in the United States. Also, data has been based on large population densities and frequencies which are not available in rural populations.

The World Health Organization studied excess mortality from respiratory diseases in 13 countries since 1970.\textsuperscript{17} Seasonal mortality curves were computed based on data from the preceding five to ten year period. Weekly records were grouped into four-week periods so that comparisons with countries who supplied only monthly data could be made. The epidemic year ran as a time period from April 1 through March 31, so that expected seasonal mortality curves incorporating data from the previous winter could be available before the start of the next influenza season in the northern hemisphere.

The WHO study by Assad, et al.,\textsuperscript{17} also used the Serfling method for constructing mortality curves and thresholds. A computer curve was constructed to show expected seasonal mortality from respiratory diseases. An estimated secular trend was built into the curve based on the number of deaths occurring during the four-week periods of low mortality. Determination of the expected seasonal variation used two data sets. Set 1 was comprised of deaths in years of low mortality during which no known sizeable outbreaks of influenza occurred. Set 2 was comprised of deaths in all years under study with the exception of
those years with very high peaks. However, experience has shown that the seasonal curve from Set 2 is entirely adequate for comparisons.

Results of this study showed that the period from 1963-1973 can be divided into two parts, before and after Influenza A/HK/1/68 (H3N2). Data for the United States showed very low mortality in 1963-64, small to moderate excess in 1965-66, markedly lower than expected mortality in 1966-67 and large excesses of mortality in the winter of 1967-68.17

The WHO study suggested that a proportion of deaths associated with influenza may have been attributed to other causes (e.g., cardiac disease). Figures for deaths from all causes were tallied for four week periods of both low and peak total mortality. These were found to correlate with data from deaths due to respiratory diseases.17

The 1968-69 influenza epidemic in Pennsylvania was studied by Hrehorovich, et al.14 Mortality figures for January, 1961 through May, 1969 were reviewed and expected rates for causes of death were calculated by fitting data to a curve using the method developed by Serfling.

Results showed that the observed number of the influenza-pneumonia deaths exceeded the epidemic threshold during the winters of 1962-63, 1964-65, 1967-68, and 1968-69, the last being the largest excess since 1962-63. A comparison of influenza-pneumonia mortality with total mortality showed a significant increase in deaths due to causes other than influenza-pneumonia during periods of influenza activity. Heart disease, CVD, diabetes, bronchitis, and asthma
exceeded their expected mortality level above the epidemic threshold during periods of influenza activity.\textsuperscript{14}

The authors of this study determined that calculating the total excess mortality during an influenza epidemic is the most direct method of assessing the extent and severity of the epidemic and its impact on the community. However, they also determined that this is less sensitive index of influenza activity than the number of excess deaths due to influenza-pneumonia. Mortality data for this study was obtained from death certificates issued throughout Pennsylvania. However, no distinction was made to separate population groups into rural-urban classifications. Therefore, it was not known whether or not conclusions made in this study were representative with respect to both sub-groups. Much has been known about urban populations due to data collection such as that used by CDC with data from 121 cities. Little has been known, however, about the effect of influenza on rural populations. It was expected that similar trends and results occur for this group as in the urban population. This question was investigated in this study.
CHAPTER III

METHODS

A standard was established to show evidence of influenza activity during the time period being studied. This provided data to which rural data was compared.

A standard of expected numbers of deaths was generated from data available on influenza-pneumonia deaths and total deaths for the East-North Central region of the United States comprised of the states of Illinois, Indiana, Michigan, Ohio, and Wisconsin including the eight major urban areas in Ohio.

The method used for establishing expected numbers of deaths was described by McDonald. This method involved using the monthly averages of the best three of the six years prior to an epidemic period to establish an expected number of deaths. The "best" three years were defined as those years with the lowest number of deaths due to respiratory causes. In this study influenza-pneumonia deaths were used due to the availability of this data. The months of September through March of each influenza season were used to provide data for this. Data was used from the years 1963-64, 1964-65, and 1966-67 to establish expected numbers of deaths for the epidemic year 1967-68. Weekly averages were used to determine expected numbers of deaths.

The actual numbers of deaths occurring during the epidemic periods were then compared with the expected numbers of deaths for
each period. This established whether or not an epidemic did occur in Ohio during this period that could be observed by excess deaths as expressed in total and influenza-pneumonia deaths.

After having generated data for eight urban counties (See Appendix) based on total deaths and deaths due to influenza-pneumonia, activity levels of other diseases and disease categories were established for these areas in Ohio. The previously described method for establishing expected numbers of deaths was used again for these diseases and categories of disease. Again, observed deaths were compared with expected deaths to determine whether or not excess deaths occurred due to these diseases. Single disease and groups of diseases were compared to determine which were more sensitive to changes in influenza activity.

Data for rural counties in Ohio was manipulated in the same manner as data for urban counties. Due to the great variety in population sizes rural counties were grouped in order to obtain large enough populations to establish relatively stable expected numbers of deaths for influenza periods.

The grouping consisted of dividing Ohio into four geographic districts—Northeast, Northwest, Southwest, Southeast. The Northeast district was made up of 12 counties with a total population of approximately 1,340,000. The Northwest district was composed of 25 counties with a total population of approximately 1,200,000. The Southwest district contained 17 counties with a total population of approximately 1,300,000. The Southeast district consisted of 26 counties with a population of approximately 1,180,000. These four
districts represented populations of approximately the same size. The Northwest and Southeast districts were studied (See Appendix).

Establishment of expected numbers of deaths for the epidemic period studied and determination of excess numbers of deaths in the rural populations were determined by methods previously described for use in urban population data. This determined whether or not an influenza epidemic occurred in the same year in the rural population as in the urban population.

As in the urban populations, specific disease categories and groupings of these categories were compared in the same way to determine which were the most sensitive to changes in influenza activity in rural populations.

The temporal occurrences of influenza activity were also compared between rural and urban populations. The peak of influenza activity was determined by noting the week (s) in which the number of excess deaths occurring was greatest. The duration of an epidemic was determined by the number of successive weeks in which excess deaths occurred above the expected number of deaths. These two factors were determined for the urban and rural populations and compared as to temporal occurrence.

The beginning of an epidemic was also studied to determine whether or not rural populations "lagged" behind urban populations in developing an epidemic. This gave evidence as to whether or not urban populations were "seeded" first with the influenza virus which then spread to rural areas or vice-versa.
The occurrence of a rise in reported morbidity was studied and compared temporally with rises in reported mortality for the period.
CHAPTER IV
MATERIALS

Data for the East North Central region of the United States and the eight major urban areas of Ohio for all causes of death and influenza-pneumonia deaths was available from the "Morbidity and Mortality Weekly Report" (MMWR) published weekly by CDC. This data was available from January, 1963 to the present time. Data was tabulated on a weekly basis.

Data for each county in Ohio was compiled by the Division of Vital Statistics in the Bureau of Supportive Services of the Ohio Department of Health. Data was supplied as to the number of deaths for all causes and for selected causes coded by the International Classification of Diseases. These selected causes included total from all causes, diseases of the heart, cerebrovascular diseases, respiratory diseases, influenza and pneumonia, and all other causes.

The data was also classified by day and week of death for each county.

Therefore, for each cause of death the number of deaths by day and week for the years 1963-68 were compiled and printed for each county in Ohio.

Morbidity data was obtained from weekly morbidity reports compiled for Ohio by the Ohio Department of Health.
CHAPTER V

RESULTS

Most of the information obtained from this study is presented graphically. Therefore an explanation is in order on how the graphs were constructed. Graphs were thought to be a good way to visually show changes from expected numbers of deaths. It was found, however, that graphing of individual weekly numbers of deaths resulted in a figure with many sharp spikes that were visually confusing. Using a three week average for each point on the graph was found to result in a smoother graph that remained fairly sensitive to changes from expected number of deaths.

Evidence of an epidemic occurring during 1967-68 is shown by the extended period of excess deaths present in the eight Ohio cities reporting in the MMWR published by CDC (Figure 1). These cities include Akron, Canton, Cincinnati, Cleveland, Columbus, Dayton, Toledo, and Youngstown. The epidemic period most graphically seen lasted approximately eight weeks--from week 51 through week 7. The large dip in expected numbers of deaths around weeks 52 and 1 are reflected in all graphs.

The epidemic occurred in both the urban and rural populations being studied. Using results for the category of total deaths due to all causes it can be seen that the epidemic period in the urban and rural populations was about 8 weeks in length and occurred at
Figure 1: Three Week Average of Total Deaths Due to All Causes in Eight Ohio Cities*, 1967-68

*Source: MMWR-CDC
approximately the same time in all populations. This period of excess deaths lasted from week 51 to week 7 (Figures 2, 3, and 4).

The peak week of excess deaths was week 2 in all populations. Also interesting is the fact that during this peak week the percent rise of observed deaths over expected deaths was between 16-18 percent in all three populations for the category of total deaths. Corresponding peaks of other disease categories being studied mirrored each other and the peak of deaths due to influenza-pneumonia in both urban and rural population. Figures 2, 5, and 8 show similar peaks and durations of excess deaths in the urban population. Figures 3, 4, 6, 7, 9, and 10 show similar peaks (week 2) and duration (approximately 8 weeks) of excess deaths in both rural populations. Similar results were found in other disease categories not illustrated (CVD, Resp., CVD+P/I).

The best indicators for excess deaths appear to be heart disease and total for all causes. Figures 2 and 5 for the urban population and Figures 3 and 6 for the S.E. rural population can be compared to Figures 8 and 9 for these same populations. It is obvious that heart and total deaths categories graphically show more change due to excess deaths than the most commonly used category of deaths due to influenza-pneumonia. It was also found that the categories of cerebrovascular deaths and respiratory deaths were no more sensitive graphically than influenza-pneumonia deaths. Combining the categories of cerebrovascular deaths and influenza-pneumonia deaths or respiratory deaths and influenza-pneumonia deaths also did not appear to provide more sensitive disease categories for
Figure 2: Three Week Average of Total Deaths Due to All Causes—Urban Ohio Counties, 1967-68
Figure 3: Three Week Average of Total Deaths Due to All Causes—S.E. Rural Ohio Counties, 1967-68
Figure 4: Three Week Average of Total Deaths Due to All Causes—N.W. Rural Ohio Counties, 1967-68
Figure 5: Three Week Average of Deaths Due to Heart Disease--Urban Ohio Counties, 1967-68
Figure 6: Three Week Average of Deaths Due to Heart Disease--S.E. Rural Ohio Counties, 1967-68
Figure 7: Three Week Average of Deaths Due to Heart Disease—N.W. Rural Ohio Counties, 1967-68

OBS. DEATHS

EXP. DEATHS

Week #  36  40  44  48  52  4  8  12

1967  1968
Figure 8: Three Week Average of Deaths Due to Influenza-Pneumonia—Eight Urban Ohio Counties, 1967-68
Figure 9: Three Week Average of Deaths due to Influenza-Pneumonia--S.E. Rural Ohio Counties, 1967-68
Figure 10: Three Week Average of Deaths Due to Influenza-Pneumonia—N.W. Rural Ohio Counties, 1967-68
epidemic surveillance. Similar results for the N.W. rural population were obtained (Figures 4, 7, and 10).

An interesting result of the study of the two rural populations is that while at least superficially they appear to be two different types of rural populations and geographically distinct, similar rises and peaks in excess deaths during the epidemic period occurred. This indicates that the influenza epidemic had similar effects on both populations as far as mortality data is concerned. The similarity in results for total deaths, heart disease deaths, and influenza-pneumonia deaths can be seen in Figures 3 and 4 for total, 6 and 7 for heart, and 9 and 10 for influenza-pneumonia.

The most sensitive indicator for excess deaths during an influenza epidemic in rural populations appears to be heart disease. The most easily observed deviation from expected deaths of any category used was heart disease with a very distinct rise and fall in numbers of excess deaths (Figures 3 and 4). Table 1 shows net numbers of excess or deficit (below expected) deaths for the 29 week study period. Here again the distinct rise and fall in numbers of excess deaths for heart disease can be seen and compared to the other categories. Respiratory disease also appears to be a fairly sensitive indicator but its response begins later in time than does heart disease and extends somewhat beyond the end of the epidemic as do most of the other categories.

A deficit in observed deaths following an influenza epidemic is expected to occur and does, as can be seen in all graphs for all categories and populations. This deficit appears to last generally for approximately 1.5 - 2 weeks after the epidemic. However, a
TABLE 1: NET DEATHS IN RURAL POPULATIONS FOR SELECTED CAUSES OF DEATH--FIVE WEEK PERIODS*, 1967-68

**N.W. RURAL**

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(−) deficit deaths in observed  
(+) excess deaths in observed

*Period #1 is four weeks long due to the entire study time period of 29 weeks.*

37
deficit in observed deaths immediately preceding the epidemic period is also observed. This deficit is especially obvious in deaths due to heart disease in both rural populations (Figures 6 and 7). This deficit occurs in the four weeks immediately prior to the beginning of the epidemic. Similar deficits can also be observed in the total and influenza-pneumonia deaths categories (Figures 3, 4, 9, and 10). The deficit does not appear for the urban population in total deaths and is not as prominent in heart and influenza-pneumonia deaths (Figures 2, 5, and 8).

Influenza morbidity for the State of Ohio began its epidemic period about three weeks prior to the rise in urban mortality. Table 2 shows that reported morbidity began a consistent increase over the expected numbers of cases about week 48 and continued this increase to the end of the study period. Excess mortality for the urban population began its epidemic period in week 51 and ended at week 7.
TABLE 2: COMPARISON OF THE THREE WEEK AVERAGE OF REPORTED CASES OF INFLUENZA AND MORTALITY FROM HEART DISEASE, OHIO, SELECTED YEARS

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Epidemic weeks are underlined

Morbidity=State-wide (Ohio) for Influenza
Mortality=Eight Urban Counties (Ohio) for Heart Disease
CHAPTER VI

DISCUSSION

This study has attempted to empirically compare the effect of an influenza epidemic on urban and rural populations in Ohio, using the concept of excess mortality. Some of the observed results of this study should be discussed.

The first item that should be observed is the lack of "lag-time" in the epidemic reaching rural populations as compared to it reaching urban populations. The peaks and durations of excess deaths in all three populations studied support the observation that in spite of the greater isolation of rural populations the epidemic was not delayed from affecting the population as reflected in mortality data. This is contrary to findings in most previous epidemics studied—especially the pandemic of 1918 in which it appeared that rural populations experienced increased numbers of deaths well after urban populations in time. This difference is probably due to the increased mobility of people and greater mixing of populations due to improved transportation.

The "mirroring" of influenza-pneumonia excess deaths in other selected disease categories served to illustrate the mortality effect of influenza-pneumonia disease on other already existing chronic disease problems. This supports the popular hypothesis that influenza-pneumonia disease prematurely increases the mortality in those persons
who would probably die within a short time period whether or not other factors (influenza-pneumonia disease) occurred.

Heart disease and total deaths due to all causes appeared to be the best indicators of excess deaths in the populations studied. The main reason for this is probably that these categories of disease contributed the greatest numbers of deaths thereby making changes from expected numbers of deaths more easily observable and more likely significant. Other categories of diseases, especially in rural populations, provided numbers of deaths too low to accurately reflect changes from expected deaths that were probably due to an influenza epidemic.

Heart disease appeared to be the most sensitive indicator of excess deaths due to an influenza epidemic in rural populations. It most accurately reflected a rise in observed deaths to an excess level and then a decrease in these deaths to a more expected level following the epidemic period. Although respiratory disease was also a fairly sensitive indicator at the beginning of an epidemic period it did not clearly indicate the end of the period.

The deficit of observed deaths immediately prior to the epidemic period is an interesting if not a readily explainable observation. The deficit of deaths immediately following the period is predictable based on the hypothesis that the deaths observed during the epidemic period represent premature deaths in those with chronic diseases. Another factor of this deficit prior to the epidemic might well involve weather conditions present during this time period. These
conditions were not studied. However, they must be considered as possible contributing factors in the causes of death.

The delay in mortality as compared to reported morbidity was also observed in this study. One may infer that it took longer for the epidemic to affect those most seriously at risk from dying due to their social isolation from large heterogeneous groups of people. Another observation was that death is delayed with reference to the time people had their influenza infection.

The geographic differences in the two rural populations were not reflected in the figures illustrating excess deaths. These two populations are somewhat different, at least superficially, based on the nature of their populations and land use. This suggests that the empirical excess death data may be similar for other rural areas of Ohio.

Review of the data suggests that the number of consecutive weeks of excess deaths needed to indicate a significant epidemic rise appeared to be four. The CDC, using the Serfling method, considers a consecutive excess of at least two weeks to be significant. It does not appear that this two week excess can be applied to the method used in this study due to the fact that the expected numbers of deaths curve is too variable to allow this short a period of excess deaths to be significant.

Some technical limitations should also be noted. First, the actual number of weekly deaths presented some problems graphically in providing easy interpretation of the data. The use of a three week running average for each point on the graphs was necessary to remedy
this problem. The three week method provided less variability in numbers of deaths while allowing deviations from expected numbers of deaths to be easily observed. This averaging method was especially useful in working with the rural populations whose data consisted of relatively small numbers. The use of a running average of greater than three weeks might have reduced the variability to a point where deviations could not be easily observed. It was felt that the use of a three year average for expected numbers of deaths yielded reasonable numbers of expected deaths.

An interesting question that could not be answered by this study concerned the severity of the epidemic. The relative severity of this epidemic cannot be determined by this study alone. Other epidemic periods should be studied so that a comparison of total excess deaths occurring over the epidemic period can be made. The comparative severity of different strains of influenza might also be studied in this way.

While this study provides preliminary data and results on urban and rural populations as determined and presented by this method, these results require validation. The reproducibility of these results in other epidemic and non-epidemic years should be tested. Repeatability of results is probably the most important test of their validity. Non-epidemic period studies should help to determine whether or not results obtained in this study are observed exclusively during epidemic periods. In studying other epidemic periods it would be useful to employ those caused by different influenza strains, so that it may be determined whether or not they are characteristic of influenza.
strains other than the A2 strain, type prevalent during the time period included in this study.

Data for both rural populations studied was derived from relatively small population bases. Both populations were approximately 1.2 million. The question of how small the population base can be and still provide useful results should be investigated. Lower limits should be established so that future investigators of this problem have some idea of the minimum population to which it can be applied. This might be accomplished by grouping rural counties by population rather than geographically.

Lastly, a statistical examination of empirical data is an important tool in establishing the validity of the results. Statistical significance of these results would reinforce the usefulness of this empirical method. The relatively low numbers of deaths contributing to the differences observed in rural populations make conclusions about what actually occurred and why it occurred somewhat precarious. In addition statistical limits should be generated to determine the number of excess deaths during any time period that is a significant deviation from the expected number of deaths for that same time period.

Thus while the results obtained appear very promising, they should be viewed as being preliminary and requiring many types of validation before being applied as a routine surveillance tool. Should they be reinforced they would be quite helpful in assisting in the assessment of the effects of influenza in limited populations.
CHAPTER VII
CONCLUSIONS AND SUMMARY

The 1967-68 influenza epidemic resulted in excess deaths occurring at approximately the same time in both urban and rural populations being studied. These populations temporally had the same peak and duration of excess deaths over this epidemic period. Excess deaths due to selected disease categories other than influenza-pneumonia reacted the same way in all populations studied and mimicked results of influenza-pneumonia excess deaths. Death due to heart disease was the most sensitive index of excess deaths during an influenza epidemic in both rural populations studied. Geographic differences between the two rural populations did not appear to be significant.

Eight urban Ohio counties and fifty-one rural counties in two areas in Ohio were compared for effects of an influenza epidemic in 1967-68 using the concept of excess mortality to measure these effects. The method used was derived from McDonald and involved comparing observed deaths from the epidemic period with expected deaths for that period. Deaths due to different disease categories were compared. Little temporal difference in occurrence of excess deaths was found between the three populations studied. Heart disease was found to be the most sensitive index of excess mortality associated with the influenza epidemic in both rural populations.
# APPENDIX

## Counties Used in this Study

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**TOTAL POPULATION**

- **5,800,500**
- **1,216,000**
- **1,178,000**

*Source: 1970 U.S. National Census*
References


