2

Trends in mortality and causes of death in Japanese colonial period Taiwan

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Introduction

This paper explores trends in mortality and causes of death in colonial Taiwan primarily through the study of patterns of mortality by age and sex for selected leading causes of death. The discussion concentrates on the following causes of death in the period 1905-1942: malaria, respiratory tuberculosis, respiratory diseases, diarrhea and enteritis, and infant causes. Note that due to an early Japanese period vaccination campaign, smallpox was no longer a leading cause by 1905 when our data series begins (Shepherd 2001). There is not space to treat other causes, many of them the source of important epidemics (e.g., plague, influenza, cholera), but less important to the patterns of mortality overall.

Important early studies of causes of death in Taiwan come from Li T'eng-yueh (1938), George W. Barclay (1954), and Chen Shao-hsing (1955). Ensuring the consistent definition of cause categories, and a minimum quality of diagnostic skill by those making the determinations of cause is a prerequisite to the use of cause of death reports. Issues of reporting quality in the Taiwan cause of death reports are discussed in detail in the Appendix. The data series for several causes appear to be inconsistently reported between the early years when reporting quality was low and the later years. Such inconsistencies arise from improving diagnostics and training on the part of personnel filling out death certificates, and also changes in the definitions of disease categories (and also rules for deciding between two or more contributing causes). Previous studies of trends in causes of death in Japanese period Taiwan have failed to take into account these inconsistencies (e.g., Chen 1955). In the discussion below of specific causes, those reported inconsistently in the early years will be reported only for the years 1924-41, when the third and fourth international cause of death lists were used to compile the cause of death reports, and reporting quality was highest.

There are two causes, however, malaria and respiratory tuberculosis, that appear to provide relatively consistently reported series for more extended periods. These causes of death present symptoms relatively easy for certifiers to identify, periodic chills and fevers and swollen spleens in the case of malaria, and bloody sputum in the case of respiratory tuberculosis. The international lists for compiling death statistics in use by the colonial authorities also consistently reserved separate categories specific to these causes, which immunized them from inconsistencies arising from changing category definitions.

Reports of Deaths by Cause, Age and Sex in the Taiwan Population Record

The information necessary to compute age, cause, and sex specific rates of death comes from two sources: the annual volumes of vital statistics reports of cause of death by age and sex, and the census tables reporting the population at risk in each age and sex category. The Japanese colonial government conducted the first census of Taiwan in 1905, and subsequent censuses every five years from 1915 to 1940. Age-specific death rates are based on the notion of deaths during a period, per person-years lived at the specified age. The person years lived are approximated by the number of persons of the specified age present at the middle of the base period (Barclay 1958: 45). The censuses reported population age groups by calendar (not lunar) year of birth from 1905 to 1925 but shifted to western style reporting of age at last birthday on the date of the census 1930-40. To calculate cause specific death rates by age we must convert the census reports of age 1905-1925 to age in western years; this has been done by estimating the midyear population by western age from life tables constructed for 1906-1926.

For the periods presented in our tables the base period is the date of the census (October 1) or a midyear population in the case of 1906-08 and 1909-13 rates. The rates presented here are computed from the averages of deaths occurring in the three years centered on the base period (five years in the case of the 1909-13 rates).

All the tables of cause, age and sex specific death rates presented below report an infant death rate at ages 0-1. The infant death rates are computed following Barclay (1958:141,143, 287) by dividing the three year average of infant deaths by the average number of births for the corresponding period, rather than by using a midyear estimate of the infant population (five years in the case of the 1909-13 rates)(cf. Barclay 1958: 47). This ensures a continuity of presentation when infant mortality is analyzed separately by using the infant death rates. Infant death rates for 'all causes' are corrected for unregistered nonsurvivors for the years 1906-1915 following Barclay (1954: 159-60, see Shepherd 1998 for a fuller discussion of the method used to estimate the extent of underregistration). I have assigned deaths attributed to unregistered nonsurvivors to the 'ill-defined and unknown' cause category.

The use of rates based on averages for multiple years is intended to moderate the effect of yearly variation and give a better picture of long-term trends. Thus the effects of epidemics, such as the malaria outbreak in 1915, and the influenza epidemics in late 1918 and early 1920, and the cholera outbreak in 1919, have been somewhat disguised in this presentation. The tables below present multiple year averages for eight periods, four periods covering all years 1906-1921, and four three-year periods centered on each five year census 1925-1940. The tables thus present the mortality experience of 28 of the 36 years in the period 1906-41.

Introduction to the Tables Presented for Each Cause Group

For each cause group discussed below I present a series of three tables. The first table for each cause group presents the deaths per 10,000 person years for each age and sex category, 1906-1941. Male rates are presented in the upper panel and female rates in the lower. It is very easy to see the degree of variation in death rates across the age groups in this table.

To facilitate the identification of historic trends, a second table presents rates for each period that have been indexed on the rate for the first period, 1906-08. These indexed rates make it easy to perceive patterns of decline in terms of percentages of the 1906-08 rates. Do the 1906-08 rates fairly represent the 'normal' level of mortality at the starting point of the Japanese period? Death rates fluctuated greatly in response to periodic epidemics in the early years, and the reduction of epidemic disease was a priority of Japanese policy. The 1906-08 rates, for example reflect the impact of plague deaths in 1906-7 (over a thousand in each sex each year), and may be somewhat elevated above the 'normal', just as the rates for the succeeding period, 1909-13, are unusually low. The underreporting of deaths prior to 1906 means that we lack reliable death rates that could establish pre-1906 levels of mortality. However, stable population analysis using the 1906-08 rates suggests close agreement with the age structure of the 1905 census, indicating that the 1906-08 rates are close to the average rates in the pre-1906 period (Shepherd 1998b: 64ff.).

The indexed tables make it easier to compare the degrees of decline (or increase) across the age and sex categories. A third table presents the sex ratios (male age specific death rate / female age specific death rate) of mortality in each age and sex group. These rates make it easy to see the extent of divergence in the experience of males and females at various ages (values above 1.00 show male excess mortality and values below show female excess mortality). Looking at the change in these ratios over time also shows whether the divergence in male and female mortality increased or decreased over the period.

All Causes

We begin our discussion by considering the overall trends in age and sex specific mortality for all causes. Because it includes all deaths regardless of cause this series is unaffected by changes in quality of cause of death reporting.

It is easy to see in the first table reporting death rates per 10,000 person years, that the impact of mortality varied greatly across the age groups. The highest death rates are regularly found at the extremes, among infants and those aged 70 and over. Death rates decline rapidly from infancy to age 9, reach their lowest levels in ages 10-14, and then begin an accelerating rise to age 70. The rates by age form a typical j–shaped mortality curve, found in most populations. We will see below the degree to which specific groups of causes vary in their contribution to mortality levels at different ages.

The unevenness of the decline in the death rates is immediately observable in the first and second tables. Rates of death in many age groups fell dramatically in 1909-13, resurged again in 1914-16, remained above the 1909-13 rates in

Table 1. **Death rates, Taiwan, 1906-1941**

a. Cause, Age and Sex specific death rates of Taiwanese, All Causes, 1906-1941. Deaths per 10,000 person years. The infant death rate is used for age 0-1.

Years	*All causes* Age at beginning of interval:															
Males	0*	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70
1906-08	1940	491	139	79	103	154	204	263	333	418	503	602	705	885	1154	1673
1909-13	1794	385	90	54	74	125	168	213	264	335	415	503	626	761	988	1499
1914-16	1933	419	96	58	79	130	182	228	287	350	427	518	649	812	1033	1651
1919-21	1825	432	98	53	82	129	173	210	251	305	357	452	569	722	985	1500
1924-26	1817	356	67	39	60	89	117	154	197	243	302	372	485	674	881	1443
1929-31	1703	299	46	29	46	69	86	107	133	179	230	296	384	534	749	1266
1934-36	1620	296	47	30	46	67	86	103	128	173	222	291	388	509	710	1267
1939-41	1440	289	46	27	45	66	77	96	116	156	210	293	381	527	712	1291
Females																
1906-08	1930	617	166	91	116	154	178	202	226	258	297	370	462	624	847	1352
1909-13	1524	485	102	50	82	123	136	159	181	190	227	286	370	470	672	1187
1914-16	1676	524	115	54	83	120	138	161	191	201	223	297	397	537	712	1370
1919-21	1547	512	115	56	86	129	148	173	185	194	213	259	348	457	625	1195
1924-26	1515	417	71	36	56	84	101	124	144	148	168	217	284	414	578	1120
1929-31	1418	335	46	26	48	64	73	89	106	120	135	171	241	327	486	1020
1934-36	1356	324	48	28	46	62	70	84	101	114	131	173	237	323	493	1056
1939-41	1208	317	45	24	38	53	61	76	91	107	126	165	229	316	451	1071

* Infant death rate, calculated as a ratio of infant deaths to registered live births for corresponding periods. Estimates of unregistered nonsurvivors have been added in the years 1906-1915.

1919-21, and then began a more consistent decline. These bumps in the decline are commonly attributed to the impact of epidemic malaria in 1915, the influenza epidemics of late 1918 and early 1920, and the cholera epidemic in 1919.

The degree of decline in the death rates over time also varied by age group. The indexed rates show that the biggest declines occurred in ages 5-14, followed by ages 15-54; the next largest declines occur in ages 55-69 and 1-4. The smallest declines in death rates occurred among infants and those over age 70. That age groups in the middle of the age range benefited most from the decline in mortality overall is a pattern commonly found in studies of the mortality transition.

Infants and the elderly remain the most vulnerable segments of the population; public health measures only gradually succeed in reducing their expo-

Table 1. **Death rates, Taiwan, 1906-1941**

b. Indices of Cause, Age and Sex specific death rates of Taiwanese, All Causes, 1906-1941. Death rates of 1906-8 = 100

Years	***All causes*** *Age at beginning of interval:*															
Males	**0***	**1**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**
1906-08	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
1909-13	*92.5*	*78.4*	*64.7*	*68.4*	*71.8*	*81.2*	*82.4*	*81.0*	*79.3*	*80.1*	*82.5*	*83.6*	*88.8*	*86.0*	*85.6*	*89.6*
1914-16	*99.6*	*85.3*	*69.1*	*73.4*	*76.7*	*84.4*	*89.2*	*86.7*	*86.2*	*83.7*	*84.9*	*86.0*	*92.1*	*91.8*	*89.5*	*98.7*
1919-21	*94.1*	*88.0*	*70.5*	*67.1*	*79.6*	*83.8*	*84.8*	*79.8*	*75.4*	*73.0*	*71.0*	*75.1*	*80.7*	*81.6*	*85.4*	*89.7*
1924-26	*93.7*	*72.5*	*48.2*	*49.4*	*58.3*	*57.8*	*57.4*	*58.6*	*59.2*	*58.1*	*60.0*	*61.8*	*68.8*	*76.2*	*76.3*	*86.3*
1929-31	*87.8*	*60.9*	*33.1*	*36.7*	*44.7*	*44.8*	*42.2*	*40.7*	*39.9*	*42.8*	*45.7*	*49.2*	*54.5*	*60.3*	*64.9*	*75.7*
1934-36	*83.5*	*60.3*	*33.8*	*38.0*	*44.7*	*43.5*	*42.2*	*39.2*	*38.4*	*41.4*	*44.1*	*48.3*	*55.0*	*57.5*	*61.5*	*75.7*
1939-41	*74.2*	*58.9*	*33.1*	*34.2*	*43.7*	*42.9*	*37.7*	*36.5*	*34.8*	*37.3*	*41.7*	*48.7*	*54.0*	*59.5*	*61.7*	*77.2*
Females																
1906-08	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
1909-13	*79.0*	*78.6*	*61.4*	*54.9*	*70.7*	*79.9*	*76.4*	*78.7*	*80.1*	*73.6*	*76.4*	*77.3*	*80.1*	*75.3*	*79.3*	*87.8*
1914-16	*86.8*	*84.9*	*69.3*	*59.3*	*71.6*	*77.9*	*77.5*	*79.7*	*84.5*	*77.9*	*75.1*	*80.3*	*85.9*	*86.1*	*84.1*	*101.3*
1919-21	*80.2*	*83.0*	*69.3*	*61.5*	*74.1*	*83.8*	*83.1*	*85.6*	*81.9*	*75.2*	*71.7*	*70.0*	*75.3*	*73.2*	*73.8*	*88.4*
1924-26	*78.5*	*67.6*	*42.8*	*39.6*	*48.3*	*54.5*	*56.7*	*61.4*	*63.7*	*57.4*	*56.6*	*58.6*	*61.5*	*66.3*	*68.2*	*82.8*
1929-31	*73.5*	*54.3*	*27.7*	*28.6*	*41.4*	*41.6*	*41.0*	*44.1*	*46.9*	*46.5*	*45.5*	*46.2*	*52.2*	*52.4*	*57.4*	*75.4*
1934-36	*70.3*	*52.5*	*28.9*	*30.8*	*39.7*	*40.3*	*39.3*	*41.6*	*44.7*	*44.2*	*44.1*	*46.8*	*51.3*	*51.8*	*58.2*	*78.1*
1939-41	*62.6*	*51.4*	*27.1*	*26.4*	*32.8*	*34.4*	*34.3*	*37.6*	*40.3*	*41.5*	*42.4*	*44.6*	*49.6*	*50.6*	*53.2*	*79.2*

* Infant death rate, calculated as a ratio of infant deaths to registered live births for corresponding periods. Estimates of unregistered nonsurvivors have been added in the years 1906-1915.

sure to disease and susceptibility to infection and degenerative conditions. We will see below the degree to which specific groups of causes contribute to decline or increase in the various age groups.

The degree of decline in the death rates is impressive. Death rates in the earliest two periods are as much as 2 to 3 times the rates at the end of the period for age groups 5-14, and girls at this age benefited somewhat more than boys. Death rates that have fallen to 40-50% of the rates at the beginning of the period are common in ages 15-54, and death rates that have fallen to 50-60% are common in ages 55-69 and 1-4. Infant death rates fell to a range of 65-75% (the female rate fell more) and rates over 70 fell to 70-80% of the rates in the earliest periods.

We next turn to discuss the pattern of the sex ratios of mortality, shown in

Table 1. **Death rates, Taiwan, 1906-1941**

c. Sex Ratios of Cause, Age and Sex specific death rates of Taiwanese, All Causes, 1906-1941. Male Death Rate / Female Death Rate.

Years	*All causes* *Age at beginning of interval:*															
	0*	**1**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**
1906-08	1.01	0.80	0.84	0.87	0.89	1.00	1.15	1.30	1.47	1.62	1.69	1.63	1.53	1.42	1.36	1.24
1909-13	1.18	0.79	0.88	1.08	0.90	1.02	1.24	1.34	1.46	1.76	1.83	1.76	1.69	1.62	1.47	1.26
1914-16	1.15	0.80	0.83	1.07	0.95	1.08	1.32	1.42	1.50	1.74	1.91	1.74	1.63	1.51	1.45	1.21
1919-21	1.18	0.84	0.85	0.95	0.95	1.00	1.17	1.21	1.36	1.57	1.68	1.75	1.64	1.58	1.58	1.26
1924-26	1.20	0.85	0.94	1.08	1.07	1.06	1.16	1.24	1.37	1.64	1.80	1.71	1.71	1.63	1.52	1.29
1929-31	1.20	0.89	1.00	1.12	0.96	1.08	1.18	1.20	1.25	1.49	1.70	1.73	1.59	1.63	1.54	1.24
1934-36	1.19	0.91	0.98	1.07	1.00	1.08	1.23	1.23	1.27	1.52	1.69	1.68	1.64	1.58	1.44	1.20
1939-41	1.19	0.91	1.02	1.13	1.18	1.25	1.26	1.26	1.27	1.46	1.67	1.78	1.66	1.67	1.58	1.21

* Infant death rate, calculated as a ratio of infant deaths to registered live births for corresponding periods. Estimates of unregistered nonsurvivors have been added in the years 1906-1915.

the table above. First, note the pattern across the age groups in the early years. There is an expected male excess in infancy, followed by female excess in ages 1-9 and 15-19. Sex ratios of mortality are most balanced at ages 10-14 (with some fluctuation) and consistently at ages 20-24. A male excess beginning at age 25 steadily increases to a peak at 45-54, declines somewhat up to 69 and remains high in the terminal age group. These patterns remain largely intact into the later, lower mortality periods, with the exception of the following. Most notable are the declines in the female excess at ages 5-9 and 15-19 which shift to balanced sex ratios of mortality, and a smaller but certain decline at ages 1-4 where the female excess persists. The pattern of female excess mortality in early childhood is commonly attributed to the son preference of the Chinese family system, resulting in comparative neglect of daughters' health and diet (Barclay 1954: 157). In areas practicing minor marriage, high rates of female adoption which subject girls to additional mortality risks (Wolf 1995: 302-07) also contributed to the female excess at young ages. The decline in young female excess mortality is not to be attributed to declines in the degree of son preference (declining rates of adoption for minor marriage in selected areas may have contributed to decline), but rather to the improvement in the disease environment that reduced the risks to which young girls were subjected. Under these circumstances, both boys and girls benefited substantially from the mortality decline, but young girls relatively more. The other often noted feature of the Taiwanese pattern of sex differential mortality is the large male excess at adult ages 25 and above, despite the added female risk from childbearing in these ages. Many populations show a female excess in the childbearing years (Japan, India and The Netherlands among them)(Barclay 1954: 155-56). The large male excess in the childbearing years is to be attributed to mortality that is much higher among males, not unusually low among females (see further discussion in the maternal mortality paper, this volume). Adult male excess mortality is commonly observed among premodern Chinese populations, though an excess in the childbearing years is unusual (see Chiao et al. 1938:52-54, Liu Ts'ui-jung 1985: 49-55, Goldman 1980, Campbell 1995: 55ff.).

Analysis of cause specific mortality rates for the leading causes will reveal which causes contribute most to these patterns of male and female excess.

Malaria

As mentioned above, it appears that the reports of malaria deaths provide a relatively consistently reported series for the entire period, 1906-1941. Malaria presents identifiable symptoms, periodic chills and fevers and swollen spleens, which would be known to family members of the deceased and easily reported to the personnel certifying the cause of death (who may or may not have attended the deceased before death). Special training was not needed to correctly identify the bulk of deaths caused by malaria. In addition, the international lists for compiling death statistics in use by the colonial authorities consistently reserved a separate title for malaria, so these reports are free of inconsistencies arising from changing category definitions.

We turn first to the varying impact of malaria deaths across the age groups, focusing on the pattern in the early years when malaria death rates were highest. Rates of death attributed to malaria are at their highest in infancy, decline at ages 1-9 to reach their lowest point at ages 10-14, then begin a steady rise to high rates at ages 55 plus. Male rates at ages 55 plus exceed those at ages 1-4, but female rates generally remain below. Malaria age specific death rates thus display a typical j-shaped mortality curve, with the highest rates at the extremes in infancy and old age and the lowest rates 10-14.

Malaria was consistently a leading cause of death in nineteenth and early twentieth century Taiwan and as such early became a target of Japanese colonial public health efforts (see discussion by Ku Ya-wen, this volume). Decline in malaria death rates was interrupted in 1915 by epidemic rates of malaria (which did not reach the 1906-08 rates for most age groups), but regained momentum thereafter. Over the entire period the degree of the decline in malaria death rates is dramatic and the greatest of the major cause groups. Malaria death rates for most age groups have fallen to half of the 1906-08 levels by 1924-26 and to less

Table 2. **Malaria related death rates, Taiwan, 1906-1941**

a. Cause, Age and Sex specific death rates of Taiwanese, Malaria, 1906-1941. Deaths per 10,000 person years. The infant death rate is used for age 0-1.

Years	*Malaria* *Age at beginning of interval:*															
Males	**0***	**1**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**
1906-08	91	54	24	15	19	25	28	33	39	43	48	53	58	56	60	78
1909-13	66	37	14	10	15	20	24	26	27	33	35	36	40	44	42	49
1914-16	87	54	22	12	18	24	28	30	33	37	39	41	41	48	47	65
1919-21	58	35	14	9	13	18	19	22	22	24	24	25	27	30	39	47
1924-26	52	27	12	9	12	13	14	15	18	19	19	20	21	24	31	35
1929-31	19	11	5	4	5	5	6	7	8	8	9	9	10	11	11	17
1934-36	15	10	5	4	5	6	6	6	7	8	9	8	10	11	14	22
1939-41	13	9	5	4	6	7	6	6	7	7	8	9	9	12	13	18
Females																
1906-08	99	77	31	18	19	22	24	27	30	32	36	41	45	51	66	80
1909-13	69	51	17	10	13	16	17	19	20	21	25	26	28	31	41	47
1914-16	98	72	27	13	16	20	21	22	25	26	26	29	38	43	49	69
1919-21	65	44	17	10	10	13	14	14	15	18	18	22	24	30	33	43
1924-26	53	34	14	8	8	9	11	13	14	12	14	17	17	22	30	42
1929-31	20	13	6	4	4	4	5	6	6	6	6	7	10	10	11	16
1934-36	16	11	5	3	4	4	4	5	5	5	6	7	9	9	14	22
1939-41	12	10	5	3	4	4	5	5	5	5	5	7	7	9	10	18

* Infant death rate, calculated as a ratio of infant deaths to registered live births for corresponding periods.

than 20% by 1939-41. Somewhat smaller degrees of decline occur in age groups that began the period with the lowest (10-24 for males, 15-29 for females) and the highest rates (age 70 plus and infants in 1924-26), but overall the gains were widely shared across all age and sex groups.

We turn next to discuss the pattern of the sex ratios of mortality for malaria, shown in table 2.c below. First, note the pattern across the age groups in the early years when malaria mortality was highest. Instead of the usual male excess in infancy we find a female excess, followed by female excesses in ages 1-14 that are deeper than reported for All Causes. At ages 15-19, instead of female excess mortality we find for malaria moderate male excesses, which continue to age 64 but at lower levels than for All Causes. From ages 65 on, we find a mix of female excess and nearly balanced sex ratios of mortality, again in contrast to the large

Table 2. **Malaria related death rates, Taiwan, 1906-1941**

b. Indices of Cause, Age and Sex specific death rates of Taiwanese, Malaria, 1906-1941. Death rates of 1906-8 = 100.0

Years	*Malaria* *Age at beginning of interval:*															
Males	0*	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70
1906-08	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
1909-13	*72.5*	*68.5*	*58.3*	*66.7*	*78.9*	*80.0*	*85.7*	*78.8*	*69.2*	*76.7*	*72.9*	*67.9*	*69.0*	*78.6*	*70.0*	*62.8*
1914-16	*95.6*	*100.0*	*91.7*	*80.0*	*94.7*	*96.0*	*100.0*	*90.9*	*84.6*	*86.0*	*81.3*	*77.4*	*70.7*	*85.7*	*78.3*	*83.3*
1919-21	*63.7*	*64.8*	*58.3*	*60.0*	*68.4*	*72.0*	*67.9*	*66.7*	*56.4*	*55.8*	*50.0*	*47.2*	*46.6*	*53.6*	*65.0*	*60.3*
1924-26	*57.1*	*50.0*	*50.0*	*60.0*	*63.2*	*52.0*	*50.0*	*45.5*	*46.2*	*44.2*	*39.6*	*37.7*	*36.2*	*42.9*	*51.7*	*44.9*
1929-31	*20.9*	*20.4*	*20.8*	*26.7*	*26.3*	*20.0*	*21.4*	*21.2*	*20.5*	*18.6*	*18.8*	*17.0*	*17.2*	*19.6*	*18.3*	*21.8*
1934-36	*16.5*	*18.5*	*20.8*	*26.7*	*26.3*	*24.0*	*21.4*	*18.2*	*17.9*	*18.6*	*18.8*	*15.1*	*17.2*	*19.6*	*23.3*	*28.2*
1939-41	*14.3*	*16.7*	*20.8*	*26.7*	*31.6*	*28.0*	*21.4*	*18.2*	*17.9*	*16.3*	*16.7*	*17.0*	*15.5*	*21.4*	*21.7*	*23.1*
Females																
1906-08	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
1909-13	*69.7*	*66.2*	*54.8*	*55.6*	*68.4*	*72.7*	*70.8*	*70.4*	*66.7*	*65.6*	*69.4*	*63.4*	*62.2*	*60.8*	*62.1*	*58.8*
1914-16	*99.0*	*93.5*	*87.1*	*72.2*	*84.2*	*90.9*	*87.5*	*81.5*	*83.3*	*81.3*	*72.2*	*70.7*	*84.4*	*84.3*	*74.2*	*86.3*
1919-21	*65.7*	*57.1*	*54.8*	*55.6*	*52.6*	*59.1*	*58.3*	*51.9*	*50.0*	*56.3*	*50.0*	*53.7*	*53.3*	*58.8*	*50.0*	*53.8*
1924-26	*53.5*	*44.2*	*45.2*	*44.4*	*42.1*	*40.9*	*45.8*	*48.1*	*46.7*	*37.5*	*38.9*	*41.5*	*37.8*	*43.1*	*45.5*	*52.5*
1929-31	*20.2*	*16.9*	*19.4*	*22.2*	*21.1*	*18.2*	*20.8*	*22.2*	*20.0*	*18.8*	*16.7*	*17.1*	*22.2*	*19.6*	*16.7*	*20.0*
1934-36	*16.2*	*14.3*	*16.1*	*16.7*	*21.1*	*18.2*	*16.7*	*18.5*	*16.7*	*15.6*	*16.7*	*17.1*	*20.0*	*17.6*	*21.2*	*27.5*
1939-41	*12.1*	*13.0*	*16.1*	*16.7*	*21.1*	*18.2*	*20.8*	*18.5*	*16.7*	*15.6*	*13.9*	*17.1*	*15.6*	*17.6*	*15.2*	*22.5*

* Infant death rate, calculated as a ratio of infant deaths to registered live births for corresponding periods.

male excesses found at these ages for All Causes. At the end of the period in 1939-41 when malaria death rates have fallen dramatically, the female excesses have disappeared in all but ages 1-4 where they have moderated significantly.

Overall, when malaria death rates were high and making an important contribution to the All Causes pattern, malarial deaths rates show a smaller male excess than for All Causes in adulthood, but a significantly greater female excess at ages 0-9. What makes females susceptible to higher death rates from malaria especially at ages 0-9? I have only speculations at this point. Greater exposure seems unlikely, but perhaps females were more exposed to house dwelling anophelines than brothers moving about out of doors (but this would not explain the male excess at higher ages). Differences in resistance seem more likely, if young girls had diets poorer in proteins needed for immune functioning, and

Table 2. **Malaria related death rates, Taiwan, 1906-1941**

c. Sex Ratios of Age specific death rates of Taiwanese, Malaria, 1906-1941. Male ASDR/ Fem ASDR.

Years	*Malaria* *Age at beginning of interval:*															
	0*	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70
1906-08	0.92	0.70	0.77	0.83	1.00	1.14	1.17	1.22	1.30	1.34	1.33	1.29	1.29	1.10	0.91	0.98
1909-13	0.96	0.73	0.82	1.00	1.15	1.25	1.41	1.37	1.35	1.57	1.40	1.38	1.43	1.42	1.02	1.04
1914-16	0.89	0.75	0.81	0.92	1.13	1.20	1.33	1.36	1.32	1.42	1.50	1.41	1.08	1.12	0.96	0.94
1919-21	0.89	0.80	0.82	0.90	1.30	1.38	1.36	1.57	1.47	1.33	1.33	1.14	1.13	1.00	1.18	1.09
1924-26	0.98	0.79	0.86	1.13	1.50	1.44	1.27	1.15	1.29	1.58	1.36	1.18	1.24	1.09	1.03	0.83
1929-31	0.95	0.85	0.83	1.00	1.25	1.25	1.20	1.17	1.33	1.33	1.50	1.29	1.00	1.10	1.00	1.06
1934-36	0.94	0.91	1.00	1.33	1.25	1.50	1.50	1.20	1.40	1.60	1.50	1.14	1.11	1.22	1.00	1.00
1939-41	1.08	0.90	1.00	1.33	1.50	1.75	1.20	1.20	1.40	1.40	1.60	1.29	1.29	1.33	1.30	1.00

* Infant death rate, calculated as a ratio of infant deaths to registered live births for corresponding periods.

received less care when stricken with fevers. At higher ages pregnant women whose immune system is weakened (to tolerate the fetus) become more susceptible to infectious diseases, malaria among them. This might contribute to higher malaria deaths in fertile age women that would reduce the degree of male excess mortality (Weinberg 1984, Gilles, et al. 1969, Shepherd 2002). The pattern of male excess mortality in adult ages may be due to a combination of greater exposure (e.g., work in foothill areas infested with anophelines), and lowered resistance from concurrent diseases, and overwork combined with inadequate nutrition.

The decline in malaria death rates is to be attributed to reduced exposure, the result of public health efforts suppressing anopheline mosquitoes and using quinine to stop the transmission of the plasmodium. We must remember that malaria in the early years is an important contributor to large differences in death rates among the prefectures; malaria death rates were much higher in Tainan and Ahou/Kaohsiung than in the north (see Shepherd "Regional" infra). Malarial death rates are highest in climates most favorable to the propagation of anopheline mosquitoes and the malaria plasmodium. Malaria is most deadly in warmer areas where the falciparum variety can survive, such as south Taiwan. The Taiwan cause, age and sex specific death reports are only available for the island as a whole and not for individual prefectures. We do well to remember that a majority of the malaria deaths reported in our table come from the southern prefectures. This suggests conditions peculiar to the south, including comorbidity with other diseases having higher rates in the south, may be important factors contributing to the pattern of malaria mortality we see in our tables.

Respiratory Tuberculosis

The reports of deaths from respiratory tuberculosis appear to provide a relatively consistently reported series for the period, 1906-1937. Respiratory tuberculosis presents identifiable symptoms, bloody sputum, coughing, lethargy, which would be known to family members of the deceased and easily reported to the personnel certifying the cause of death. Special training was not needed to correctly identify the bulk of deaths caused by respiratory tuberculosis. In addition, the international lists for compiling death statistics in use by the colonial authorities consistently reserved a separate title for respiratory TB, so these reports are free of inconsistencies arising from changing category definitions.

The sudden and dramatic decline in respiratory tuberculosis death rates in 1939-41 reflects underreporting to avoid tuberculosis prevention measures put into force in 1938 that required registration of TB cases, and threatened quarantine and even cremation (*Kekkaku yoboho* 1938, Chen et al. 1961:16, Lee 2001:67; cf. Wm. Johnston 1995: 248, 268, 274-75). There is an obvious and sudden discontinuity in the respiratory TB death reporting series between 1937 and 1938 when the new regulations came into effect. From 1937 to 1938, reported deaths attributed to respiratory tuberculosis declined among Taiwanese from 6981 to 4770, but increased among Japanese in Taiwan from 313 to 374. Pulmonary tuberculosis cases reported by the public doctors also declined suddenly from 5696 in 1937 to 3462 in 1938 (*Taiwan Sōtokufu Tōkeisho* 1937: 468, 1938: 470). Because of the threat of intrusive interference, many Taiwanese families implored doctors to report deaths as due to causes other than tuberculosis; it appears the Japanese population and/or its doctors were less concerned about the consequences of reporting. The obvious underreporting frustrates attempts to measure any effect of increasing public health attention to tuberculosis in the years beyond 1938.

We turn first to the varying impact of respiratory TB deaths across the age groups. A glance at the table below immediately reveals a very different pattern compared to the All Causes averages. Respiratory TB has its mortality impact almost exclusively in adulthood. From very low levels in infancy and childhood respiratory TB death rates rise rapidly from age 20 to 39, and continue to increase to peaks most often occurring in the 60's. This pattern of adult mortality reflects the nature of respiratory TB as a progressive and wasting disease, often following a long incubation period. The absence of a sudden spike in respiratory TB mortality in adolescence and early adulthood, found in many populations in Europe, U.S., and Japan, perhaps due to stresses from adolescent maturation, or increasing

Table 3. **Respiratory tuberculosis related death rates, Taiwan, 1906-1936**

a. Cause, Age and Sex specific death rates of Taiwanese, Respiratory Tuberculosis, 1906-1936 (and 1939-41 affected by underreporting). Deaths per 10,000 person years. The infant death rate is used for age 0-1.

Years	***Respiratory Tuberculosis*** *Age at beginning of interval:*															
Males	**0***	**1**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**
1906-08	6	4	1	1	3	9	17	25	36	45	52	62	57	56	53	53
1909-13	4	2	1	1	3	9	16	23	31	41	51	55	57	54	52	38
1914-16	2	2	1	1	4	9	17	24	35	43	53	64	72	70	61	44
1919-21	2	2	1	1	4	12	19	28	40	51	65	78	88	98	109	80
1924-26	3	2	1	1	5	11	17	27	36	50	65	77	87	97	95	80
1929-31	3	2	1	1	4	11	17	22	27	38	52	65	74	80	88	80
1934-36	9	5	1	1	5	12	18	22	26	36	45	58	68	80	90	77
1939-41	*5*	*3*	*1*	*1*	*4*	*9*	*12*	*14*	*17*	*19*	*23*	*29*	*35*	*35*	*34*	*26*
Females																
1906-08	6	4	2	1	3	7	10	12	14	18	21	21	24	27	25	30
1909-13	3	2	1	1	3	7	10	12	16	17	20	20	23	21	24	26
1914-16	3	2	1	1	4	7	11	13	17	20	22	26	31	28	31	30
1919-21	2	2	1	1	5	10	12	17	22	25	32	33	40	45	51	51
1924-26	3	2	1	1	4	9	13	15	20	23	28	37	38	41	51	47
1929-31	3	3	1	1	4	8	11	13	16	21	25	30	38	43	40	47
1934-36	6	5	1	1	5	8	12	12	15	18	23	28	34	39	48	49
1939-41	*5*	*3*	*1*	*1*	*3*	*5*	*7*	*7*	*7*	*8*	*10*	*13*	*14*	*15*	*17*	*16*

* Infant death rate, calculated as a ratio of infant deaths to registered live births for corresponding periods. The 1939-41 rates shown in italics are affected by false reporting.

workloads, and exposure in factory worksites, also deserves further consideration.

Respiratory TB also presents a distinctive temporal pattern in our record. Instead of declining through most of the period, respiratory TB death rates rise to peaks in the 1919-1926 period, then decline slightly but remain above the 1906-08 rates, except for males 30-54. It should also be noted that respiratory TB in Taiwan was never as significant a cause of death as in some European populations, such as mid-nineteenth century Britain where it was the leading single cause of death (Szreter 1988:11).

The sex ratios of respiratory TB mortality present a distinctive pattern of extremely high sex ratios. The degree of excess male mortality, especially above

Table 3. **Respiratory tuberculosis related death rates, Taiwan, 1906-1936**

b. Indices of Cause, Age and Sex specific death rates of Taiwanese, Respiratory Tuberculosis, 1906-1936. Death rates of 1906-8 = 100.0

Years	***Respiratory Tuberculosis*** *Age at beginning of interval:*															
Males	0*	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70
1906-08	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
1909-13	*66.7*	*50.0*	*100.0*	*100.0*	*100.0*	*100.0*	*94.1*	*92.0*	*86.1*	*91.1*	*98.1*	*88.7*	*100.0*	*96.4*	*98.1*	*71.7*
1914-16	*33.3*	*50.0*	*100.0*	*100.0*	*133.3*	*100.0*	*100.0*	*96.0*	*97.2*	*95.6*	*101.9*	*103.2*	*126.3*	*125.0*	*115.1*	*83.0*
1919-21	*33.3*	*50.0*	*100.0*	*100.0*	*133.3*	*133.3*	*111.8*	*112.0*	*111.1*	*113.3*	*125.0*	*125.8*	*154.4*	*175.0*	*205.7*	*150.9*
1924-26	*50.0*	*50.0*	*100.0*	*100.0*	*166.7*	*122.2*	*100.0*	*108.0*	*100.0*	*111.1*	*125.0*	*124.2*	*152.6*	*173.2*	*179.2*	*150.9*
1929-31	*50.0*	*50.0*	*100.0*	*100.0*	*133.3*	*122.2*	*100.0*	*88.0*	*75.0*	*84.4*	*100.0*	*104.8*	*129.8*	*142.9*	*166.0*	*150.9*
1934-36	*150.0*	*125.0*	*100.0*	*100.0*	*166.7*	*133.3*	*105.9*	*88.0*	*72.2*	*80.0*	*86.5*	*93.5*	*119.3*	*142.9*	*169.8*	*145.3*
Females																
1906-08	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
1909-13	*50.0*	*50.0*	*50.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*114.3*	*94.4*	*95.2*	*95.2*	*95.8*	*77.8*	*96.0*	*86.7*
1914-16	*50.0*	*50.0*	*50.0*	*100.0*	*133.3*	*100.0*	*110.0*	*108.3*	*121.4*	*111.1*	*104.8*	*123.8*	*129.2*	*103.7*	*124.0*	*100.0*
1919-21	*33.3*	*50.0*	*50.0*	*100.0*	*166.7*	*142.9*	*120.0*	*141.7*	*157.1*	*138.9*	*152.4*	*157.1*	*166.7*	*166.7*	*204.0*	*170.0*
1924-26	*50.0*	*50.0*	*50.0*	*100.0*	*133.3*	*128.6*	*130.0*	*125.0*	*142.9*	*127.8*	*133.3*	*176.2*	*158.3*	*151.9*	*204.0*	*156.7*
1929-31	*50.0*	*75.0*	*50.0*	*100.0*	*133.3*	*114.3*	*110.0*	*108.3*	*114.3*	*116.7*	*119.0*	*142.9*	*158.3*	*159.3*	*160.0*	*156.7*
1934-36	*100.0*	*125.0*	*50.0*	*100.0*	*166.7*	*114.3*	*120.0*	*100.0*	*107.1*	*100.0*	*109.5*	*133.3*	*141.7*	*144.4*	*192.0*	*163.3*

*Infant death rate, calculated as a ratio of infant deaths to registered live births for corresponding periods.

age 30 is much greater than the All Causes average. The divergence between the sexes accelerates with age and reaches a peak usually at 50-54 after which there are moderate declines. The male excess remains high throughout the period 1906-1936. Also distinctive, though the rates are very low, are the balanced sex ratios throughout infancy and childhood, 0-19. Why Taiwanese men were much more vulnerable to respiratory tuberculosis than women demands explanation; such a large male excess contrasts with known patterns of female excess in Japan at ages 15-20, followed by much more moderate male excesses up to age 40. Szreter cites Cronje's finding that adult male rates of respiratory TB mortality exceeded female rates in urban counties but fell below female rates in rural counties in Britain (Szreter 1988: 13-14, Cronje 1984).

The Taiwanese sex ratios of respiratory tuberculosis mortality diverge from common American ones. Rich cites evidence showing that childbearing in women acts to depress resistance and aggravate symptoms of the active disease

Table 3. **Respiratory tuberculosis related death rates, Taiwan, 1906-1936**

c. Sex Ratios of Cause, Age and Sex specific death rates of Taiwanese, Respiratory Tuberculosis, 1906-1936. Male ASDR/ Fem ASDR.

Years	*Respiratory Tuberculosis* *Age at beginning of interval:*															
	0*	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70
1906-08	1.00	1.00	0.50	1.00	1.00	1.29	1.70	2.08	2.57	2.50	2.48	2.95	2.38	2.07	2.12	1.77
1909-13	1.33	1.00	1.00	1.00	1.00	1.29	1.60	1.92	1.94	2.41	2.55	2.75	2.48	2.57	2.17	1.46
1914-16	0.67	1.00	1.00	1.00	1.00	1.29	1.55	1.85	2.06	2.15	2.41	2.46	2.32	2.50	1.97	1.47
1919-21	1.00	1.00	1.00	1.00	0.80	1.20	1.58	1.65	1.82	2.04	2.03	2.36	2.20	2.18	2.14	1.57
1924-26	1.00	1.00	1.00	1.00	1.25	1.22	1.31	1.80	1.80	2.17	2.32	2.08	2.29	2.37	1.86	1.70
1929-31	1.00	0.67	1.00	1.00	1.00	1.38	1.55	1.69	1.69	1.81	2.08	2.17	1.95	1.86	2.20	1.70
1934-36	1.50	1.00	1.00	1.00	1.00	1.50	1.50	1.83	1.73	2.00	1.96	2.07	2.00	2.05	1.88	1.57

*Infant death rate, calculated as a ratio of infant deaths to registered live births for corresponding periods.

leading to an increasing mortality rate in the fertile ages (Rich 1951:187-9). At later ages as female childbearing declines, this source of aggravation to female health diminishes and, in the American population, the female tuberculosis mortality rate also declines (Rich 1951:204). Rich uses this evidence to explain the common observation in the American population of an excess of female over male tuberculosis mortality in the childbearing years, that then gives way to an excess male mortality at older ages (1951:183, 201ff.). Rates do increase for women in the childbearing years in Taiwan, but not to the degree found among young adult men, nor do they decline following the end of the fertile years.

To explain higher male mortality after the childbearing years in the American population, Rich emphasizes the occupational hazards of males not shared by females: "occupations that involve exposure to the elements, over-exertion and insufficient rest may reasonably be expected to contribute to the tuberculosis mortality of those living in heavily tubercularized communities; for latent infections may be reanimated by such circumstances, and active infections markedly influenced for the worse," (Rich 1951:205). Rich discounts the effect of differential exposure between the sexes to sources of infection, as men bring the infection into households where women are present, and the key to mortality remains the individual's ability to resist progression of the disease (1951:205).

Nutritional status is a key determinant of an individual's ability to resist the progress of tuberculosis infection. Rich reviews the great variety of evidence (studies of economic status, body weight, food supply crises, and animal experiments) that demonstrates that nutritional deficiencies lower resistance to tuberculosis infection (1951:618 ff., Comstock 1975:377-8). Nutrition must be evaluated against the demands put on the body by activity level as well as sickness ("nutritional stress" when demand exceeds supply). Nevertheless, it would be unexpected to discover that adult males were malnourished compared to adult females in the Taiwanese population and thus to appeal to differentials in nutrition to explain the excess adult male tuberculosis mortality. This factor cannot be ruled out, however, if we appeal to a concept of nutritional stress.

Nutritional stress arising from a higher load of concurrent disease could leave the victim susceptible to respiratory tuberculosis. The disease can reactivate and begin to spread when the immune resistance of the host is weakened, e.g. by another disease or stressful condition. Szreter (1988:14-17) suggests that *co-morbidity* is an especially important factor in TB, and that reductions in smallpox, whooping cough, and the enterics (gastrointestinal diseases like typhoid, cholera, diarrheas) are especially important to enabling people to resist the spread of TB, and to keep it in remission in those who already have nascent cases. Some diseases are very debilitating, and leave those who have survived their onslaught with poor health and weakened immune systems. These people are then more vulnerable to attacks from other diseases that prey on them 'opportunistically' or as 'secondary infections'. This effect is called 'co-morbidity'. One disease may 'set up' a patient to be the victim of a second disease, by weakening, preoccupying and diverting the patient's immune system resistance. Comorbidity is certainly a possible explanation for excess male respiratory tuberculosis death rates in Taiwan, but we should note that death rates due to many other diseases began to decrease much earlier than TB, which seems to have lagged in its decline.

There remains the suggestion that high male rates are the product of a genetically determined weakness in male lungs (Waldron 1983). But genetic weakness does not produce male excess mortality in all populations. In other populations where males enjoy more favorable circumstances female rates in the fertile ages eclipse those of males, and male rates overtake female rates only thereafter. In the Taiwanese population however, it appears adverse circumstances for males result in higher death rates even in the fertile years.

Hypotheses accounting for differentials in the incidence of respiratory tuberculosis variously emphasize diet (TB is considered to be a nutritionally sensitive disease, The Conferees 1985), exposure to active cases (e.g. within the family), environmental conditions such as crowded living spaces, poor ventilation, and polluted cities, and reduced immune response due to co-morbidity. These factors are often the targets of public health efforts aiming to reduce TB, and their amelioration plays an important role in reducing mortality from respiratory TB.

Respiratory Diseases (PBI): Pneumonia, Bronchitis, Influenza, Other

The remaining disease groups to be discussed, respiratory diseases, diarrhea and enteritis, and diseases of infancy are most consistently reported and defined in the period 1924-41.

"Respiratory diseases" is a broad category including pneumonia, bronchitis, influenza ("PBI"), and other respiratory diseases, that weighed heavily on the health of Taiwanese in this period. When combined they are the leading cause of death in all periods, and all prefectures suffered from high rates of these diseases.

We turn first to the varying impact of respiratory disease deaths across the age groups in the 1924-41 period. Respiratory diseases exhibit a j-shaped age curve of mortality, with especially high levels at the extremes in infancy and old age. Levels remain high in early childhood, then reach a low point at ages 5-19, after which they begin a slow rise that only after age 55 reaches levels as high as those experienced at ages 1-4.

Our data series for respiratory diseases covers a smaller range of years, but the degree of decline is nevertheless substantial. The decline in respiratory disease death rates is greatest for both sexes in the 25-39 age groups, but is fairly evenly spread among all the age groups beyond infancy and early childhood. Rates in infancy especially were slow to show improvement, even increasing slightly when rates in other ages were decreasing in 1929-31 and 1934-36, but falling by 1939-41 below the initial period. It is not unusual to find rates in infancy responding less to improvements enjoyed more readily at older ages.

The sex ratios of mortality from respiratory diseases exhibit a pattern generally similar to that for All Causes. The sex ratios of mortality for respiratory diseases show a similar male excess in infancy, a small female excess at ages 1-4, approach balance in most years at ages 5-14, then rapidly increase to peaks at ages 40-54 that are much higher than those for all causes. The sex ratio of mortality then declines somewhat but remains higher than that for All Causes from age 55 to the terminal age group. The high excess male mortality in respiratory diseases reaches levels as high as do those for respiratory tuberculosis at ages 40-54, but falls below the TB ratios from ages 55 to the terminal age group. Clearly both groups of respiratory disease, tubercular and the larger nontubercular PBI group, contribute greatly to the male excess mortality at adult ages seen in the All Causes averages.

Pneumonia death rates were the highest of the three PBI diseases; cases of pneumonia often bring on death after a person has been stricken by some other disease. Many of the same factors discussed under respiratory tuberculosis may account for the higher male rates – nutritional stress due to diet inadequate to need (pneumonia is nutritionally sensitive, meaning that victims of the disease who are malnourished will suffer more serious cases), work outdoors that increases exposure to the elements, and lowered resistance due to a heavier inci-

Table 4. **Respiratory disease related death rates, Taiwan, 1924-1941**

a. Cause, Age and Sex specific death rates of Taiwanese, Respiratory Diseases (PBI), 1924-1941. Deaths per 10,000 person years. The infant death rate is used for age 0-1.

Years	*Respiratory: Pneumonia, Bronchitis, Influenza, Other* Age at beginning of interval:															
Males	**0***	**1**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**
1924-26	496	140	20	10	16	26	37	49	63	77	96	117	153	214	278	406
1929-31	513	122	15	8	12	19	24	29	39	52	66	86	112	155	205	335
1934-36	520	120	15	8	12	18	24	29	38	52	69	89	116	152	197	318
1939-41	468	116	15	7	12	19	23	30	37	52	70	100	124	170	213	315
Females																
1924-26	425	152	22	9	13	18	24	29	32	35	44	56	82	120	154	273
1929-31	432	129	15	8	11	13	15	18	22	25	33	42	60	83	126	221
1934-36	438	125	15	8	11	14	15	17	20	24	29	41	60	84	119	221
1939-41	387	120	15	8	9	13	15	18	21	26	33	44	64	83	116	207

* Infant death rate, calculated as a ratio of infant deaths to registered live births for corresponding periods.

b. Indices of Cause, Age and Sex specific death rates of Taiwanese, Respiratory Diseases (PBI), 1924-1941. Death rates of 1924-1926 = 100.

Years	*Respiratory: Pneumonia, Bronchitis, Influenza, Other* Age at beginning of interval:															
Males	**0***	**1**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**
1924-26	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
1929-31	*103.4*	*87.1*	*75.0*	*80.0*	*75.0*	*73.1*	*64.9*	*59.2*	*61.9*	*67.5*	*68.8*	*73.5*	*73.2*	*72.4*	*73.7*	*82.5*
1934-36	*104.8*	*85.7*	*75.0*	*80.0*	*75.0*	*69.2*	*64.9*	*59.2*	*60.3*	*67.5*	*71.9*	*76.1*	*75.8*	*71.0*	*70.9*	*78.3*
1939-41	*94.4*	*82.9*	*75.0*	*70.0*	*75.0*	*73.1*	*62.2*	*61.2*	*58.7*	*67.5*	*72.9*	*85.5*	*81.0*	*79.4*	*76.6*	*77.6*
Females																
1924-26	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
1929-31	*101.6*	*84.9*	*68.2*	*88.9*	*84.6*	*72.2*	*62.5*	*62.1*	*68.8*	*71.4*	*75.0*	*75.0*	*73.2*	*69.2*	*81.8*	*81.0*
1934-36	*103.1*	*82.2*	*68.2*	*88.9*	*84.6*	*77.8*	*62.5*	*58.6*	*62.5*	*68.6*	*65.9*	*73.2*	*73.2*	*70.0*	*77.3*	*81.0*
1939-41	*91.1*	*78.9*	*68.2*	*88.9*	*69.2*	*72.2*	*62.5*	*62.1*	*65.6*	*74.3*	*75.0*	*78.6*	*78.0*	*69.2*	*75.3*	*75.8*

* Infant death rate, calculated as a ratio of infant deaths to registered live births for corresponding periods.

c. Sex Ratios of Cause, Age and Sex specific death rates of Taiwanese, Respiratory Diseases (PBI), 1924-1941. Male ASDR/ Fem ASDR.

	Respiratory: Pneumonia, Bronchitis, Influenza, Other															
Years	*Age at beginning of interval:*															
	0*	**1**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**
1924-26	1.17	0.92	0.91	1.11	1.23	1.44	1.54	1.69	1.97	2.20	2.18	2.09	1.87	1.78	1.81	1.49
1929-31	1.19	0.95	1.00	1.00	1.09	1.46	1.60	1.61	1.77	2.08	2.00	2.05	1.87	1.87	1.63	1.52
1934-36	1.19	0.96	1.00	1.00	1.09	1.29	1.60	1.71	1.90	2.17	2.38	2.17	1.93	1.81	1.66	1.44
1939-41	1.21	0.97	1.00	0.88	1.33	1.46	1.53	1.67	1.76	2.00	2.12	2.27	1.94	2.05	1.84	1.52

* Infant death rate, calculated as a ratio of infant deaths to registered live births for corresponding periods.

dence of concurrent diseases. Pneumonia is often a secondary infection setting in after the victim is weakened by a concurrent disease, which underlines the probable importance of comorbidity in elevating respiratory disease death rates. In this connection it is interesting to note (Shepherd "Regional" infra) that the same north-south gradient in death rates (despite the north's having colder, wetter winters) appears in the case of respiratory diseases as in the case of malaria. Dusty conditions during the southern winter drought period may have aggravated respiratory conditions, though why men should be more affected than women remains a puzzle (Chen Cheng-siang 1995: 9-11).

Diarrhea and Enteritis

Deaths due to diarrhea and enteritis are most consistently reported and defined in the period 1924-41. In this disease group we turn to important water and food borne sources of infection and disease, in contrast to the airborne sources important in respiratory tuberculosis and the PBI diseases, and the mosquito vector in malaria.

We turn first to the varying impact of these enteric diseases across the age groups in the 1924-41 period. Diarrhea and enteritis exhibit a j-shaped age curve of mortality, but one that has especially high levels in infancy and early childhood ages 1-4. Death rates remain very low from 5 to 34 then begin a slow rise that continues to the end of the age range. The second peak at ages 70 and above, which is generally only a third of the rates in infancy, reaches the levels of mortality at ages 1-4 in the case of males but not females.

The data series presented for diarrhea and enteritis covers only the period 1924-1941, but the degree of decline is nevertheless substantial. Diarrhea and enteritis death rates decline most in the middle age ranges 5-54 where rates were already low. Lower degrees of decline that are nevertheless substantial are record-

Table 5. **Diarrhea and enteritis related death rates, Taiwan, 1924-1941**

a. Cause, Age and Sex specific death rates of Taiwanese, Diarrhea and Enteritis, 1924-1941. Deaths per 10,000 person years. The infant death rate is used for age 0-1.

Years	*Diarrhea and Enteritis* *Age at beginning of interval:*															
Males	**0***	**1**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**
1924-26	297	89	7	3	3	4	6	9	13	16	20	27	32	52	61	94
1929-31	322	91	6	2	3	3	5	6	7	12	15	18	27	37	57	93
1934-36	274	70	4	1	2	2	3	4	5	8	10	13	21	26	40	71
1939-41	227	64	4	2	2	2	3	4	4	7	11	16	22	32	42	77
Females																
1924-26	275	110	8	2	2	3	5	6	8	9	10	13	20	28	43	77
1929-31	306	111	6	2	2	3	4	5	6	7	9	10	17	21	37	73
1934-36	255	83	4	1	1	2	2	3	4	6	6	9	14	19	31	66
1939-41	209	77	5	1	1	2	3	3	4	5	6	8	13	21	29	70

*Infant death rate, calculated as a ratio of infant deaths to registered live births for corresponding periods.

b. Indices of Cause, Age and Sex specific death rates of Taiwanese, Diarrhea and Enteritis, 1924-1941. Death rates of 1924-1926 = 100.

Years	*Diarrhea and Enteritis* *Age at beginning of interval:*															
Males	**0***	**1**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**
1924-26	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
1929-31	*108.4*	*102.2*	*85.7*	*66.7*	*100.0*	*75.0*	*83.3*	*66.7*	*53.8*	*75.0*	*75.0*	*66.7*	*84.4*	*71.2*	*93.4*	*98.9*
1934-36	*92.3*	*78.7*	*57.1*	*33.3*	*66.7*	*50.0*	*50.0*	*44.4*	*38.5*	*50.0*	*50.0*	*48.1*	*65.6*	*50.0*	*65.6*	*75.5*
1939-41	*76.4*	*71.9*	*57.1*	*66.7*	*66.7*	*50.0*	*50.0*	*44.4*	*30.8*	*43.8*	*55.0*	*59.3*	*68.8*	*61.5*	*68.9*	*81.9*
Females																
1924-26	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
1929-31	*111.3*	*100.9*	*75.0*	*100.0*	*100.0*	*100.0*	*80.0*	*83.3*	*75.0*	*77.8*	*90.0*	*76.9*	*85.0*	*75.0*	*86.0*	*94.8*
1934-36	*92.7*	*75.5*	*50.0*	*50.0*	*50.0*	*66.7*	*40.0*	*50.0*	*50.0*	*66.7*	*60.0*	*69.2*	*70.0*	*67.9*	*72.1*	*85.7*
1939-41	*76.0*	*70.0*	*62.5*	*50.0*	*50.0*	*66.7*	*60.0*	*50.0*	*50.0*	*55.6*	*60.0*	*61.5*	*65.0*	*75.0*	*67.4*	*90.9*

* Infant death rate, calculated as a ratio of infant deaths to registered live births for corresponding periods.

c. Sex Ratios of Cause, Age and Sex specific death rates of Taiwanese, Diarrhea and Enteritis, 1924-1941. Male ASDR/ Fem ASDR.

Years	*Diarrhea and Enteritis* *Age at beginning of interval:*															
	0*	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70
1924-26	1.08	0.81	0.88	1.50	1.50	1.33	1.20	1.50	1.63	1.78	2.00	2.08	1.60	1.86	1.42	1.22
1929-31	1.05	0.82	1.00	1.00	1.50	1.00	1.25	1.20	1.17	1.71	1.67	1.80	1.59	1.76	1.54	1.27
1934-36	1.07	0.84	1.00	1.00	2.00	1.00	1.50	1.33	1.25	1.33	1.67	1.44	1.50	1.37	1.29	1.08
1939-41	1.09	0.83	0.80	2.00	2.00	1.00	1.00	1.33	1.00	1.40	1.83	2.00	1.69	1.52	1.45	1.10

* Infant death rate, calculated as a ratio of infant deaths to registered live births for corresponding periods.

ed at ages 0-4 and 55-69. The rates in the terminal age group declined the least. It is impressive that the very high rates in infancy, despite a surge in 1929-31, declined to the degree they did.

The sex ratios of mortality from diarrheal diseases exhibit a somewhat distinctive pattern. The diarrheal diseases show a smaller male excess in infancy, and a deeper female excess at ages 1-4 than for is the case for All Causes. Ratios at ages 5-34 generally show a male excess, but the rates at these ages are so low for both males and females that they cause the sex ratios to be less meaningful (i.e., very small absolute differences (e.g., 2 to 1) produce very large ratios (2.00)). When the rates begin to rise significantly from age 35 there is a consistent and substantial male excess that then declines somewhat at ages above 65. The sex ratios of mortality for diarrheal diseases at ages 35 and above generally resemble the ratios for All Causes.

The low sex ratios of diarrheal disease mortality at ages 0-4 reveal these diseases to be important contributors to the mortality of female infants and young girls, and to the pattern of female excess mortality at ages 1-4 in the All Causes average. The female excess mortality at ages 1-4 for diarrheal diseases 1924-1941 is greater than that found in any of the other disease groups we have discussed, including malaria (excepting 1924-26). The diarrheal death rates are also greater in absolute terms than malaria death rates in the 1924-1941 period.

Why should the excess female mortality at ages 1-4 be greater from diarrheas than from respiratory tuberculosis and respiratory diseases, when all are considered nutritionally sensitive? Diarrheal diseases stem from water and food borne sources of infection, so food and drink sanitation practices play an important role in their spread. Were boys and girls differentially exposed to contaminated food and drink? Did son preference mean that boys ate fresher foods and daughters left-overs? Or were differences in resistance related to nutrition more important, perhaps because boys' resistance to disease benefited from eating more and more nutritious (meat) foods? Or did the difference lie in the degrees of care and rest allowed boys vs. girls suffering from diarrheas? And what about the male excess at ages above 35? Is this the result of greater exposure or lower resistance?

It is important to note that diarrheas, because they interfere with the absorption of nutrients when the immune system is most in need of them, can be important causes of the worsening of concurrent diseases. Diarrheas thus are linked to nutritional distress on the immune system, and are debilitating infections that can leave the victim vulnerable to opportunistic infections, especially respiratory diseases that are nutritionally sensitive, including respiratory tuberculosis and other bacterial infections such as whooping cough, and pneumonia (Lunn 1991). Omran (1971) refers to the 'pneumonia-diarrhea- malnutrition' complex in children. Higher rates of diarrhea and enteritis thus could play an important role in raising the rates of death from other diseases.

Separate work on regional variation in causes of death (Shepherd "Regional" infra) shows a divide between the northern and the southern prefectures (including Taichung) in diarrhea and enteritis death rates similar to that found for malaria and respiratory tuberculosis, though not as extreme as in the case of malaria. Higher rates in the south for all three disease groups suggest that comorbidity may have further elevated mortality in those prefectures. The cooler northern climate likely reduces the amount of food and drink contaminated by bacteria in that region.

The importance of food and drink sanitation practices to the spread of diarrheal diseases points to the importance of reducing exposures to contaminated water and food to the historic decline of these diseases. Public water works and sewer systems were not important outside the major cities in colonial Taiwan (where only a small proportion of the population lived). I hypothesize that the spread of more sanitation-conscious food and drink preparation and preservation practices were more important to reducing the sources of diarrheal diseases. These practices would include publicly supervised slaughter houses and markets, as well as changes in domestic kitchens.

Causes of Death in Infancy

We turn next to examine together the many important causes leading to death in infancy. Newborns in colonial Taiwan suffered from rates of mortality higher than those in any other age group, as the All Causes table reveals. Deaths in infancy are most consistently reported and defined in the period 1924-41.

The table below reports the infant death rates attributed to ten leading causes of death in infancy, as well as the All Causes average. Of the four disease groups discussed above, three are represented here: malaria, respiratory diseases (PBI) and diarrhea and enteritis. Rates of death in infancy from Respiratory TB are too low to be considered. Two cause groups, 'certain diseases of infancy' and tetanus, not previously discussed, are of very great significance to infant mortality.

Certain diseases of infancy includes causes occurring overwhelmingly in the first month of life, such as congenital malformation and debility (the two largest subgroups), prematurity, and birth trauma. Certain diseases of infancy reports primarily endogenous and neonatal deaths, rather than exogenous causes related to environmental exposures.

Infantile tetanus is also a cause of death that occurs overwhelmingly in the first month of life. It is likely that infantile tetanus was 'overreported' in our data sources, as neonatal deaths from other causes were carelessly reported as infantile tetanus. This is the conclusion of Li T'eng-yue based on a review of the cause of death reports for the year 1934 (1938d: 1616). Li discovered that slightly more than half of all infant deaths classified as tetanus were reported to have occurred within five days of birth, too soon for most tetanus infections to have incubated and caused death (infantile tetanus on average shows symptoms within seven days with death following in a few days). Thus half of tetanus deaths should be reclassified as due to other neonatal causes, including jaundice/icterus. The overwhelming balance of deaths classified as tetanus took place within ten days of birth. This leaves a very significant number of deaths attributed to tetanus proper. Medical authorities in colonial Taiwan regularly criticized midwives and other birth attendants for unsanitary practices in cutting the umbilical cord that led to tetanus (see Wu Chia-ling 2006). Reclassification of a portion of these deaths does not affect our assessment that the infantile tetanus category reports overwhelmingly neonatal deaths.

Five diseases that also contributed significantly to infant death rates will be discussed briefly. Most of these causes arise from infections contracted from the environment. Congenital syphilis is a partial exception as it is transmitted to the infant from an infected mother. Convulsions is a symptomological category rather than an identifiable disease, but is usually associated with the dehydration brought on by infantile diarrheas (Szreter 1988: 17). Stomach complaints is a category that captures a variety of gastrointestinal problems Meningitis, measles, and whooping cough are infectious diseases which easily overwhelm immature infant immune systems.

The All Causes average of infant mortality declined consistently over the period 1924-41 for both sexes, despite increases in measles 1934-41, and temporary surges in respiratory diseases 1929-36, diarrheas 1929-31, certain diseases of infancy in 1934-36, and syphilis 1939-41. Major contributors to the overall decline were diarrhea and enteritis, and tetanus. Convulsions also declined dramatically, but many of these deaths may have been reclassified to other causes (perhaps diarrhea) in the later years as this was a disfavored symptomological category. All the remaining diseases contributed significant but smaller absolute amounts to the decline with the exception noted of measles.

Table 6. **Infant mortality, Taiwan, 1924-1941**

a. Infant Death Rates by Cause and Sex, Taiwanese, 1924-41. Deaths per 10,000 births.

Infant Death Rate*	All Causes	Respir-atory (PBI)	Diarrhea, Enteritis	Certain Dis.Inf.	Tetanus	Malaria	Measles, Whoop-ing cough	Convul-sions	Stomach	Con-genital Syphilis	Menin-gitis
Males											
1924-26	1817	496	297	324	293	52	27	88	30	35	18
1929-31	1703	513	322	284	289	19	22	44	19	28	14
1934-36	1620	520	274	310	256	15	43	15	17	27	5
1939-41	1440	468	227	284	231	13	52	3	11	28	3
Females											
1924-26	1515	425	275	251	203	53	24	74	30	31	14
1929-31	1418	432	306	219	201	20	22	36	18	24	10
1934-36	1356	438	255	243	187	16	45	12	16	22	4
1939-41	1208	387	209	235	172	12	50	3	9	24	2

* Infant death rate, calculated as a ratio of infant deaths to registered live births for corresponding periods.

b. Indices of Infant Death Rates by Cause and Sex, Taiwanese, 1924-41. Death rates of 1924-1926 =100

Infant Death Rate*	All Causes	Respir-atory (PBI)	Diarrhea, Enteritis	Certain Dis.Inf.	Tetanus	Malaria	Measles, Whoop-ing cough	Convul-sions	Stomach	Con-genital Syphilis	Menin-gitis
Males											
1924-26	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
1929-31	*93.7*	*103.4*	*108.4*	*87.7*	*98.6*	*36.5*	*81.5*	*50.0*	*63.3*	*80.0*	*77.8*
1934-36	*89.2*	*104.8*	*92.3*	*95.7*	*87.4*	*28.8*	*159.3*	*17.0*	*56.7*	*77.1*	*27.8*
1939-41	*79.3*	*94.4*	*76.4*	*87.7*	*78.8*	*25.0*	*192.6*	*3.4*	*36.7*	*80.0*	*16.7*
Females											
1924-26	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
1929-31	*93.6*	*101.6*	*111.3*	*87.3*	*99.0*	*37.7*	*91.7*	*48.6*	*60.0*	*77.4*	*71.4*
1934-36	*89.5*	*103.1*	*92.7*	*96.8*	*92.1*	*30.2*	*187.5*	*16.2*	*53.3*	*71.0*	*28.6*
1939-41	*79.7*	*91.1*	*76.0*	*93.6*	*84.7*	*22.6*	*208.3*	*4.1*	*26.7*	*77.4*	*14.3*

* Infant death rate, calculated as a ratio of infant deaths to registered live births for corresponding periods.

c. **Sex Ratios of Infant Death Rates by Cause, Taiwanese, 1924-41. Male ASDR/ Fem ASDR.**

Infant Death Rate*	All Causes	Respiratory (PBI)	Diarrhea, Enteritis	Certain Dis.Inf.	Tetanus	Malaria	Measles, Whooping cough	Convulsions	Stomach	Congenital Syphilis	Meningitis
1924-26	1.20	1.17	1.08	1.29	1.44	0.98	1.13	1.19	1.00	1.13	1.29
1929-31	1.20	1.19	1.05	1.30	1.44	0.95	1.00	1.22	1.06	1.17	1.40
1934-36	1.19	1.19	1.07	1.28	1.37	0.94	0.96	1.25	1.06	1.23	1.25
1939-41	1.19	1.21	1.09	1.21	1.34	1.08	1.04	1.00	1.38	1.17	1.50

* Infant death rate, calculated as a ratio of infant deaths to registered live births for corresponding periods.

Maternal and infant health are linked in many ways, and poor maternal health through pregnancy is thought to increase the chance of neonatal deaths, particularly those in the 'certain diseases of infancy' category (malformation, debility, prematurity, birth trauma)(cf. Loudon 1992). Low birth weight neonates and those whose mothers are unable to produce adequate breastmilk are also at added risk of death. The decline in mortality in infancy cannot be attributed to improved maternal and infant health arising from lower fertility and lengthened birth intervals, however. Birth rates increased over the period and remained higher in 1930-40 than in any previous decade (Barclay 1954: 241, 243, 246). This suggests that explanations relying on excess fertility and crowded spacing to explain high neonatal death rates are less important than factors related to the disease environment. The sharp declines in deaths among women in the fertile ages over the period so obvious in the All Causes and other tables above suggest that improved maternal health made it possible to achieve both higher fertility and lower rates of infant mortality.

The sex ratio of infant death for the All Causes average shows a consistent male excess; this is as expected in most populations. Male infants generally report larger numbers in the malformation and debility categories, have lungs that are less mature than those of female infants (Waldron 1983), and are generally more vulnerable to infection. The sex ratios of infant mortality reflect these patterns: male excess mortality is substantial in certain diseases of infancy, respiratory diseases, and tetanus. Significant male excesses are also reported in convulsions, meningitis, and syphilis. The lowest sex ratios are reported for diarrheas and stomach, malaria, and measles, all primarily post-neonatal causes of death. We have already discussed possible sources of excess female mortality in diarrheas at ages 1-4, and these considerations likely apply to deaths due to diarrheas and stomach complaints in infancy, which are largely postneonatal. Poorer quality nutrition and earlier weaning that exposes the grastrointestinal tract to infected food and drink undoubtedly contribute to elevate female rates in the postneona-

Table 7. **Infant, Neonatal and Post-neonatal Death Rates, Taiwanese, 1924-41. Deaths per thousand.**

	Deaths per thousand.				Indexed Infant Death Rates, 1924-26 = 100.			
	Infant Death Rate	**Neonatal Death Rate**	**Post-neonatal Death Rate***	**Neonatal % of IDR**	**Infant Death Rate**	**Neonatal Death Rate**	**Post-neonatal Death Rate***	**Neo-natal %**
Males								
1924-26	181.7	90.9	99.9	50.0	*100*	*100*	*100*	*100*
1929-31	170.3	81.9	96.3	48.1	*94*	*90*	*96*	*96*
1934-36	162.0	74.8	94.3	46.1	*89*	*82*	*94*	*92*
1939-41	144.0	67.7	81.8	47.0	*79*	*74*	*82*	*94*
Females								
1924-26	151.5	67.3	90.3	44.4	*100*	*100*	*100*	*100*
1929-31	141.8	60.1	86.9	42.4	*94*	*89*	*96*	*95*
1934-36	135.6	55.4	84.9	40.9	*90*	*82*	*94*	*92*
1939-41	120.8	52.0	72.6	43.1	*80*	*77*	*80*	*97*

* PNN death rate calculated as deaths per survivors of the first month of life.

Source: *Taiwan jinkō dōtai tōkei.*

Table 8. **Sex Ratios of Infant, Neonatal and Post-neonatal Death Rates, Taiwanese, 1924-41. Male ASDR/ Fem ASDR.**

	Infant Death Rate	**Neonatal Death Rate**	**Postneonatal Death Rate***	**Neonatal % of IDR**
1924-26	1.20	1.35	1.11	1.13
1929-31	1.20	1.36	1.11	1.13
1934-36	1.19	1.35	1.11	1.13
1939-41	1.19	1.30	1.13	1.09

tal period (and lower the sex ratio). Measles and whooping cough are nutritionally sensitive and the lower sex ratio for these diseases may reflect poor nutrition and earlier weaning in females. More curious is the low sex ratio for malaria.

The tables above confirm that the male disadvantage in infancy is greatest in the neonatal period, where certain diseases of infancy and tetanus are concentrated. The male disadvantage relative to females declines in the postneonatal period when exogenous causes and environmental exposures increase. Over the period 1924-1941, the decline in the neonatal period is slightly greater than the decline in the postneonatal period.

Our knowledge of the distribution of the infant causes between the neonatal and postneonatal periods is much indebted to Li T'eng-yue's analysis of the cause of death reports for 1934 (1938d). Li was a medical doctor and member of staff at Taipei Imperial University Medical College. He obtained the original cause of death tickets from the Government-general's statistical office for the year 1934 in order to conduct a detailed statistical analysis of the timing of death in infancy by cause (1938d: 1451). The results of Li's analysis are summarized in Table 9 below (as precisely as his tables allow; supplemented by the reports of infant deaths by month in the 1934 *Taiwan jinkō dōtai tōkei*). A second table calculates neonatal and postneonatal death rates for the leading causes in 1934.

Li's analysis shows that certain diseases of infancy and tetanus combined accounted for 71% of neonatal deaths in 1934. More than 90% of deaths attributed to certain diseases of infancy occur in the first month of life, and more than 96% of deaths attributed to tetanus occur in the first month of life, confirming that these two causes are overwhelmingly neonatal. Respiratory diseases and diarrheas and enteritis accounted for 75% of post-neonatal deaths. Deaths attributed to diarrhea and enteritis increase especially in the last six months of the first year of life, a pattern which is likely related to weaning from breastfeeding and increasing amounts of supplements to breastmilk that are susceptible to contamination. Measles also noticeably increases in the last six months; weaning could also play a role here by reducing the transfer of passive immunities passed from mother to infant in breastmilk. Overall, 82% of all infant deaths are accounted for by four causes: certain diseases of infancy, tetanus, respiratory diseases and diarrhea and enteritis.

The Causes Combined

The tables below combine the rates for All Causes, and the four individual cause groups discussed here, respiratory diseases, diarrhea and enteritis, malaria and respiratory tuberculosis for the initial and terminal years for which we have consistent series for all these causes, 1924-26 and 1939-41. The proportion of total deaths that these four causes account for is shown in the accompanying tables. The four selected causes account for half or more of all deaths in most age groups in the 1924-26 period, and somewhat lower proportions in 1939-41. The proportion of total female deaths accounted for is generally lower than for males. Much work remains to be done.

Table 9. **Causes of infant death in neonatal and post-neonatal periods, Taiwanese, 1934.**

1934	*Neonatal*		*Postneonatal*	
Cause of death	*Male*	*Female*	*Male*	*Female*
Certain Dis. Inf.	38.0%	38.9%	2.5%	2.5%
Tetanus	33.0	32.7	0.7	0.8
Respiratory (PBI)	11.8	11.5	46.3	44.6
Diarrhea and enteritis	6.5	5.6	28.6	29.4
Stomach	0.5	0.6	1.0	0.9
Measles	0.2	0.2	4.0	5.0
Beriberi	0.2	0.2	0.7	0.6
Syphilis	1.3	1.5	1.7	1.6
Septicemia	1.5	1.5	1.5	1.5
Mening. & Inf.Convul.	1.5	1.3	2.1	1.9
Malaria	0.2	0.2	1.4	1.7
Erysipelis	0.9	1.0	1.2	1.3
Other & unknown	4.4	4.6	8.3	8.0
Total %	100.0%	100.0%	100.0%	100.0%
Total deaths	*8520*	*6084*	*10303*	*9147*
NN% of IDR	*45.3%*	*39.9%*		

Source: Li T'eng-yue 1938d: 1609-1615, *Taiwan jinkō dōtai tōkei*, 1934.

Many more cause groups await individual analysis. The age group with the lowest proportions is the elderly. Adding degenerative causes, such as stroke, heart diseases, and nephritis will increase the proportion of total deaths accounted for among the elderly. Adding maternal causes will increase the proportion among women in fertile ages. And for both sexes at adult ages, adding stomach related causes including ulcers, and accidents will account for significant increases. Rates in infancy and childhood can also be raised by adding a few significant causes. We saw above that adding certain infant causes and tetanus increases the proportion of infant deaths accounted for to 82% in 1934. The proportion of deaths accounted for by the four causes is highest in early childhood, ages 1-4, despite the very low contribution of respiratory TB and the declining significance of malaria to rates at this age. Clearly respiratory causes and diarrheas play a dominant role in mortality in early childhood. Adding infectious diseases (e.g., measles and whooping cough) will also raise the rates in childhood significantly.

Table 10. **Infant death rates by cause in the neonatal and post-neonatal periods, Taiwanese, 1934.* Deaths per 1000.**

1934	*Neonatal Death Rates*		*Postneonatal Death Rates***	
Cause of death	*Male*	*Female*	*Male*	*Female*
Certain Dis. Inf.	29.05	22.44	2.52	2.34
Tetanus	25.25	18.88	0.65	0.74
Respiratory (PBI)	9.02	6.63	46.32	41.02
Diarrhea and enteritis	4.94	3.24	28.61	27.07
Stomach	0.40	0.37	0.98	0.86
Measles	0.19	0.13	4.05	4.61
Beriberi	0.14	0.11	0.67	0.58
Syphilis	0.98	0.87	1.70	1.48
Septicemia	1.12	0.87	1.48	1.42
Mening. & Inf.Convul.	1.12	0.77	2.13	1.78
Malaria	0.16	0.12	1.39	1.54
Erysipelis	0.65	0.60	1.24	1.24
Other & unknown	3.40	2.65	8.34	7.34
All Causes	76.43	57.68	100.07	92.03
Total deaths	*8520*	*6084*	*10303*	*9147*
*Births**	*111474*	*105480*		

* Calculated using the births of 1933 and 1934, and a separation factor of 0.3 (Barclay 1958: 140-141).

** PNN death rate calculated as deaths per survivors of the first month of life. Based on Li T'eng-yueh 1938d: 1609-1615 and the table above.

Conclusion

The All Causes table presented at the beginning of this discussion summarizes our main story: there was a significant decline in mortality through the period 1906-1941 that was shared broadly by all age and sex groups. We have investigated the contribution to that decline made by four separate cause groups, malaria, respiratory TB, respiratory causes (PBI), and diarrhea and enteritis. And in the case of infant deaths we have also assessed the contribution of several additional causes, in particular certain diseases of infancy and tetanus.

For each cause group we have been concerned to detect patterns of differential incidence and decline among the age groups and sexes that would provide insight into the epidemiological factors elevating or decreasing death rates. Both disease environment and factors of social position played a role in whether a particular age and sex group exhibited death rates higher or lower than the period

Table 11. **Cause, Age and Sex specific death rates of Taiwanese, All Causes and Selected Leading Causes, 1924-26. Deaths per 10,000 person years. The infant death rate is used for age 0-1.**

1924-26	*All Causes and Selected Leading Causes, 1924-26*															
Years	*Age at beginning of interval:*															
Males	**0***	**1**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**
AllCaus	1817	356	67	39	60	89	117	154	197	243	302	372	485	674	881	1443
Resp	496	140	20	10	16	26	37	49	63	77	96	117	153	214	278	406
Diarr.	297	89	7	3	3	4	6	9	13	16	20	27	32	52	61	94
Malar.	52	27	12	9	12	13	14	15	18	19	19	20	21	24	31	35
RespTB	3	2	1	1	5	11	17	27	36	50	65	77	87	97	95	80
Females																
AllCaus	1515	417	71	36	56	84	101	124	144	148	168	217	284	414	578	1120
Resp	425	152	22	9	13	18	24	29	32	35	44	56	82	120	154	273
Diarr.	275	110	8	2	2	3	5	6	8	9	10	13	20	28	43	77
Malar.	53	34	14	8	8	9	11	13	14	12	14	17	17	22	30	42
RespTB	3	2	1	1	4	9	13	15	20	23	28	37	38	41	51	47

* Infant death rate, calculated as a ratio of infant deaths to registered live births for corresponding periods.

Table 12 Proportion of All Causes accounted for by selected leading causes, 1924-26.

1924-26	*Proportion of All Causes accounted for by Selected Leading Causes, 1924-26*															
Years	*Age at beginning of interval:*															
Age	**0**	**1**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**
Males	46.7	72.5	59.7	59.0	60.0	60.7	63.2	64.9	66.0	66.7	66.2	64.8	60.4	57.4	52.8	42.6
Females	49.9	71.5	63.4	55.6	48.2	46.4	52.5	50.8	51.4	53.4	57.1	56.7	55.3	51.0	48.1	39.2

Table 13. **Sex Ratios of Age and Sex specific death rates of Taiwanese, All Causes and Selected Leading Causes, 1924-26. Male ASDR/ Female ASDR.**

924-26 *All Causes and Selected Leading Causes, 1924-26*

Years	*Age at beginning of interval:*															
	0	**1**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**
AllCaus	120	85	94	108	107	106	116	124	137	164	180	171	171	163	152	129
Resp	117	92	91	111	123	144	154	169	197	220	218	209	187	178	181	149
Diarr.	108	81	88	150	150	133	120	150	163	178	200	208	160	186	142	122
Malar.	98	79	86	113	150	144	127	115	129	158	136	118	124	109	103	83
RespTB	100	100	100	100	125	122	131	180	180	217	232	208	229	237	186	170

Table 14. **Cause, Age and Sex specific death rates of Taiwanese, All Causes and Selected Leading Causes, 1939-41. Deaths per 10,000 person years. The infant death rate is used for age 0-1.**

1939-41 *All Causes and Selected Leading Causes, 1939-41*

Years	*Age at beginning of interval:*															
Males	**0**	**1**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**
AllCaus	1440	289	46	27	45	66	77	96	116	156	210	293	381	527	712	1291
Resp	468	116	15	7	12	19	23	30	37	52	70	100	124	170	213	315
Diarr.	227	64	4	2	2	2	3	4	4	7	11	16	22	32	42	77
Malar.	13	9	5	4	6	7	6	6	7	7	8	9	9	12	13	18
RespTB*	5	3	1	1	4	9	12	14	17	19	23	29	35	35	34	26
Females																
AllCaus	1208	317	45	24	38	53	61	76	91	107	126	165	229	316	451	1071
Resp	387	120	15	8	9	13	15	18	21	26	33	44	64	83	116	207
Diarr.	209	77	5	1	1	2	3	3	4	5	6	8	13	21	29	70
Malar.	12	10	5	3	4	4	5	5	5	5	5	7	7	9	10	18
RespTB*	5	3	1	1	3	5	7	7	7	8	10	13	14	15	17	16

Respiratory TB rates are seriously underreported in 1939-41, as noted in the text.

Table 15. **Proportion of All Causes accounted for by selected leading causes, 1939-41.**

1939-41	*Proportion of All Causes accounted for by Selected Leading Causes, 1939-41*															
Years	*Age at beginning of interval:*															
Age	0	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70
Males	49.5	66.4	54.3	51.9	53.3	56.1	57.1	56.3	56.0	54.5	53.3	52.6	49.9	47.2	42.4	33.8
Females	50.7	66.2	57.8	54.2	44.7	45.3	49.2	43.4	40.7	41.1	42.9	43.6	42.8	40.5	38.1	29.0

Table 16. **Sex Ratios of Age and Sex specific death rates of Taiwanese, All Causes and Selected Leading Causes, 1939-41. Male ASDR/Female ASDR.**

1939-41	*All Causes and Selected Leading Causes, 1924-26*															
Years	*Age at beginning of interval:*															
	0	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70
AllCaus	119	91	102	113	118	125	126	126	127	146	167	178	166	167	158	121
Resp	121	97	100	88	133	146	153	167	176	200	212	227	194	205	184	152
Diarr.	109	83	80	200	200	100	100	133	100	140	183	200	169	152	145	110
Malar.	108	90	100	133	150	175	120	120	140	140	160	129	129	133	130	100
RespTB	100	100	100	100	133	180	171	200	243	238	230	223	250	233	200	163

average. Each cause of death leaves a distinctive imprint on the population that creates different patterns and levels of mortality across the age and sex groups.

While all causes decreased significantly, the most dramatic decline is in the malaria death rates. Malaria was a very significant leading cause in 1906-08, and its decline represents perhaps the greatest achievement of the Japanese public health effort in colonial Taiwan. As the substantial declines in the other cause groups demonstrate, the reduction in deaths rates was not by any means confined to malaria. Yet part of the decline in these other causes may be traced to the benefits of reduced comorbidity associated with malaria (and smallpox, whose near elimination preceded our data series). In general the pattern of decline occurring broadly across many causes simultaneously suggests that the benefits of reduced comorbidity from many diseases compounded the effects of limited public health efforts. Future study of temporal patterns of fluctuation to detect cause rates that increased and decreased together may shed light on which diseases were more tightly linked by comorbid relationships. That the same pattern of broad decline was replicated in the separate prefectures (Shepherd "Regional" infra) underlines the likelihood that reduced comorbidity played an important role in the Taiwanese colonial mortality decline.

Appendix: Issues of Reporting Quality in the Reports of Deaths by Cause in the Taiwan Population Record.

Reports of cause of death by age and sex for the Taiwanese population are included in the annual volumes of vital statistics available from 1905 to 1942 (*Taiwan jinkō dōtai tōkei*). These volumes classify deaths according to a succession of four different cause of death lists. Because some previous studies ignored the issues of consistency introduced by changes between lists (drawing erroneous conclusions from inconsistent data), it is important to clarify the nature and significance of these changes for studies of long term trends in causes of death.

The Japanese devised an abridged version of the first revision of the international classification of causes of death in 1899 for use in Japan. This list provided for forty-six primary categories of disease and it was this list that was adopted for use in Taiwan in 1905 when the new household registration and vital statistics system was implemented following the first census (the following discussion of quality of cause of death reporting is drawn from the fuller discussion in Shepherd 2003).

Decennial revisions adopted by the International Commission regularly updated the international lists of causes of death. The second revision was adopted in 1909, the third in 1920, and the fourth in 1929. While Japan had only adopted the abridged version of the first revision, it adopted both the much longer detailed lists and the intermediate or abridged lists when implementing the subsequent revisions. In Taiwan the detailed lists were used in tables reporting cause of death by age and sex, while the abridged or intermediate lists were most often used for statistics on cause of death by prefecture, season, ethnicity, and occupation. The periods during which Taiwan used the various revisions for vital statistics reporting and the numbers of causes in each list are presented in the table on the next page.

The successive revisions added categories by subdividing causes and creating new titles, as well as reclassifying causes according to updated medical understandings. Thus as time progressed, inconsistencies were introduced as the detailed list expanded and subcategories were reclassified. In many cases these inconsistencies can be minimized by broad groupings of subcategories that achieve continuity across the revisions. Thus we are not prevented by revisions in the international lists from following trends for causes consistently defined and reported. However, inconsistent implementation of the classifications by statistical personnel sometimes frustrates this task.

Another important source of inconsistency arises from misreporting due

Classifications of causes of death employed in Taiwan, 1905-1942.

International Classification:	*No. of Titles:*	*Years in use:*
1st revision, 1900	Abridged: 46+	1905-1915
2nd revision, 1909	Intermediate: 61 Detailed: 217	1916-1922
3rd revision, 1920	Abridged: 38 Detailed: 205	1923-1931
4th revision, 1929	Intermediate: 85 Detailed: 206	1932-1942

Source: *Taiwan jinkō dōtai tōkei*, various years.

to poor quality of diagnosis, the use of popular and imprecise terms in certificates, and inadequate training and education of the personnel authorized to certify causes of death. The Taiwan cause of death statistics were compiled at the central statistical office from tickets reporting the cause of death set forth in the death certificate which had to be completed before a burial permit would be issued to the family of the deceased (Appendix, *Taiwan jinkō dōtai tōkei*, 1906, supp.1, p. 4, supp. 2, p. 1). The Vital Statistics volume for 1906 explains that causes of death were to be certified by either of two classes of licensed medical practitioner. The 'first class doctors' (J: *ishi*, C: *yi-shi*, 醫師) were those who had received training in modern medical science (J: *konnichi no igaku*; C: *jinri yixue*, 近日醫學) (i.e. Western biomedicine) and the second class were Chinese-style traditional practitioners who had been licensed by the government-general (J: *isei*, C: *yisheng*, 醫生). Policemen also certified causes where no medical man was available.

The 1906 Vital Statistics volume explains that the assignment of cause in many cases had to depend on Chinese-style doctors who were not well versed in modern medicine or modern systems of disease classification. These doctors often certified causes using popular or imprecise terms. It was up to statistical coders to classify terms used in the death certificates according to the title categories of the official nomenclature. In the first years of the reporting system, there were many cases where cause was assigned to the "ill-defined and unknown condition" titles. Often these were cases where the certifying practitioner was unfamiliar with the case and the circumstances leading up to death and uncertain as to cause of death. Cases also had to be assigned to the "ill-defined" title due to the use of an ambiguous name by a Chinese-style doctor.

Over time the increase in the number of trained modern doctors (and the

Indicators of improving quality of cause of death reporting, Taiwan, 1906-1935.

	% of Total Causes certified by first class doctors		*% of Total Causes assigned to Senility and Ill-defined titles*	
Year	Male	Female	Male	Female
1906	8.8%	8.3%	46.2%	49.6%
1915	36.2	33.0	16.4	19.7
1920	58.2	56.8	8.1	10.0
1925	73.3	71.2	5.7	7.8
1930	81.4	79.7	4.2	6.2
1935	89.2	88.5	3.0	4.9

Source: *Taiwan jinkō dōtai tōkei*. Taiwanese only.

decline in the number of licensed traditional practitioners) led to increases in the proportion of all causes certified by first class doctors, as shown in the table above. In 1906 only 8% of all causes were certified by modern doctors, but the proportion increased rapidly, to more than 56% by 1920, and 89% by 1935, the final year for which cause statistics were reported by class of doctor. Similar rapid improvement was made in reducing the numbers of deaths reported in the vague and imprecise categories "ill-defined and unknown" and "senility."

The rapid improvement in diagnosis quality documented in the table above was experienced broadly in all age and sex groups. As the quality of cause of death reporting increased, more and more causes became reliably and consistently reported. This increased comparability in the annual reports and enables us to assess historic trends in death rates by cause, age and sex.