Journal of Historical Geography, **6**, 2 (1980) 179–202

Mortality differentials between rural and urban areas of states in the northeastern United States 1890–1900

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Data from a number of countries show much higher mortality rates in urban than in rural areas in the nineteenth century. In this paper we examine the urban-rural mortality differential in the death registration states of the United States in 1890 and 1900. Before proceeding with the analysis, the data are evaluated and we determine that the data used for the 1900 analysis are more complete than data used in other analyses for the same date. An attempt is made to correct for the deficiencies in the 1890 data. When the urban and rural mortality levels are examined for individual states at both dates, urban mortality is generally higher than rural mortality. However, there is variability across states in urban mortality levels, rural mortality levels, and the urban-rural mortality differences. In general, the urban-rural mortality difference is larger in 1890 than in 1900. When the urban-rural mortality differences are examined in terms of the causes of death which account for the differential, we conclude that higher urban mortality rates are generally attributable to a few diseases—tuberculosis, diarrheal diseases and several other communicable diseases—the transmission of which depend heavily on close human contact or contamination of the environment.

Research[1] on the mortality experience of the United States in the nineteenth century has generally shown a fairly large and persistent rural-urban differential in mortality.[2] Urban mortality which is significantly higher than rural mortality has also been observed in the history of a number of other developed countries.[3]

Although cities may often have had better data collection systems than rural areas, the mortality differentials in most studies have been large enough that a real difference in mortality is assumed to have existed. Theoretical arguments lend credibility to the empirical findings by suggesting that high population

[1] The research on which this paper is based was partially supported by grants from NICHD (1–RO1–HD–05427) and NIA (1 RO1 HG AG 11745–01POP). Valuable assistance in this research was provided by Nancy Neuman, Rutgers University and Mahmoud S. A. Issa, University of Pennsylvania

[2] Yasakichi Yasuba, *Birth rates of the white population in the U.S., 1800–1860: an economic study* (Baltimore 1962); Robert Higgs, Mortality in rural America, 1870–1920: estimate and conjectures *Explorations in Economic History* **19** (1973) 177–93; Conrad Taeuber and Irene B. Taeuber, The changing population of the United States (New York 1958); Louis I. Dublin, Alfred J. Lotka and Mortimer Spiegelman, *Length of life* (New York 1949)

[3] John Knodel, Town and country in nineteenth-century Germany: a review of urban-rural differentials in demographic behavior *Social Science History* **1** (1977) 356–82; Kingsley Davis, Cities and mortality *International Population Conference* **3** (Liege 1973) 259–82; D. V. Glass, Some indicators of differences between urban and rural mortality in England and Wales and Scotland *Population Studies* **17** (1964) 263–67

0305–7488/80/020179 + 24/$02.00/0

density, overcrowding, inadequate water supplies, and inadequate sewage disposal systems aided in the spread of infectious diseases and contributed to high urban mortality levels in the nineteenth century.[1] While certain diseases (e.g., cholera, typhus and smallpox) declined earlier than others, urban mortality in general appears to have remained high and may even have been rising until late in the century, while rural mortality levels were probably declining earlier.[2]

Therefore, the demographic transition which is assumed to have accompanied the shifts from largely agricultural to heavily industrial economies and from predominantly rural to predominantly urban populations in many countries, may have been, at least with regard to mortality, a fairly complex phenomenon. The differences in both the levels of mortality and in the timing of the mortality transitions in rural and urban areas are no doubt a reflection of differences in the underlying factors affecting mortality levels in areas of different size and density. The analysis of differential urban and rural mortality has therefore become an important part of the recent increase in research on the history of mortality and the factors accounting for mortality decline.[3] Documentation of the extent of rural-urban mortality differentials adds not only to our knowledge of the demographic transition but also, because differential mortality influences population growth, to our understanding of the processes of urbanization and industrialization accompanying that transition.

In this paper, we focus on the differential mortality of urban and rural areas in the United States in 1890 and 1900. The existence of a fairly large rural-urban differential in mortality in those years and earlier in the nineteenth century has been documented in a number of previous studies. Jaffe and Lourie constructed life tables for 1830 showing expectations of life at age five of 54 years in rural areas, 47 years in small cities and 36 years in large cities.[4] Jaffe and Lourie's mortality rates for rural areas were constructed using data from 1826 to 1835 for 40 rural Massachusetts towns and 6 other rural New England towns. They estimated mortality rates for small cities from data referring to Salem, Massachusetts and New Haven, Connecticut. Finally, they calculated mortality rates for large cities using mortality records from New York, Philadelphia, and Boston. On the basis of Jaffe and Lourie's results, Yasuba assumed a ratio of urban to rural childhood death rates of somewhere between 1·5:1 and 2:1.[5] He assumed a constant urban to rural mortality ratio across the country and estimated state death rates adjusting for the rural-urban distribution of the population in each state.

[1] Taeuber and Taeuber, *op. cit.*; Yasuba, *op. cit.*; Edward Meeker, The improving health of the United States, 1850–1915 *Explorations in Economic History* **9** (1972) 353–74; Edward Meeker, Public Health and medicine in Glenn Porter (Ed.), *Dictionary of American economic history* (New York forthcoming); Dublin, *et al.*, *op. cit.*

[2] Edgar Sydenstriker, *Health and environment* (New York 1933); John K. Gore, On the improvement in longevity in the United States during the nineteenth century *Proceedings of the Fourth International Congress of Actuaries* **1** (1904); Taeuber and Taeuber, *op. cit.*; Gretchen A. Condran and Eileen Crimmins-Gardner, Public health measures and mortality in U.S. cities in the late nineteenth century *Human Ecology* **6** (1978) 27–54

[3] Michael R. Haines, Mortality in nineteenth century America: estimates from New York and Pennsylvania census data, 1865 and 1900 *Demography* **14** (1977) 289–312; Fogel, Robert W., *et al.*, The economics of mortality in North America 1650–1910: a description of a research project *Historical Methods* **11** (1978) 75–108; Higgs, *op. cit.*; Thomas McKeown, *The Modern Rise of Population* (New York 1976)

[4] A. J. Jaffe and W. I. Lourie, Jr, An abridged life table for the white population of the United States in 1830 *Human Biology* **14** (1942) 352–71

[5] Yasuba, *op. cit.*

Vinovskis[1] calculated crude death rates for rural areas and two city-size groups in Massachusetts and suggests that the difference between rural and urban areas in 1830 was smaller than that reported by Jaffe and Lourie. His argument is based on two points. First, towns with incomplete registration systems were included in the rural category in Jaffe and Lourie's calculation. Second, the inclusion of Philadelphia and New York in the Jaffe and Lourie urban category increased the rural-urban differential by compounding it with regional differences.

> Jaffe and Lourie's aggregate data suggested a difference of 19·8 deaths per thousand between the largest cities and rural communities. However, the data on Massachusetts, after adjusting for anticipated under-registration of rural deaths, reveals a difference of only 6·3 per thousand. In addition, though Jaffe and Lourie found a difference of 16·5 deaths per thousand between large and small cities, the difference between Boston and Salem is only 3·2 deaths per thousand during that decade. Consequently, the significance of the rural-urban differences in mortality rates set forth by Jaffe and Lourie is greatly reduced. In short, if their average crude death rates based chiefly on Massachusetts data, do not represent the probable experience of Massachusetts, then there is serious doubt as to whether the death rates derived by Jaffe and Lourie can represent the experience of the United States as a whole. Whether this is so must await further research on other parts of the country.[2]

Vinovskis extended his work to 1860, and found that although the rural-urban differential in mortality in Massachusetts is smaller than that suggested by Jaffe and Lourie, rural towns did have lower death rates than Boston and Salem, in both 1830 and 1860.

Higgs estimated rural mortality for the country as a whole from 1870 to 1920 using Kuznets' census-survival estimates of the aggregate crude death rate and estimates of urban mortality from registration cities. By estimating an upper limit on the urban crude death rate and a consequent lower bound on the rural crude death rate, he obtained the following upper bounds for the ratios of urban to rural mortality:[3]

Decade	*Ratio*
1870–1880	1·38
1880–1890	1·50
1890–1900	1·35
1900–1910	1·33
1910–1920	1·21

Higgs' work suggests that rural and urban mortality rates were both declining after 1870, but for most of the time urban mortality was declining more rapidly than rural, leading to a decrease in the differential over time.

Several major questions are left unanswered by this previous research on the rural-urban mortality differential. First, the actual size of the differential and its

[1] Maris Vinovskis, Mortality rates and trends in Massachusetts before 1860 *The Journal of Economic History* **32** (1972) 184–213

[2] *Ibid.* 305

[3] Higgs, *op. cit.* 183. In Higgs' analysis the lower bound for urban mortality and the upper bound for rural mortality are equal, and therefore using these figures produces an urban/rural ratio of 1·0 for every decade

variation over time have not been firmly established. Second, whether the differential is constant across geographic areas remains to be studied. And finally, none of the above research has addressed the question of what causes of death account for the differential and what these causes of death suggest about the factors underlying the differences in rural and urban mortality.

The data

We can make some progress toward answering these questions by using county and city level mortality data for registration states published in the federal censuses of 1890 and 1900. By 1890 Connecticut, Delaware, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont were covered by systems of death registration. In 1900 the registration states included all of the above except Delaware, while Maine and Michigan were added to the registration area. The mortality data published in the federal censuses refer to deaths occurring in the twelve months preceding the census date of 1 June and include the total number of deaths, the deaths to persons under one year of age, the deaths to persons under five years of age, and the deaths from a small group of causes. All of these are available for counties, rural parts of counties, and individual cities within counties. In our analysis, data have been aggregated to produce mortality rates for the rural and urban parts of each registration state. The mortality rates constructed from these data are shown in Table 1.

Division of states into rutal and urban areas

In these data, a standard definition of "urban" or "city" was not used. In both 1890 and 1900, a "city" could be any incorporated place, such as a city, town, village, or borough for which vital registration data were available and considered sufficiently accurate; however, in 1890 the minimum size of a city was 5,000 while in 1900 the minimum size was 8,000.[1] For the analysis reported here, county divisions in the seven states which were included in the registration area in both 1890 and 1900 were matched so that the places included in the rural and urban parts of counties are the same for the two dates.[2] The possibility of using a uniform definition of rural and urban has been sacrificed to allow us to examine changes over the decade in the mortality of uniform areas.

The rural and urban areas for the registration states as defined by matching areas over time do not differ greatly from those based on the definitions of rural and urban used in the published statistics. In the published data the number of deaths in the rural and urban parts of the registration states in 1900 are 110,003 and 191,667, respectively. Using our matched areas, these figures are 113,517 and 188,153. The effect of matching varies by state, however. In Massachusetts our definition of the rural and urban areas in 1900 is identical to that used in the published figures. At the same time, comparing our figures with published figures for 1900 shows that matching areas at the two dates results in 8% of the deaths in Connecticut, and 5% of the deaths in Vermont being shifted from urban to rural areas.

[1] U.S. Census Office, Census Bulletin no. 83 (Washington D.C. 1901)

[2] In Maine and Michigan, which are included in the registration area only in 1900, the rural and urban areas are defined as in the published volumes. Delaware is eliminated from the analysis because the quality of registration was thought to be significantly worse in Delaware than in the rest of the registration states. Delaware was eliminated from the registration area in 1900 for this reason

TABLE 1

Death rates, rural and urban parts of registration states, 1890 and 1900 (rates per 1,000 population)

	Total death rates			Infant death rates (under 1 year)			Childhood death rates (1–4 years)		
	Rural	Urban	Ratio urban/ rural	Rural	Urban	Ratio urban/ rural	Rural	Urban	Ratio urban/ rural
1890—Data unadjusted for underregistration									
Total (weighted average of 7 states)	16·0	18·8	1·18	123·9	184·0	1·49	13·3	26·2	1·97
Total (unweighted average of 7 states)	16·8	18·6	1·11	138·5	192·5	1·39	14·9	24·3	1·63
Connecticut	16·6	17·4	1·05	152·0	162·0	1·07	14·0	18·6	1·33
Massachusetts	17·1	17·9	1·05	128·3	190·8	1·49	13·8	22·7	1·64
New Hampshire	17·7	18·6	1·05	147·9	215·5	1·46	15·3	28·3	1·85
New Jersey	15·5	18·8	1·21	140·7	185·2	1·32	15·9	26·4	1·67
New York	15·3	19·2	1·26	102·4	180·7	1·77	11·3	28·1	2·49
Rhode Island	18·5	20·1	1·09	183·8	206·4	1·12	22·8	28·6	1·25
Vermont	16·9	17·8	1·05	114·5	206·8	1·81	11·2	17·1	1·53
Total (weighted average of 9 states)	15·4	18·5	1·20	119·3	182·9	1·53	13·0	25·5	1·96
Total (unweighted average of 9 states)	16·4	18·4	1·12	134·0	190·2	1·42	14·6	23·1	1·58
Maine	16·5	16·9	1·02	132·9	199·6	1·51	14·5	20·7	1·43
Michigan	12·5	13·3	1·06	103·9	165·1	1·59	12·2	17·0	1·39
1890—Data unadjusted for underregistration									
Total (weighted average of 7 states)	15·3	22·3	1·46	121·3	242·8	2·00	16·0	36·1	2·26
Total (unweighted average of 7 states)	16·7	20·8	1·25	138·1	227·0	1·64	19·2	32·6	1·70
Connecticut	17·1	20·8	1·22	143·0	186·0	1·30	19·4	32·2	1·67

TABLE 1—*continued*

Death rates, rural and urban parts of registration states, 1890 and 1900 (rates per 1,000 population)

	Total death rates			Infant death rates (under 1 year)			Childhood death rates (1–4 years)		
	Rural	Urban	Ratio urban/ rural	Rural	Urban	Ratio urban/ rural	Rural	Urban	Ratio urban/ rural
				1890—Data unadjusted for underregistration					
Massachusetts	17·0	20·1	1·18	130·0	227·6	1·75	17·9	31·9	1·78
New Hampshire	17·9	18·8	1·05	140·1	222·2	1·59	16·4	35·3	2·15
New Jersey	15·4	23·3	1·51	149·7	263·3	1·76	17·4	39·6	2·28
New York	13·7	23·3	1·70	99·5	249·5	2·51	13·3	37·3	2·80
Rhode Island	20·3	21·4	1·05	202·6	226·8	1·12	35·4	35·6	1·01
Vermont	15·7	17·6	1·12	101·5	211·7	2·09	14·7	16·1	1·10
				1890—Data adjusted for underregistration					
Total (weighted average of 7 states)	18·2	23·2	1·27	154·2	251·2	1·63	18·0	37·3	2·07
Total (unweighted average of 7 states)	19·7	21·7	1·10	154·7	236·4	1·53	21·5	34·0	1·58
Connecticut	19·0	21·8	1·15	158·7	195·3	1·23	21·5	33·8	1·57
Massachusetts	17·0	20·1	1·18	130·0	227·6	1·75	17·9	31·9	1·78
New Hampshire	19·9	19·7	0·99	155·5	233·3	1·50	18·2	37·1	2·04
New Jersey	18·8	24·5	1·30	182·6	276·5	1·51	21·2	41·6	1·96
New York	15·8	24·5	1·55	114·4	262·0	2·29	15·3	39·2	2·56
Rhode Island	22·5	22·5	1·00	224·9	238·1	1·06	39·3	37·4	0·95
Vermont	18·1	18·5	1·02	116·7	222·3	1·90	16·9	16·9	1·00

Sources: U.S. Census Office, *Twelfth Census: 1900 Vital Statistics, Part I, Analysis and Ratio Tables* (Washington, D.C.: U.S. Census Office, 1902), Table XIX, pp. 285–555

U.S. Census Office, *Eleventh Census: 1890 Vital and Social Statistics, Part I, Analysis and Rate Tables* (Government Printing Office: Washington, D.C., 1896), Table 1, pp. 513–657

TABLE 2

Per cent of state population living in cities and towns of specified sizes included in matched urban areas, 1890 and 1900

	≥ 10,000		2,500–9,999	
	1890	1900	1890	1900
Connecticut	79·2	77·1	0·0	0·0
Massachusetts	100·0	100·0	23·2	16·9
New Hampshire	100·0	100·0	8·4	8·8
New Jersey	97·0	92·1	5·1	0·0
New York	96·6	96·1	5·9	2·3
Rhode Island	84·0	80·3	0·0	0·0
Vermont	100·0	100·0	0·0	0·0

Source: U.S. Census Office, *Twelfth Census: Population. Part I* (Government Printing Office: Washington, D.C., 1902), Table 5, pp. 89–275

Examination of Table 2 which is based on our matched areas for 1890 and 1900 indicates that most of the population living in cities over 10,000 is included in the urban parts of states. Only in Connecticut and Rhode Island are significant proportions of the population living in cities over 10,000 omitted from the urban. Very few people living in smaller cities are classified as urban, except in Massachusetts. In each state, the proportion of the population in each size class included in the urban category is similar at the two dates. Thus, our rural-urban division results in very comparable populations in the rural and urban areas of each state at the two dates. However, in comparing data across states, we must be aware that the urban population in Massachusetts contains people living in smaller cities than the urban populations of other states while the rural populations of Connecticut and Rhode Island contain people in larger cities than the rural population of other states.

Quality of the data

The mortality data published in the federal censuses of 1890 and 1900 were from two sources. Where registration systems existed and were considered reliable, the deaths obtained from these registration systems were published in the census. Where reliable registration data were not available, the published mortality information was collected during the census enumeration by means of a retrospective question concerning the deaths occurring in the year prior to the census. All the mortality data published for registration states in 1890 were collected through registration procedures. In 1900, however, because the registration of deaths was not considered complete, deaths in Vermont, Maine and parts of New Jersey and New York were enumerated in the census. For these areas, the mortality figures published in the 1900 census consist of the registration returns plus any enumerators' returns which were not found among the registration data. In the other registration areas, Massachusetts, Connecticut, Rhode Island, New Hampshire and the remainder of New Jersey and New York, the registration of deaths was considered reliable enough that the enumeration of deaths was not undertaken and the published figures are registration figures alone.[1]

[1] For a more complete discussion of the mortality data published in the federal censuses from 1850 to 1900 see Gretchen Condran and Eileen Crimmins, A description and evaluation of mortality data in the federal census: 1850–1900 *Historical Methods* **12** (1979) 1–23

There are, therefore a number of reasons to expect variation in the quality of mortality data from state to state. The history of vital registration varied from state to state. Because the completeness of registration improved with experience, the date of first publication of vital registration data from each of the states included in our analysis is shown in Table 3. Actual collection of data often preceded publication and all states except Maine began publication of data, several years before 1889–1890, the first year for which data are taken for our analysis.

TABLE 3

First year of publication of state reports on vital statistics for registration states and per cent incompleteness of state death registration systems by 1900 as estimated by state boards of health

State	Year	Per cent incomplete in 1900
Connecticut	1854	1
Maine	1892	3
Massachusetts	1841–2	1
Michigan	1867–8	5
New Hampshire	1880	1
New Jersey	1871	1
New York	1884	5[1] 1[2]
Rhode Island	1852–3	1
Vermont	1857	3

[1] New York state exclusive of New York City, Brooklyn, Yonkers, Albany, and Buffalo
[2] New York City

Sources: Year—U.S. Bureau of the Census, *The Federal Registration Service of the United States: Its Development, Problems, and Defects* (Washington, D.C.: U.S. Government Printing Office, 1916)
Per cent Incomplete—American Economic Association, *The Federal Census: Critical Essays* (New York: Macmillan, 1899), p. 128

The Massachusetts system was the oldest and probably the best. Its history and improvement over time have been elaborated especially by Gutman[1] who estimates that by 1900 only 1 or 2% of deaths were unregistered. Rhode Island was the second oldest system. Fulton[2] examined the quality of the Rhode Island registration system from the earliest years and concludes that death reporting became more complete over time with some improvement in the 1890–1900 decade. By 1900, the system was probably very reliable.

At the end of the 1890s representatives of the various state boards of health estimated the completeness of the death returns in their respective states. Their estimates of the percentage of deaths missing from the registration data are also given in Table 3. While these estimates cannot be accepted at face value, five of the nine state registration systems included in our analysis were estimated to be within 1% complete. In Maine, Michigan, New York, and Vermont, representatives

[1] Robert Gutman, Birth and death registration in Massachusetts, II *Milbank Memorial Fund Quarterly* **37** (1958) 373–402; Robert Gutman, Birth and death registration in Massachusetts, III *Milbank Memorial Fund Quarterly* **37** (1959) 297–326

[2] John P. Fulton, Evaluation of mortality data from a single source for a population open to migration: the case of Rhode Island, 1860–1970 (paper presented at the meetings of the Population Association of America 1977)

admitted to less complete death registration. In general, the older systems were estimated to provide more complete returns than the newer systems.[1]

An issue of particular importance in looking at rural-urban differences in mortality is the comparability of the data collected in the rural and urban parts of states. Death registration generally began first in cities then spread to the rest of the state, therefore we expect that deaths will be more fully reported in urban areas than in rural areas. In addition, as noted above, a few small cities whose registration systems were considered unreliable were included in the rural area of the

TABLE 4

Per cent of all deaths occurring to those less than one year of age: urban and rural parts of selected registration states, 1890 and 1900

	Urban	Rural
	1900	
Connecticut	21·2	19·2
Massachusetts	23·9	14·1
New Hampshire	24·8	15·6
New Jersey	24·1	19·4
New York	22·2	12·4
Rhode Island	23·4	21·4
Vermont	21·6	13·4
Maine	18·7	15·4
Michigan	23·3	17·8
Average (unweighted)	22·6	16·5
	1890	
Connecticut	17·8	14·9
Massachusetts	21·6	12·6
New Hampshire	21·3	12·2
New Jersey	25·4	18·4
New York	23·2	12·5
Rhode Island	19·5	20·0
Vermont	23·0	10·8
Average (unweighted)	21·7	14·5
West Model Life Tables—Life Table Population		
	% deaths < 1	
Female $e_0 = 37{\cdot}5$	19·5	
$e_0 = 47{\cdot}5$	13·2	
$e_0 = 52{\cdot}5$	10·5	

Sources: Registration states, percentages calculated from data in—U.S. Census Office, *Twelfth Census: 1900, Vital Statistics, Part I: Analysis and Ratio Tables* (U.S. Census Office: Washington, D.C., 1902), Table XIX, pp. 285–555

U.S. Census Office, *Eleventh Census: 1890, Vital and Social Statistics, Part I: Analysis and Ratio Tables* (Government Printing Office: Washington, D.C., 1896), Table 1, pp. 513–657

Model life tables—Ansley Coale and Paul Demeny, *Regional Model Life Tables and Stable Populations* (Princeton University Press: Princeton, 1966)

[1] Michigan appears to be an anomalous case, however, in its initial years the Michigan collection of vital statistics was based on enumeration rather than registration. See Condran and Crimmins, "A Description," *op. cit.* for a discussion of the early period of registration in Michigan

state. Although the task is difficult, some evaluation of the relative quality of mortality data from rural and urban areas within and across states can be made.

Where death registration is deficient, the deficiency is usually greatest among infants; therefore, the proportion of all deaths occurring to those under one year can serve as an indicator to the quality of the reporting. This measure calculated from the data for rural and urban parts of states in 1890 and 1900 and from three West Model Life Tables is shown in Table 4.

Examination of Table 4 shows that the proportions of all deaths occurring to infants for rural areas of states were lower than those for urban areas in all but one case (Rhode Island in 1890). With the exception of New York the proportions of infant deaths for rural areas increased from 1890 to 1900. In urban areas the change over time was mixed, with the proportion having increased for four states and having decreased for three. These results are consistent with better reporting of deaths in urban than rural areas and with an improvement in reporting over time especially in rural areas.

Because the proportion of deaths occurring to those less than one depends not only on the completeness of death reporting but also on the age structure of the population and the levels of fertility and mortality experienced by the population, this test is only suggestive of differences in death reporting across areas and time. Other things being equal, low mortality should be accompanied by smaller proportions of infant deaths than high mortality, therefore the differences in the proportions of deaths under one between rural and urban areas reported in Table 4 are also consistent with lower rural than urban mortality levels.

Further evaluation of the mortality data for 1900 can be accomplished by comparing the data collected by registration systems with the mortality statistics collected as part of the federal census in the five states for which both kinds of data are available. For counties and cities in these states, census officials matched individual deaths collected from the two sources and published the number of registration returns, the number of enumeration returns and the number of deaths added to the registration returns from the enumeration returns. Using a technique developed by Chandra Sekar and Deming,[1] we can estimate the total number of deaths occurring in the census year and the completeness of both the enumeration and registration procedures.

The total number of deaths, D, is estimated by the following formula:[2]

[1] C. Chandra Sekar and W. E. Deming, On a method of estimating birth and death rates and the extent of registration *Journal of the American Statistical Association* **44** (1949) 101–15

[2] Discussion of the technique can be found in: William Seltzer, Some results from Asian population growth studies *Population Studies* **23** (1969) 395–406 and U.S. Bureau of the Census, *The methods and materials of demography* (Washington 1973). Use of this method gives only an approximate value for D. "In order that coverage estimates based on matching studies should be unbiased, the two systems employed in each study must be statistically independent (i.e. that there is no correlation between the missing deaths in the two systems), the net matching error should be zero (i.e. the number of false matches equal to the number of false nonmatches) and all spurious (out of scope) reports must be eliminated from each system." (Seltzer, *op. cit.* 401.) The assumption of statistical independence is violated to some extent because deaths to infants are most likely to be unreported in both systems. Lack of independence will lead to an underestimate of D and an overestimate of the coverage of the systems. We cannot determine the accuracy of the possible bias of the matching procedure used by the Census Bureau because no description is given. We know that there are some out of scope reports (i.e. still-births and nonresidents) included in these preliminary tabulations of the registration returns. Including these out of scope returns increases D and reduces the estimated completeness of the death returns. An estimate of the magnitude of the effect of

$$D = \frac{E \cdot R}{C}$$

where D = the estimated number of deaths occurring in the census year
E = the actual number of deaths enumerated by the census marshalls
R = the actual number of deaths registered in the vital registration system
C = the number of deaths recorded in both systems.

The estimated completeness of the enumeration and registration systems is given by $\frac{E}{D}$ and $\frac{R}{D}$, respectively. The completeness of death reports combined from the dual systems is given by $\frac{C + N_1N_2}{D}$ where:

N_1 = the deaths reported only by registration,
N_2 = the deaths reported only by enumeration.

These estimates are presented in Table 5 for the rural and urban parts of the five states for which they can be computed. Supplementation of the registered deaths with the enumerated deaths in these states results in virtually complete reporting of deaths in both rural and urban areas. The combination of registration and enumeration data is estimated to be 4% short of complete in both rural and urban areas. Used alone, registration systems provided less complete coverage and a wider rural-urban differential in coverage than the two systems combined.

TABLE 5

Estimated completeness of death collection systems for rural and urban areas of selected states: 1900

	Per cent of total estimated deaths reported					
	Enumeration		Registration		Combination	
	Rural	Urban	Rural	Urban	Rural	Urban
New Jersey[1] (Part)	55·5	56·5	79·2	88·7	90·7	95·1
New York[1] (Part)	74·6	58·3	84·9	92·6	96·2	96·9
Vermont	81·5	67·1	86·5	95·0	99·4	97·6
Maine	78·2	63·0	84·7	92·4	96·7	97·2
Michigan	72·9	49·8	89·2	90·5	97·1	95·2
Average (unweighted)	72·5	58·9	84·9	91·8	96·0	96·4

[1] Enumeration schedule was only collected in sections of these States.
In New Jersey approximately 74 per cent of the rural deaths and 2 per cent of the urban deaths occurred in the area of death enumeration. In New York these figures were 59 per cent and 13 per cent respectively

Source: U.S. Census Office, *Twelfth Census: 1900 Vital Statistics, Part I, Analysis and Ratio Tables* (Washington, D.C.: U.S. Census Office, 1902), pp. xv–xxiii.

including still-borns in the 1900 figure was made by assuming the proportion of all registered deaths due to still-births in rural and urban areas of individual states in 1900 was equal to the reported proportion for 1890. This estimate of the registration returns minus still-borns was used to reestimate D and resulted in an increase in average estimated enumeration completeness of 3%. There was little or no effect on the estimated completeness of the registration and combined coverage

On the average 92% of the urban deaths and 85% of the rural deaths were registered. The coverage of the enumeration procedure was considerably worse than the registration procedure in both rural and urban areas. In contrast to the registration procedure, however, the death enumeration was more complete in rural than in urban areas.

After examining the data in Table 5, we do not think it is necessary to adjust the mortality data for 1900 for underreporting of deaths. For the five states considered to have poor registration, the use of enumeration as a supplement to registration resulted in virtually complete death reporting in both rural and urban areas in 1900. In the other states where registration was considered complete enough that the enumeration was not undertaken, the reporting of deaths may have been more deficient than the officials recognized or admitted, however we assume that registration in these states was more complete than the 85 to 92% indicated for the rural and urban parts of the states in Table 5. The registration systems of both Massachusetts and Rhode Island, as noted previously, have been thoroughly studied and judged nearly complete by 1900.

The mortality figures reported in the 1890 census are obviously less complete than those for 1900 because they are based solely on registration data. While we can't directly estimate the underregistration in 1890, the estimates of registration completeness for rural and urban parts of New York, New Jersey and Vermont in 1900 can be used to adjust the 1890 figures. For the areas not included in Table 5, the reported mortality figures in 1890 were assumed to be 90% complete in rural areas and 95% complete in urban areas except in Massachusetts, where the published figures were considered accurate and were not adjusted. The same correction factor was used to adjust the total death rates, the infant death rates and the childhood death rates.

Certainly, the adjusted mortality rates for 1890 represent the mortality levels of rural and urban areas more accurately than the unadjusted figures. However, the correction factors used are by no means perfect. Where the reporting of deaths is deficient, it is usually most deficient among infants, so that our use of a standard adjustment for all our mortality rates probably results in an underestimate of infant mortality rates. In addition, if reporting improved over time, the use of 1900 data may underestimate the adjustment needed for 1890.

We should note, however, that no adjustment was made for the underenumeration in the population figures used as denominators in calculating the mortality rates in Table 1. While estimates of the quality of the population enumeration in 1890 and 1900 are available for the country as a whole, we have no idea how the population undercount varied across states or between rural and urban areas.[1] We know that the use of unadjusted population figures raises our mortality rates, however, because the error works in the opposite direction from that introduced by the underreporting of deaths, it may compensate to some extent for the failure of even our adjusted deaths to accurately reflect the deaths occurring.

Expectation of life at birth

Although the data available for rural and urban parts of registration states are limited to only two age groups and the total population, we have estimated the

[1] A. Coale and M. Zelnik in *New estimates of fertility and population in the United States* (Princeton 1963) estimate that the 1900 census undercount for the native white population less than five was 7%. This estimated undercount is higher than the estimated mortality return deficiency in all but rural New Jersey

expectation of life at birth by fitting the mortality rates for the 1 to 4 age group to West Model Life Tables.[1]

The estimated expectations of life at birth in 1890 and 1900 for urban and rural parts of states as well as estimates for whole states based on the rural and urban figures are presented in Table 6. These estimates of expectation of life at birth must be viewed with some caution. Selecting a life table on the basis of one age group and inferring mortality for the whole age range from that age group assumes that there was no abnormal variation in mortality for that age group in the years in question. Our estimate of expectation of life at birth might, for example, be low if the age group used had been particularly susceptible to epidemic diseases. In addition, the estimates of expectation of life at birth are based on the assumption that the age pattern of mortality in West Model Life Tables matches the age pattern of mortality which actually existed. This latter assumption has recently been called into question and therefore, we have included in Table 6 estimates of state expectations of life at birth available from other sources for comparison.[2] E_0's estimated from our data and West Model Life Tables are very close to estimates from other sources, even though there are a number of reasons to expect them to differ. These include the fact that the life tables constructed by Glover for the U.S. Bureau of the Census[3] were based on age-specific mortality data for 1900, 1901, and 1902 rather than data for one age group from the census year. Glover's data are from registration alone, while the published data for 1900 which we used in calculating our mortality rates are registration data supplemented by enumeration data. The lower e_0's in our estimates than in the estimates from the U.S. Bureau of the Census for the whole registration area, the rural and urban parts of the registration area and for New Jersey, New York, and Michigan are partially explainable in terms of different sources of data. The comparison e_0's for Rhode Island were calculated by Fulton[4] using registration data for five years surrounding and including the census year and matching ${}_5m_5$ to Rhode Island model life tables. Therefore, while we consider our estimates of expectation of life only approximate, the fact that our figures for whole states are so close to those from other sources, using different data and methods gives us

[1] Ansley Coale and Paul Demeny, *Regional model life tables and stable populations* (Princeton 1966)

[2] Michael Haines, The use of model life tables to estimate mortality for the United States in the late nineteenth century *Demography* **16** (1979) 289–312; John P. Fulton, *op. cit.* Haines and Fulton have questioned the appropriateness of using West Model Life Tables for estimating U.S. mortality. Of particular relevance for our use of the West Models is the fact that it is the relation between the level of childhood mortality and mortality at other ages that is the main point of discussion. Interestingly, the implications of Haines' and Fulton's findings for our research are quite different. Haines argues that the ratio of childhood mortality to adult mortality in the U.S. is high compared to that in the West Models. Therefore our use of the death rate for those aged one to four with West Models would underestimate the expectation of life at birth in the registration states. The implication of Fulton's work is that inferring life expectancies from ${}_4m_1$ and West Models rather than models specific to Rhode Island would lead to an overestimate of the expectation of life in Rhode Island. Haines concedes that beginning in 1900, the West Model life tables fit the U.S. experience quite well. In fact, the fit is very close between the West Model and the 1900–2 U.S. life table for registration states. In addition, Haines suggests that the West Models might provide a better fit to the rural than urban U.S. experience. The difference between Haines' results and Fulton's, however, remain unexplained

[3] U.S. Bureau of the Census, *United States life tables, 1890, 1901, 1910 and 1901–1910* (Washington D.C. 1921)

[4] Fulton, *op. cit.*

TABLE 6

Estimated expectation of life at birth for rural and urban areas of selected registration states: 1890–1900[1]

State	Urban	Rural	Total	Estimates from other sources
		1900		
Connecticut	49·3	53·0	51·3	
Massachusetts	46·4	53·2	48·0	47·7[2] (1901)
New Hampshire	42·5	51·9	48·8	
New Jersey	43·7	51·3	47·0	48·4[2] (1901)
New York	42·6	55·7	46·8	47·4[2] (1901)
Rhode Island	42·3	46·3	46·8	45·5[3] (1900)
Vermont	50·4	55·8	55·3	
Total (unweighted—7 states)	45·2	52·2	49·1	
Total (weighted—7 states)	44·0	53·9	47·4	
Maine	47·8	52·6	51·7	
Michigan	50·5	54·8	53·5	54·2[2] (1901)
Total (unweighted—9 states)	46·1	52·5	49·9	
Total (weighted—9 states)	44·6	54·1	48·6	49·6[4] (1901) 46·0[4]—urban (1901) 54·7[4]—rural (1901)
		1890—Unadjusted for underregistration		
Connecticut	40·0	48·7	45·2	
Massachusetts	40·2	49·8	42·8	43·5[2] (1890)
New Hampshire	38·2	50·9	47·2	
New Jersey	35·9	50·9	47·2	
New York	37·1	53·7	43·4	
Rhode Island	38·1	38·2	38·1	38·0[3] (1890)
Vermont	51·2	52·4	52·3	
Total (unweighted—7 states)	39·8	48·9	44·5	
Total (weighted—7 states)	37·9	51·5	43·5	
		1890—Adjusted for underregistration		
Connecticut	39·1	47·3	44·0	
Massachusetts	40·2	49·8	42·8	43·5[2] (1890)
New Hampshire	37·2	49·6	46·0	
New Jersey	35·0	47·4	40·7	
New York	36·1	51·9	42·1	
Rhode Island	37·1	36·1	36·7	38·0[3] (1890)
Vermont	50·6	50·6	50·6	
Total (unweighted—7 states)	39·3	47·5	43·3	
Total (weighted—7 states)	37·2	49·8	42·8	

[1] Expectation of life at birth was estimated from ${}_4m_1$ using the following procedure: (a) ${}_4m_1$ was transformed to ${}_4q_1$ using the Reed–Merrell tables (U.S. Bureau of the Census, 1973, p. 886); (b) the level of mortality corresponding to the observed ${}_4q_1$ was selected from the West Model Life Tables (Coale and Demeny, 1966); (c) the e_0 for the state total population was computed by weighting the urban and rural e_0's by the proportions of the population urban and rural; (d) the total unweighted e_0 is a simple average; (e) the total weighted e_0 is computed by weighting each state urban or rural e_0 by the proportion of the total urban or rural population in that state.

[2] From U.S. Bureau of the Census

[3] From Fulton

[4] Includes only the white population in the nine states plus Indiana and the District of Columbia. From U.S. Bureau of the Census

TABLE 6—*continued*

Sources: Table 1

U.S. Bureau of the Census, *United States Life Tables, 1890, 1901, 1910, and 1901–1910* (Washington, D.C.: U.S. Government Printing Office, 1921). John P. Fulton, "Evaluation of Mortality Data from a Single Source for a Population Open to Migration: The Case of Rhode Island, 1860–1970", paper presented at the meetings of the Population Association of America (April 1977).

confidence that these estimates are reasonable indicators of the levels and differences in mortality.

The rural-urban mortality differential

As shown in Tables 1 and 6, urban death rates were higher than rural death rates in almost all states for both 1890 and 1900.[1] The expectation of life at birth in the nine states in 1900 was 44·6 years in urban areas and 54·1 years in rural areas. The rural-urban difference in life expectancy was even larger in 1890 than in 1900. Rural areas had an expectation of life at birth of 49·8 years compared to 37·2 years for urban places. The ratios of urban to rural mortality shown in Table 1 were, respectively for infants and children, 1·53 and 1·96 in 1900 and 1·63 and 2·07 in 1890.

All of the above figures are weighted averages of the registration states in each year. However, the data contained in Tables 1 and 6 also show that while urban death rates were generally higher than rural death rates, the size of the difference in mortality was not constant across all states. There were variations across states in rural rates, variations across states in urban rates and variations in the difference between rural and urban rates.

In 1900 the expectation of life at birth ranged from 46 to 56 years in rural parts of states and from 42 to 51 years in urban parts of states. At this date, the difference between the state rural and urban expectations of life ranged from 4 to 13 years. In 1900, the ratio of urban to rural infant death rates ranged from 1·07 in Connecticut to 1·81 in Vermont. The range for the ratios of death rates was even larger in 1890 from 1·06 in Rhode Island to 2·29 in New York. The comparison between childhood mortality in rural areas and childhood mortality in urban areas shows similar variation. This state variation in the rural to urban ratio produces weighted averages that differ considerably from the unweighted averages. For instance, the unweighted average of the rural-urban ratio of the death rates for those one to four in 1900 is 1·58. When the ratios are weighted by the state's populations, the average is 1·96. This difference is due in large part to the large population and high ratio (2·49) for New York. The weighted average life expectancies shown in Table 6 are also heavily influenced by New York's experience and therefore unweighted averages have been calculated. These show a smaller rural-urban difference than the weighted averages.[2]

In each state the ratio of urban-rural mortality rates was higher for infants

[1] The figures for 1890 are shown both unadjusted and adjusted for underregistration. The discussion refers to adjusted figures

[2] It should be noted that the Census Bureau life tables for the white populations of the rural and urban parts of registration states are also heavily weighted by the experience of New York with its lower than average rural mortality and higher than average urban mortality. These tables may therefore be exaggerating the rural-urban difference in the country as a whole

and children than for the total population even when the total rate is age standardized. In addition, in most states there were large declines in mortality for both rural and urban areas between 1890 and 1900 and in most states there was a decrease in the size of the differential between rural and urban mortality levels over the decade.

Mortality differentials and causes of death

Most discussions of the rural-urban differences in mortality have attributed higher urban than rural mortality to such characteristics of urban areas as high population density, lack of sewage facilities and contaminated water supplies. In order to assess the factors underlying the mortality differential, the difference in rural and urban mortality rates, which existed at the end of the nineteenth century in the registration states can be analyzed in terms of differences in the mortality rates from specific causes of death in the two areas. The causes of death for which data are available in 1900 have been divided into: (1) the causes of death for which urban rates were generally higher than rural rates, (2) the causes of death for which rural rates were generally higher than urban, and, finally, (3) the causes of death for which there were no consistent differences across states in the urban and rural rates.[1]

Causes of death in rural and urban areas

Only a few causes of death showed consistently higher rates in urban than in rural parts of states (Table 7). Consumption (tuberculosis) was probably the largest single cause of death in both rural and urban areas and showed substantially higher rates in urban areas. The higher urban rates of mortality from tuberculosis are not surprising. Tuberculosis (non-bovine) is transmitted largely through exposure to the bacilli in airborne droplets from the sputum of infected persons or from long exposure to infected persons. Poor social conditions, such as the overcrowding which occurs in urban areas, are thought to increase the risk of becoming infected. In addition undernourished and fatigued persons are less resistant to the disease. Finally, age distribution may have accounted for some of the difference between rural and urban rates.[2] Susceptibility to tuberculosis is general, but is highest in children under three years, lowest later in childhood then high again in adolescents and young adults. Young adults made up a larger proportion of the urban population than the rural population.

The other two major disease categories which had higher rates in urban areas are pneumonia and diarrheal diseases. The former may also be affected by crowding; however, the connection between pneumonia and conditions prevailing in urban areas is much less clear cut than in the case of tuberculosis. The other category, diarrheal diseases, is a very broad classification including a number of diseases. Two major factors can probably safely be isolated as influencing the level of diarrheal diseases. One is nutritional adequacy especially in infants and young children. The other is the purity of water and food supplies. The large urban-rural difference in death from this cause can probably be attributed in part to the in-

[1] A similar analysis could be done with the 1890 data, however, we have chosen to limit our present analysis to 1900 when the data are considered good enough to use without adjustment

[2] The mortality rates by cause of death are the number of deaths by cause per 100,000 of the total population. These rates are not age-standardized

TABLE 7

Death rates by cause: causes of death for which urban rates are generally higher than rural rates, selected registration states, 1900
(per 100,000 population)

	Diphtheria and croup		Diarrheal diseases		Consumption	
	Rural	Urban	Rural	Urban	Rural	Urban
Average unweighted	24·4	40·6	109·1	150·9	145·9	185·3
Connecticut	31·0	41·6	136·0	144·8	147·8	192·4
Massachusetts	24·8	52·0	90·1	154·4	162·5	193·7
New Hampshire	18·7	41·2	103·9	161·8	142·4	173·0
New Jersey	36·5	58·5	114·8	147·4	151·7	202·4
New York	21·7	56·3	82·5	164·3	137·7	220·4
Rhode Island	30·0	30·5	178·6	195·7	165·1	221·4
Vermont	18·5	16·6	66·7	142·7	152·2	155·9
Maine	22·9	30·4	110·8	129·2	159·3	191·6
Michigan	15·7	37·9	98·3	117·6	94·1	116·6

	Pneumonia		Measles		All others	
	Rural	Urban	Rural	Urban	Rural	Urban
Average unweighted	158·6	210·3	13·2	17·6	450·7	537·2
Connecticut	140·0	187·1	18·8	16·5	512·9	517·6
Massachusetts	162·5	195·8	5·8	12·8	470·2	533·5
New Hampshire	209·3	217·9	9·4	14·2	465·0	552·0
New Jersey	152·3	228·0	6·6	14·3	413·0	537·3
New York	128·8	275·0	6·4	20·7	413·2	517·1
Rhode Island	200·6	223·0	43·4	51·9	512·0	601·4
Vermont	179·6	225·6	6·1	6·6	449·1	550·8
Maine	155·7	204·3	7·8	4·2	418·9	524·3
Michigan	98·2	136·0	14·6	17·3	402·4	500·5

Source: same as Table 1

TABLE 8

Death rates by cause: causes of death for which rural rates are generally higher than urban rates, selected registration states, 1900
(per 100,000 population)

	Heart disease		Old age		Cancer		Unknown	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Average unweighted	161·7	142·3	74·7	50·6	75·0	68·1	21·0	13·0
Connecticut	132·9	127·3	44·4	34·9	64·6	67·7	8·4	3·1
Massachusetts	188·6	145·8	92·9	50·5	87·3	67·7	17·1	11·0
New Hampshire	196·4	169·3	97·5	58·4	79·8	58·4	31·6	25·5
New Jersey	150·2	131·1	44·7	23·7	57·4	55·7	12·1	8·1
New York	160·5	131·3	87·5	32·9	70·3	65·1	14·2	4·9
Rhode Island	140·1	138·6	52·0	40·2	74·0	64·4	14·1	14·8
Vermont	185·6	139·4	101·1	99·5	91·2	79·6	29·7	6·6
Maine	173·4	179·0	98·8	70·9	88·5	87·8	33·3	23·6
Michigan	128·0	118·9	53·4	44·4	61·7	66·7	28·9	19·4

Source: same as Table 1

creased likelihood of contaminated water in cities as compared with rural areas. Rural areas may also have had better nutrition than urban areas.

The other diseases in Table 7 explain less of the rural-urban mortality difference because they were much less prevalent causes of death in both areas. They represent a group of highly communicable diseases largely transmitted through contact with infected persons and therefore, no doubt, aided in transmission by crowded conditions and large population agglomerations.

There are only four disease categories—old age, heart disease, cancer, and cause of death unknown—which fairly consistently show higher rates in rural than in urban parts of states (Table 8). All of these categories are associated with old age. The higher rural rates are therefore probably explainable in terms of the high proportion of old people in the rural parts of registration states. The proportions of deaths in the categories, cause of death unknown, and old age, are often used as indicators of the quality of a registration system. The higher rates in rural areas may have resulted from poorer quality registration systems than in urban areas as well as from the age structure differences.

The death rates for a group of diseases or disease categories which did not vary consistently with regard to rural and urban areas are shown in Table 9. In addition, Table 9 contains the cause-of-death categories which had very similar mortality rates in rural and urban areas. The diseases which varied between rural and urban areas, but had urban-rural ratios well exceeding 1·00 in some states and well below 1·00 in others are generally diseases, such as malaria, typhoid and whooping cough, whose overall levels varied a great deal from one geographic area to another. Two of these diseases, typhoid and malaria, are somewhat surprising members of this group. Typhoid is often transmitted through impure water supplies and is thought of as an urban disease. Malaria is transmitted by mosquitoes and is considered a rural disease. Typhoid and malaria, however, were both endemic in some areas and thus had much higher overall rates in some states than in others.

The other causes of death in this table are not surprises. They are largely categories of disease or causes of death which one would not expect to vary systematically from rural to urban areas. Diseases of the urinary system, diseases of the nervous system, etc. were unlikely to be affected by any of the concomitants of urban population concentration.

In summary, then, the pattern of rural and urban mortality by cause of death is consistent with our expectations. Diseases, the transmission of which depended heavily on close human contact or on contamination of the environment tended to be consistently higher in urban areas. Diseases affecting older populations were higher in rural areas. Other diseases generally showed no consistent variation. Higher mortality rates in urban areas were therefore generally attributable to a few diseases—tuberculosis, pneumonia, diarrheal diseases and several other communicable diseases.

The variation in death rates across states

While we can attribute the generally higher urban mortality to the above diseases, we have noted that there is variation across states in urban mortality levels, rural mortality levels, and the difference between urban and rural mortality levels and this variation can also be linked to certain diseases. States with high total urban death rates tend to have high urban death rates from tuberculosis, whooping cough, and liver diseases. High total rural mortality for a state is accompanied by high rural death rates from pneumonia and old age. Childhood mortality is high

TABLE 9

Death rates by cause: causes of death which show no consistent differences in urban and rural rates, selected registration states, 1900 (per 100,000 population)

	Scarlet fever		Whooping cough		Malaria		Typhoid		Diseases of the liver		Complications of pregnancy		Diseases of the urinary system		Diseases of the nervous system	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Average unweighted	7·5	9·8	13·6	17·4	5·2	4·8	23·7	26·5	19·5	20·7	12·1	12·4	94·5	102·4	230·7	232·0
Connecticut	7·5	5·7	15·5	10·3	12·0	12·2	24·9	30·4	21·2	19·9	13·0	12·2	106·0	111·3	224·4	205·1
Massachusetts	10·0	14·9	7·6	15·2	3·3	2·3	19·0	23·3	19·3	17·1	8·2	10·1	94·4	82·8	247·4	210·6
New Hampshire	7·6	6·0	19·1	18·7	2·5	8·2	20·1	9·7	13·3	21·0	10·0	3·0	81·3	68·2	257·9	258·4
New Jersey	7·6	16·0	14·7	19·6	7·5	4·5	21·0	21·2	16·5	23·4	11·6	13·5	90·0	115·4	245·9	261·9
New York	5·5	13·8	7·5	16·4	3·6	4·5	28·7	22·4	20·7	25·1	9·6	15·5	92·5	141·1	234·5	189·4
Rhode Island	8·0	8·6	22·6	28·9	4·3	6·6	15·3	30·1	22·0	24·2	12·2	20·3	135·2	130·8	220·8	180·0
Vermont	3·5	10·0	11·8	10·0	2·9	0·0	31·6	26·5	18·8	13·3	14·0	10·0	90·3	82·9	235·4	205·7
Maine	8·2	5·9	12·5	21·1	2·8	0·0	25·5	44·7	19·4	21·1	13·4	9·3	97·7	119·0	238·2	384·1
Michigan	9·7	7·6	11·1	16·7	7·8	4·9	27·0	30·6	24·0	21·6	16·5	17·6	62·9	69·8	171·6	193·1

Source: same as Table 1

in both rural and urban areas where death rates from diarrhea and whooping cough are high.

The variation across states in the rural to urban mortality ratio of the total death rate is not related to any particular causes of death. The large urban to rural ratio in New York, for example, shows up in all the diseases contained in Table 7. States with high urban-rural ratios of infant death rates tend to have high urban-rural ratios of death rates from diarrheal diseases and scarlet fever. Where the difference between a state's urban and rural childhood mortality rate is large, the urban-rural difference in the death rates from diphtheria and croup and measles are also large.

TABLE 10

Characteristics of registration states, 1890 and 1900

	Per cent urban	Per cent of urban population in towns and cities ≥ 25,000	≥ 100,000	Per cent of rural population in counties with cities	towns and cities ≥ 10,000
		1900			
Connecticut	46·0	88·4	18·3	67·5	22·9
Massachusetts	76·0	77·3	36·8	88·6	0·0
New Hampshire	32·4	42·7	0·0	55·1	0·0
New Jersey	56·0	87·0	52·1	51·6	7·9
New York	68·1	91·0	83·8	55·7	3·9
Rhode Island	61·0	91·7	62·0	58·9	19·7
Vermont	8·8	0·0	0·0	17·1	0·0
		1890			
Connecticut	39·4	67·7	0·0	65·9	20·8
Massachusetts	72·6	71·1	27·6	87·3	0·0
New Hampshire	29·3	39·9	0·0	56·3	0·0
New Jersey	54·0	82·0	44·2	48·5	3·0
New York	61·8	89·9	75·3	55·5	3·4
Rhode Island	57·9	79·9	66·1	57·5	16·0
Vermont	6·9	0·0	0·0	18·7	0·0

Sources: Per cent urban—
U.S. Census Office, *Twelfth Census: 1900, Population, Part I*, Table 5 (Government Printing Office: Washington, D.C., 1902).
Characteristics of urban and rural population—
same as Table 1

The nature of both urban and rural areas varied from state to state and may have affected the levels of mortality in rural and urban areas and in turn the differences between urban and rural life expectancies and ratios of urban to rural death rates. In some states a larger proportion of the urban population resided in large cities than in other states (Table 10). Because mortality rates have been found to be higher in large cities than in small cities[1] high state urban mortality rates could result from a concentration of the urban population in large cities. Indeed, while the pattern of mortality rates by city size in our data is less than perfect, there is a tendency for large cities to have had higher mortality rates than small cities within states (see Table 11). In 1890, states with larger proportions of their

[1] Taeuber and Taeuber, *op. cit.*, Vinovskis, *op. cit.*, Gore, *op. cit.*

TABLE 11

Death rates by city size, 1900

	City size				
	2,500–9,999	10,000–24,999	25,000–49,999	50,000–99,999	100,000 +
	A. Infant death rates (under 1 year)				
Connecticut	–	140·7	110·8	179·5	154·0
Massachusetts	178·2	181·8	170·8	200·0	208·0
New Hampshire	123·5	203·0	–	238·4	–
New Jersey	–	172·5	193·0	181·1	188·9
New York	130·3	181·4	164·7	189 7	182·1
Rhode Island	–	147·4	204·6	–	214·9
Vermont	–	206·8	–	–	–
Total	135·5	178·2	174·4	192·7	186·5
	B. Childhood death rates (1–4 years)				
Connecticut	–	13·7	12·0	22·9	15·3
Massachusetts	11·6	18·2	20·0	23·1	27·8
New Hampshire	*	27·5	–	32·3	–
New Jersey	–	20·9	25·0	23·1	29·4
New York	21·1	22·6	17·3	23·0	29·4
Rhode Island	–	18·6	23·3	–	32·3
Vermont	–	17·1	–	–	–
Total	13·1	20·1	20·1	23·5	29·0
	C. Total death rates				
Connecticut	–	17·2	14·3	18·0	17·2
Massachusetts	15·6	16·4	16·8	18·1	19·7
New Hampshire	13·6	18·9	–	19·2	–
New Jersey	–	17·3	17·8	17·5	20·0
New York	17·1	18·4	16·3	19·9	19·5
Rhode Island	–	19·1	18·4	–	19·9
Vermont	–	17·8	–	–	–
Total	15·8	17·5	16·9	18·3	19·5
	D. Number of places				
Connecticut	0	4	1	3	1
Massachusetts	8	21	8	7	3
New Hampshire	1	4	0	1	0
New Jersey	0	10	3	4	3
New York	3	17	5	3	4
Rhode Island	0	1	2	0	1
Vermont	0	2	0	0	0
Total	12	59	19	18	12

* Less than 30 deaths

– No cities of size category reporting in state

Source: Same as Table 1.

urban population in large cities tended to have higher urban infant and childhood death rates. However, there appears to be no relationship between the proportion of the state's urban population in cities over 100,000 or 25,000 (Table 10) and urban child or infant death rates in 1900. Thus city size doesn't seem to be the major factor responsible for variation in state urban mortality levels.

Rural parts of states varied in their proximity to urban areas, leading to a

TABLE 12

Death rates, completely rural counties and counties with cities in registration states, 1900 (per 1,000 population)

	Total death rates		Infant death rates (under 1 year)		Childhood death rates (1–4 years)	
	Rural counties with no cities	Rural parts of counties with cities	Rural counties with no cities	Rural parts of counties with cities	Rural counties with no cities	Rural parts of counties with cities
Average unweighted	16·6	16·3	135·8	145·3	14·1	14·7
Connecticut	17·0	16·4	150·5	152·7	14·6	13·7
Massachusetts	17·3	17·1	109·0	130·7	11·7	14·1
New Hampshire	17·4	17·8	131·0	155·3	10·9	17·4
New Jersey	15·9	15·2	147·0	135·2	15·3	16·4
New York	15·5	15·1	98·8	105·1	10·9	11·6
Rhode Island	20·0	17·6	237·3	151·1	24·7	21·5
Vermont	17·0	16·6	115·3	111·1	10·7	13·7
Maine	16·4	17·6	127·7	142·0	16·0	12·0
Michigan	13·2	13·5	106·0	99·1	12·4	11·9

Source: Same as Table 1

difference across states in the nature of rural areas. Rural areas close to cities may have shared some of the cities' bad health effects. Contaminated water, for example, might have extended beyond the boundaries into the surrounding rural areas; or the population in these areas may have had more contact with urban populations and their diseases. In our data, however, we do not find that completely rural counties consistently have lower mortality rates than counties which contain cities (data shown for 1900 in Table 12). In addition the percentage of the rural population living in counties with cities (Table 10) is not related to state rural death rates. Rural death rates do tend to be higher, however, in states where some of the rural population lives in towns of greater than 10,000 population (Table 10). Finally, variation from state to state in the size of the urban-rural mortality differential does not appear to be associated with states' overall levels of mortality, or with the levels of either rural or urban mortality. High urban to rural ratios of total and childhood death rates did not result from either especially high urban rates or especially low rural rates. Only for infants do high urban to rural mortality ratios appear to be associated with low levels of rural mortality.

Summary and implications

We have estimated rural and urban mortality levels for seven states in 1890 and nine states in 1900 and have concluded that urban mortality levels were consistently higher than rural mortality levels in these states. Higher urban than rural mortality resulted from higher rates of death from a group of diseases or causes of death, most of which were affected by crowding, contamination of food and water supplies and poor nutrition. The size of the rural-urban mortality difference, however, varied across age groups, over time and across states.

Infant and childhood mortality had larger rural-urban differentials than either total death rates or estimates of life expectancies at birth. This result is not surprising in that many of the diseases which were likely to be affected by population concentration are diseases of infants and children. The large differential in infant and childhood mortality between urban and rural areas has implications for other areas of research. For example, child-woman ratios have been relied on as measures of fertility in much historical research.[1] Our results show that adjusting the numerator of child-woman ratios for mortality differentials between rural and urban areas is especially important.

In most states included in our analysis, both urban and rural mortality declined between 1890 and 1900. However, urban mortality declined more than rural mortality leading to a reduction in the differential over the decade. The rural-urban difference in the rate of mortality decline suggests two important considerations for further research. First, the rural-urban differential in mortality at one time cannot be assumed to represent the differential at another time. We have chosen to limit our investigation to two dates (one decade), however, research on rural and urban mortality both before and after that time are needed if we are to understand the impact of scale factors on mortality levels. Second, the differen-

[1] Richard A. Easterlin, George Alter and Gretchen A. Condran, Farms and farm families in old and new areas: the northern states in 1860 pp. 22–85 in T. L. Hareven and M. A. Vinovskis (Eds), *Family and population in nineteenth century America* (Princeton 1978); Stanley Engerman, Changes in black fertility, 1880–1940 pp. 126–53 in T. K. Hareven and M. A. Vinovskis, *op. cit.*; Bernard Okun, *Trends in birth rates in the United States since 1870* (Baltimore 1958); Yasuba, *op. cit.*

tial in the rate of decline of rural and urban mortality levels suggests that different factors may have influenced the reduction of mortality in each. Further research on factors affecting mortality declines should avoid when possible using whole countries as the unit of analysis. Indeed, our research suggests that differentiation of space by rural and urban characteristics is essential to understanding the decline in mortality.

The levels of both rural and urban mortality as well as the differences between urban and rural mortality varied considerably across states. Because of this variation, life tables constructed for the entire rural and urban portions of the registration areas are not necessarily representative of the mortality levels of any state contained in the region. Life tables for the whole region included in our research, for example, are heavily dominated by the experience of New York, a state which compared with other registration states had an especially large rural-urban difference in mortality. Our research supports Vinovskis' suggestion that regional differences in urban mortality caused Jaffe and Lourie to exaggerate the rural-urban mortality differential in 1830. However, it also shows that the rural and urban mortality levels for Massachusetts are not representative of the whole registration area either. While the results of our attempts at explaining the variation in state rural and urban mortality rates by the size of cities in the rural and urban sections of states or the proximity of rural to urban areas were largely ambiguous, they do suggest that further research separating the factors affecting rural and urban mortality is required.

Finally, the differences in death rates by cause between rural and urban areas of registration states were as expected. Urban mortality exceeded rural mortality because death rates from diseases that are transmitted by close contact or a contaminated environment were higher in urban than rural areas. Further analysis using many more categories of cause of death with careful distinctions of the modes of transmission of diseases would likely prove fruitful in assessing the impact of urban and rural residence on life chances.

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