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Exposure, Resistance and Life Expectancy: Disease and Death during the Economic Development of Japan, 1900–1960[1]

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I. INTRODUCTION

As the first non-European country to industrialize, Japan holds a unique place in the history of world economic development. But the modernization of Japan is also distinguished by its exceptional reliance on human rather than natural resources. Among these human resources are its capacity for efficient organization, the industriousness of its people, and their relative willingness to forego individual achievement for the sake of the group.

For similar reasons, Japan also occupies a unique place in modern mortality history. Omran singled it out as the first non-Western society to make the epidemiological transition from cause-of-death patterns dominated by epidemic and endemic infectious diseases to one dominated by the degenerative diseases characteristic of old age;[2] while Taeuber argued that Japan's achievements in modern mortality history were founded on its organizational and cultural advantages, in particular the exceptional capacity of its government to organize public-health efforts and to elicit co-operation from its people.[3] But neither Taeuber nor Omran did a detailed comparison of Japan's twentieth-century mortality history with that of the European countries with which it was supposed to be similar.

At first glance such comparisons do not suggest that Japan's mortality performance before the Second World War was particularly exemplary, especially with respect to men's mortality.[4] In Table 1 the mortality of Japanese men appears to have risen slightly from 1891 to 1914 and subsequently to have stagnated from about 1900 to 1935. Figure 1 shows that during this period Japan, having achieved effective mortality parity with England and Wales and Italy by 1908, gradually fell behind both as the century progressed. It was not until the end of the Second World War that life expectancy at birth in Japan began to improve very rapidly, almost as if it was a standard developing country

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[2] A. R. Omran, 'The epidemiology transition' *Milbank Memorial Fund Quarterly*, **49**, pt. 1 (1971), pp. 509–538.

[3] I. Taeuber, *The Population of Japan* (Princeton: Princeton University Press, 1958), pp. 284–285.

[4] In this paper we focus exclusively on men's mortality, because the negative health impacts of industrialization fell disproportionately on them. Mortality differences between men and women are treated as a separate topic in Mosk and Johansson (1984), *loc. cit.* fn. 1., and in a future article.

rather than one whose contributions to the public-health or disease-specific aspects of the mortality transition were in any way distinguished.

What, then, is exceptional or admirable about Japan's modern mortality history? Why did the relatively high life expectancy it achieved in 1900 fail to provide a basis for continuing sustained increases until after the Second World War? It is the purpose of this paper to explain the history of life expectancy and disease patterns in Japan from

Table 1. *Expectation of life at birth for Japanese males, 1891–1961*

Year	Life expectancy at birth
1891–1898	42.8* (37)
1899–1903	44.0* (39)
1908–1913	44.3* (41)
1921–1925	42.1
1926–1930	44.8
1935–1936	46.9
1945	23.9
1946	42.6
1947	50.1
1948	55.6
1949	56.2
1950	58.0
1951	60.8
1952	61.9
1953	61.9
1954	63.4
1955	63.9
1956	63.6
1957	63.2
1958	65.0
1959	65.2
1960	65.5
1961	66.0

Source: *A Brief Report on Public Health Administration in Japan, 1963*. (Ministry of Health and Welfare, Japanese Government, 1963), p. 14. The starred life-expectancies for the earliest period may still be high according to alternative estimates, based on evaluating the observed data in terms of model life tables. See Carl Mosk and S. Ryan Johansson, 'Death and development in Japan, 1908–1960', report to the National Science foundation, 1984.

1900 to 1960 in the context of its modern economic and cultural development. This explanation begins with an extended consideration of the biologial determinants of life expectancy levels, and how there determinants interacted to produce a superficially similar level of life-expectancy in three countries who were otherwise socially and economically dissimilar at the turn of the century. Subsequently we extend the explanation to account for the fact that developing Japan was unable to maintain its early mortality parity with Italy or England and Wales in the decades before the Second World War, while after the war, with its economy in ruins, Japan was able to raise men's life expectancy faster and further in five years than it had in the previous five decades.

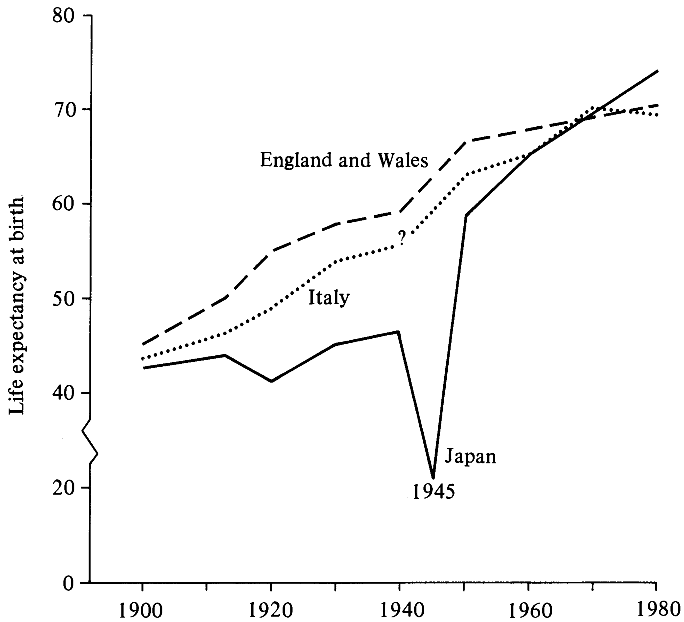

Figure 1. Life expectancy at birth (males), 1900–80, Japan, Italy, England/Wales. Sources: S. Preston, N. Keyfitz and R. Schoen, *Causes of Death*: *Life Tables for National Populations* (New York, Seminar Press, 1972), and *The United National Demographic Yearbook* (1967, 1980). For Japan: *The 14th Life Tables, Statistics and Information Department, Ministry of Health and Welfare* (1976), p. 6.

II. CURRENT MORTALITY CONTROVERSIES AND THE HISTORICAL EXPERIENCE OF JAPAN

Japan's mortality history is relevant to the critical evaluation of the ongoing debate between those who stress the importance of income and income-related factors (particularly nutrition) against those who cite the technological potential of 'public health' measures to reduce death rates during the modern era. As van de Walle characterizes the state of the current controversy, everyone agrees that reasonable, threshold standards of living must be combined with effective public-health measures to achieve life expectancies at birth in excess of 60 years. The question is 'the relative dosage' of each in the transition from much lower life expectancies at birth to those approaching and exceeding 60 years.[5]

Over the last decade McKeown has been the leading exponent of the view that improved standards of living, particularly in the area of nutrition, are the principal reason that life expectancy rose in the nineteenth and early twentieth centuries. His conviction that public-health technology had little to do with falling death rates until around 1930 was based on a close study of data from England and Wales.[6] Until the late nineteenth century, when methods for delivering treated water to a household became widespread, McKeown could not identify any form of public health that significantly affected death rates at the national level.

Samuel Preston's work has long been recognized as the best statistical demonstration that income, nutrition and other indicators of the standard of living *cannot* have been responsible for more than 25 per cent of the international rise of life expectancy at birth

[5] E. van de Walle, 'Present patterns of demographic change in the light of past experience', IUSSP, *International Population Conference*, *Florence*, *1985*, vol. 4, pp. 355–357.

[6] T. McKeown, *The Modern Rise of Population* (London: Edward Arnold, 1976).

throughout most of the twentieth century.[7] The efficiency of public-health technology, according to Preston, emerges as the residual explanation for the rise of life expectancy.[8]

In spite of Preston's careful and convincing statistical arguments, those scholars whose research is part of the mortality history project under the direction of R. W. Fogel have tried to extend and deepen McKeown's evidence for the view that ordinary people used their increasing real incomes to purchase better nutrition for themselves, and by doing so reduced their death rates.[9] The publications of this project have tried to demonstrate that income variables (real income per head and the actual distribution of income) determine nutritional status, and that this in turn determines the mean height of physically mature men. Since increases in the average stature of European men were negatively correlated with their death rates in modern Europe, this is taken as strong evidence for the pre-eminence of nutrition as a determinant of mortality. (This nutrition-centred historical school has a contemporary counterpart in research efforts focused on the presently developing countries. Scrimshaw, Martorell and others continue to believe in the pre-eminence of nutrition and stature as affecting modern morbidity and mortality).[10]

One reason why McKeown and Fogel may have found it relatively easy to dismiss the contributions of public health technology to declining death rates in their focus on two particular countries, Britain and the United States. By 1900 both countries had achieved exceptionally high standards of living; while in neither case had the national government taken an active role in the control of disease.[11] In Japan, however, the opposite state of affairs prevailed. The government's commitment to public health was exceptionally highly developed from 1870 onwards, while the material standard of living of the Japanese people was relatively low as late as the 1940s. In this context it is easier to demonstrate that only effective and pervasive public-health measures could have brought death rates down to the level observed by 1908.

At present, proponents of both approaches, using a wide variety of data and basic and/or complicated statistical techniques, continue to make very persuasive but mutually exclusive cases for the their respective viewpoints. One reason why a theoretical stalemate has been reached is that both perspectives 'start with a different set of

[7] S. H. Preston, *Mortality Patterns in National Populations* (New York: Academic Press, 1976). See also Preston, 'Causes and consequences of mortality decline in less developed countries during the twentieth century', in R. E. Easterlin (ed.), *Population and Economic Change in Developing Countries* (Chicago: Chicago University Press, 1980), pp. 289–360.

[8] In an article published in 1978 S. H, Preston and E. van de Walle explored and measured the impact of water provision and purification on the mortality patterns of several French cities during the nineteenth century and found marked impact in at least one: 'Urban trends in mortality in the nineteenth century', *Population Studies*, **32** (1978), pp. 275–297. In general it has not proved easy to measure the impact of specific forms of community level interventions on specific health problems, even under fairly controlled conditions: see L. Chen, J. Chakraborty, A. Sadar and M. Yunus, 'Estimating and partitioning the mortality impact of several modern medical technologies in basic health services', *IUSSP International Population Conference, Manila*, vol. 2 (1981), pp. 113–140.

[9] R. W. Fogel, 'Nutrition and the decline of mortality since 1700: some preliminary findings', National Bureau of Economic Research, Working paper no. 1402 (July 1984). This updated version contains reports of the results of the several cross-national studies that form part of the project, as well as an extensive bibliography on mortality history.

[10] N. S. Scrimshaw, C. E. Taylor and J. E. Gordon, *Interactions of Nutrition and Infection* (Geneva: World Health Organization, United Nations, 1968). R. Martorell, 'Child growth retardation: a discussion of its causes and its relationship to health', in *Nutrition Adaptation in Man*, K. Blaxter, and J. Waterloo, eds. (London: John Libbey, 1985), pp. 13–30. R. Martorell, J. Leslie and P. R. Moock, 'Characteristics and determinants of child nutritional status in Nepal', *American Journal of Clinical Nutrition*, **39** (1984), pp.74–86, and R. Martorell, 'Nutritional status, morbidity and mortality', *Population and Development Review*, **10** (1984), supplement.

[11] M. W. Raffel (ed.), *Comparative Health Systems* (University Park: Pennsylvania State University Press, 1984). See the chapters on England and the United States.

assumptions about the causes of ill health in populations, and their respective research frameworks generally ignore variables considered essential by the other'.[12] This absence of dialogue adversely affects the natural evolution of a coherent body of knowledge about the causes of mortality change; it also hampers the formulation of specific health policies in developing countries.

The one conclusion that historical and contemporary scholars seem to agree on is that to deal more conclusively with the causes of changing mortality patterns in countries where life-expectancy at birth is still below 60 years, a more explicitly *biological* analytic framework must be developed.[13] As Ruzicka correctly observes, the traditional demographic literature relating to mortality, whatever its interpretative perspective, rarely attempts to develop in any detail the impact of specific social or economic circumstances on morbid states that are associated with high mortality risks. Proponents of both the public-health and the income–nutrition view rest their cases on inferences based on statistical associations that are rarely explicitly related to underlying causal mechanisms, all of which must involve some assumptions about the biology of mortality, especially as this involves the deaths of persons who have not yet reached old age.

In the demographic analysis of fertility change much progress has been made by greatly expanding demographic awareness of the physiological determinants of fertility in non-contracepting populations.[14] Any complete biological perspective on mortality would need to consider the specific aetiology of every disease capable of causing death under some set of circumstances. But even with respect to something as basic as nutrition, specific diseases vary greatly in their sensitivity to the nutritional status of the body they have invaded. Smallpox, malaria and plague, for example, are diseases in which nutritional status plays a minimal role in determining the outcome of an infection. As Carmichael has pointed out, the complexity of the body's defences against infection is such that, under some circumstances, 'a malnourished host may even have a slight advantage in forestalling clinical infection'. Even in the case of nutritionally sensitive diseases like measles and various common diarrhoeas, the degree to which they are actually fatal depends as much on the kind of nursing care made available to the stricken individual, as well as on the virulence of the invading pathogen and the immunological history of the infected person.[15]

The development of a medically sophisticated, biologically based perspective for the analysis of mortality change will require a great deal of effort. It is only recently that a fairly detailed understanding has been achieved of how the body's defences against disease operate on a general and disease-specific level, and how this operation is modified by genetic heterogeneity within and between populations,[16] as well as by social and

[12] W. H. Mosley, 'Biologial and socioeconomic determinants of child survival: a proximate determinants framework integrating fertility and mortality variables, in *IUSSP International Population Conference, Florence* (1985), vol. 2, p. 189.

[13] See, L. T. Ruzicka, 'Conceptual framework for the study of socio-biological correlates of mortality', in *IUSSP International Population Conference, Florence* (1985), vol. 2, pp. 185–187.

[14] See, for example, the great attention paid to the biological determinants of birth intervals in H. J. Page and R. Lesthaeghe's, *Child-Spacing in Tropical Africa* (New York: Academic Press, 1981).

[15] A. G. Carmichael, 'Infection, hidden hunger and history', *The Journal of Interdisciplinary History* **14** (1983), pp. 249–264. How complex the aetiology of each specific disease can be at the biological level, and in interaction with the processes common to socio-economic development is very clearly brought out in E. H. O. Parry's, *Principles of Medicine in Africa* (Oxford: Oxford University Press, 1976). Because the disease patterns of Africa resemble those of developing Europe in the nineteenth century, as well as that of early twentieth-century Japan, Parry's comprehensive treatment of each major disease problem and how it is related to economic development, has some relevance to research in mortality history.

[16] See, D. Amos, R. S. Schwartz and B. W. Janicki, *Immune Mechanisms and Disease* (New York: Academic Press, 1979) for a good set of recent essays. See also D. Silberberg, 'Multiple Sclerosis, the HLA system and

economic circumstances. Even if we had a comprehensive biological, social and economic analysis of all those diseases known to be important in the modern mortality transition, their relationship to morbidity and mortality over time is so complex as to escape adequate treatment by current methods of statistical analysis.[17] But there are several basic levels at which a more explicitly biological perspective can be brought to bear on the comparative mortality history at either the national or sub-national level.

In analysing and comparing the mortality history of Japan, internally and cross-nationally, we will incorporate a more explicitly biological perspective by exploring to what degree the movement of life expectancy over time was determined by the overall balance between factors which protected the population from exposure to potentially lethal diseases[18] compared to factors which enabled those exposed to various diseases either to resist the onset of a morbid state, or to recover from one, and thus return to a state which could be characterized as relatively healthy.

III. LIFE EXPECTANCY, PROTECTION FROM EXPOSURE, AND RESISTANCE TO EXPOSURE

From the most basic biological standpoint there are two major factors which are involved in the differential distribution of disease levels in any one population at any one time, and over time. They are (1) protection from exposure and (2) resistance to/recovery from exposure as modelled in Figure 2. Each of these two major factors has two components; a natural one, and one that is achieved through investment at the community and household level.

Natural protection from exposure can be said to occur wherever the physical environment is relatively free from harmful pathogens, the standard of living is above some minimum threshold, and geographical or other factors keep the population relatively isolated. Historically, a high degree of natural protection was achieved by a small number of remote rural populations in comparatively healthy ecological settings. Protection from exposure can also be achieved through investment in environmental control measures (public health) paid for and institutionalized largely at the public level. A limited degree of protection from exposure can also be achieved at the household level, but historical data suggest that such protection will have only a limited success in raising life expectancy above the general ceiling imposed by the community's inability significantly to modify and manage disease environments.[19]

Thus, most of the variables connected with the 'public health' factors in Figure 2 are related to community level *protection from exposure* (note the set of factors in the column headed 'Community Level'). The factors listed in Figure 2 are not exhaustive; they simply remind us of how numerous and diverse are the forms that publicly managed attempts to protect health can take. There is no simple proxy for measuring the overall

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viruses' in *Infection Immunity and Genetics* (eds.) H. Friedman, T. Linna and J. Prier (Baltimore: University Park Press, 1978) pp. 141–157. Silberberg suggests that the Japanese have a genetically determined advantage in resisting multiple sclerosis, the most common chronic disease of the central nervous system currently afflicting adults in North America and Europe, pp. 141–142.

[17] See Chen *et al. loc cit.* footnote 7.

[18] We are assuming that health can be considered as the absence of disease. Disease states, when not induced by the ageing process (which eventually leads to the internal failure of one or more of the body's organs, as well as to the decreased efficiency of its immune responses) can be induced in otherwise healthy individuals by the invasion of one or more harmful viruses, rickettsia, bacteria, fungi, protozoa, helminths not normally present in the body, or to the introduction of 'enough' organic and inorganic poisons, carcinogens, etc., to cause harm, create sickness and raise the probability of dying prematurely.

[19] See, C. Mosk and S. R. Johansson, 'Income and mortality: Evidence from modern Japan, 1900–1960' *Population and Development Review* **12** (1986) pp. 415–440.

(1) PROTECTION FROM EXPOSURE =

Natural protection +	Protection achieved through investment at the:	
Ecological level	*Community level	Household level
Density	PUBLIC HEALTH	Personal cleanliness
Isolation	Water quality	Food preparation and storage
Altitude	Food quality	Human waste disposal
Climate	Human waste removal	Household cleanliness
Insects	Garbage/dirt removal	—
Snakes, etc.	Pest control/eradication	—
Micro-flora	Air quality	—
Micro-fauna	Working conditions	Co-operation with health measures
	Immunization campaigns:	—
	Quarantines	Receptivity to new information
	HEALTH INFORMATION	Regular health check-ups
	PREVENTIVE MEDICINE	Avoidance of toxic substances
	Control of toxic substances	

(2) RESISTANCE TO/RECOVERY FROM EXPOSURE =

Natural resistance +	Resistance achieved through investment at the:	
Biological level	Community level	Household level
Genetically determined characteristics of the immune system (the HLA complex)	Hospital care sanatoria, etc. Antibiotics/vaccination Medical care/information	Home nursing care Purchase of medicines Receptivity to information
and cell mediated resistance Virulence of pathogens	WELFARE MEASURES Financial aid, social support for victims of episodic or chronic 'stress', deprivation disasters (famine, war, etc.)	LIVING STANDARDS *Nutrition* Housing/space and warmth Clothing Leisure, emotional Support, security

Figure 2. The two major determinants of the relative levels of disease at the population level.

strength of public health variables in some timeless fashion. Indeed, there could not be, since the efficiency of various publicly managed environmental control measures has steadily increased through the twentieth century. Through most of history, however, variables related to the density and mobility of a population provide us with an indirect approximation of the intensity with which a population was exposed to disease. Urbanization is a crude, but not inappropriate, indicator of density and mobility, and hence of the level of exposure to disease.

The complex of variables which belong to the resistance/recovery set of factors also has a natural component, as well as one that is achieved through investment. Natural resistance involves the many processes through which the human body's immune system, in combination with cell-mediated and other physiological mechanisms, tries to identify, attack, destroy and eliminate all forms of invasion (new or previously experienced) by entities identified as foreign and harmful. The inherent overall efficiency with which the immune system can resist invasion by one or more invaders (see footnote 16) varies genetically between individuals and at the population level.[20] But the individual or collective efficiency of the immune system should not be thought of as constant. It varies exogeneously with the prevalence of acquired immunity to specific diseases, the virulence of the invading pathogens, the frequency and intensity with which exposure to one or

[20] See Amos, Schwartz and Janicki, *loc. cit.* footnote 16, *passim.*

more harmful invaders takes place, and even the degree to which individuals and populations are chronically or acutely stressed.

But collective resistance to disease also varies endogeneously according to the overall level of investment in human health, again at both the community and household level. Communities can enhance their collective resistance to/recovery from disease by investing in various forms of social welfare, as indicated in Figure 2. Households can do ever more to improve resistance to, or recovery from disease at the individual level. Although the stability to nourish the members of a household adequately will not always improve resistance or ensure recovery from a diseased state, nutrition is given special emphasis in Figure 2, because it is important to many specific diseases and it figures so prominently in the literature which ignores or minimizes the effects of public health interventions in mortality changes.

Since it would be difficult to measure the strength of collective resistance in a specific disease environment directly, real income or other income-related variables are often used as proxies for an unobservable biological state. But the use of income variables as a proxy for collective resistance depends on the assumption that people know what is best for their health, and will automatically use any increase in their disposable income to reduce their risk of dying. This is an assumption which some modern health economists dispute,[21] and one which is not borne out by historical data.

Thus, recast from a biological perspective, the continuing debate over the principal determinants of mortality change becomes a dispute over which is more important in preserving health and reducing mortality – *protection* from the major causes of premature death (which is delivered largely through various forms of public health) or the maximization of the body's *natural resistance* to those diseases which are most responsible for artificially shortening life (which is disproportionately delivered at the household level). There is not and cannot be, any simple answer. Most adult human bodies are very resilient, and many human beings can survive and endure extremely stressful conditions for a surprisingly long time. On the other hand, even an impoverished, badly nourished and extremely susceptible individual cannot die from most infectious diseases, unless he or she has been exposed to them first. Therefore, protecting individuals from the most lethal forms of disease could probably prolong their lives even under otherwise stressful forms of deprivation. On the other hand, there are threshold standards of nutrition below which survival for long is unlikely. Even before actual death by starvation, the immune system would falter, and death could be caused by an 'opportunistic infection' whose source is an ubiquitous but normally harmless micro-organism ever present in the environment, or even the body itself.

Although Figure 2 may appear to be overly complex and unwieldy, it has the virtue of synthesizing in one framework the most commonly cited proximate determinants, biological, social and economic, which appear in the debate on the causes of mortality change. It gives each a potential role, but implies nothing about the relative contribution of a single factor to any particular historical case.

It also provides the basis for understanding why *education* (particularly the education of women) appears over and over again in studies of the modern socio-economic correlates of mortality change in infancy and childhood as the most important determinant of mortality differentials at the sub-national level, even when no one specific

[21] See the discussion by V. R. Fuchs in *The New Palgrave: A Dictionary of Economic Theory and Doctrine* (1987) in 'Health Economics', Fuchs argues that even when people know what is best for them, or harmful to them, some/many will still make choices that do not maximize their health status in the short- or long-run because other things, for example, short-term pleasures, are more important to them.

type of behaviour appears to be associated with formal schooling.[22] Educating women can both improve the efficiency of public health efforts to *reduce exposure* by ensuring co-operation with the health authorities, just as it enhances the ability of women to use and allocate with maximum efficiency the material resources available to them, in order to promote the natural mechanisms which enable the body (particularly in infancy and childhood) *to resist or recover from disease*. Although education is not explicitly included in Figure 2, because it does not have a direct relationship to either avoiding exposure or enhancing resistance, it is indirectly related to the strength of almost every one of the specified community and household level variables. Education contributes useful information, weakens fatalistic resignation, encourages all forms of sanitation, promotes

Table 2. *Life expectancy as the outcome of balance between protection from exposure and resistance to exposure*

Resistance to exposure	Protection from exposure		
	Low (1)	Moderate (2)	High (3)
Low (1)	1+1 (2)	2+1 (3)	3+1 (4)
Moderate (2)	1+2 (3)	2+2 (4)	3+2 (5)
High (3)	1+3 (4)	2+3 (5)	3+3 (6)

Life expectancy outcomes: (2) produces a life expectancy value in the 20s; (3) a value in the 30s; (4) a value in the 40s; (5) a value in the 50s; (6) a value in the 60s or even higher.

a preference for modern medical assistance, encourages the practice of proper forms of home nursing, and discourages the resort to traditional healers, who can do little or nothing for most serious infectious diseases.[23] Of course, for education to have any effect on public health or the efficient use of household resources, a certain level of basic knowledge about disease and its causes must initially be present as well as some form(s) of environmental control that make it possible to reduce exposure and/or systematically enhance resistance.

For the sake of simplifying the interactions between an extremely complex set of biological, social and economic variables, let us assume that the entire set of factors involved in both effective protection from exposure and efficient resistance to exposure both contribute *equally* over the long run to the preservation of health and the extension of the normal average lifespan into the seventh decade of life and beyond. Let us further assume that we can determine in a rough fashion whether or not a population is on the whole poorly, moderately or well protected from exposure to potentially lethal infectious and other forms of disease. Similarly, assume that we are able to determine whether or not a population's natural level of resistance to disease is poor, moderate or very good, based on its standard of living (measured directly or by proxy income measures) as well as the other variables which effect resistance.

With these assumptions we can generate Table 2 in which scores have been assigned to judgments of 'low', 'medium' and 'high' along both dimensions, and these scores

[22] In Ruzicka, *loc. cit.* footnote 10, p. 186. See also S. H. Preston, 'Resources, knowledge and child mortality', *IUSSP International Population Conference, Florence* (1985), vol. 4, pp. 373–384.

[23] It was long ago pointed out by Gwendolyn Johnson that part of the health problems of the poor in developing countries are related to a lack of simple but helpful knowledge. ('Health conditions in rural and urban areas of developing countries', *Population Studies*, **17** (1964), pp. 293–310.) Under the powerful sway of tradition people will often make food choices which do nothing to help and may even harm their health. Currently, Preston's work on child mortality stresses the rôle of knowledge factors in reducing mortality through the information-enhanced choices of women at the household level, *loc. cit.* in fn. 22 pp. 373–384.

have been combined to generate probable life expectancy at birth at the population level.

In Table 2 it is clear that no population with a low degree of protection from exposure (probably because its members have little or no useful knowledge about the management of disease) and a low ability to resist repeated exposure (probably because their standard of living is low, and nutritional status unfavourable) can expect to have a life expectancy at birth which exceeds 30 years. Similarly, any population which achieves *both* a high level of protection from exposure through the control of their disease environment and a high ability to resist disease (probably because they are fed, clothed and sheltered above some minimum threshold level) is likely to achieve a life expectancy in excess of 60 years. But it is in the middle range of life expectancy that superficially similar levels of life expectancy can be achieved through quite different underlying levels of protection from exposure and resistance to disease. Life expectancies between 40 and 50 are those most likely to conceal underlying heterogeneity with respect to the relative strength of the exposure-linked complex compared with the resistance-linked complex of variables. It is this conclusion which provides us with a basis for explaining why Japan, Italy and England and Wales had all achieved life expectancies at birth between 43 and 46 years by 1900.

IV. JAPAN, ITALY, AND ENGLAND/WALES *CIRCA* 1900

As shown in Figure 1, men's life expectancies at birth were very similar in all three countries at the turn of the century. In Table 3 it is further shown that this similarity extended to life expectancy at birthday 10 and even to the infant mortality rate.

How Japan, Italy and England and Wales could share the same mortality profile for men at the turn of the century, despite their marked social and economic differences, would not be easy to explain by merely using a narrowly income-centred perspective. In terms of its income per head, England/Wales was the second-wealthiest country in the world (after the United States); its income level was at least five times greater than Japan's (even after a generous upward adjustment for Japan) and about twice that of Italy. Adult men's heights reflected these income differences in a perfectly consistent manner.[24] Italian men were the shortest in Europe, but Japanese men were shorter still. The extremely short stature of Japanese adult men was consistent with estimates of food consumption per head, which in 1900 were a little above 2,000 calories per day. This figure is exceptionally low by recent standards prevailing in the poorest agricultural countries, as estimated by the United States Department of Agriculture.[25]

England and Wales was also the world's most urbanized country. Both its income advantages and its high rate of urbanization were the result of industrialization, which had long ago transferred most men of working age out of the primary sector of the economy. Japan and Italy were both still in the early stages of development. Only a minority of the population of both countries lived in towns, and their economies were still predominantly agrarian. But during the last few decades of the nineteenth century Japan had committed itself to a policy of basic universal grade school level education for its people, extending over six years for both boys and girls. In England and Wales there was also a system of universal state-supported education which extended to even higher

[24] R. Steckel, 'Height and per capita income', *Historical Methods*, **16** (1983), pp. 1–15.

[25] C. Mosk, 'The decline of marital fertility in Japan', *Population Studies*, **33**, 1 (March 1979), pp. 19–37, esp. p. 25.

Table 3. *Resistance, exposure and mortality in Japan, Italy, England/Wales 1900*

	Resistance proxies		Exposure proxies		Protection from exposure		Mortality/variables		
Period	Income per head	Adult height, males (cm)	Urban (%)	Primary industry (%)	Public health type	Education, per cent literate	e_0 (M)	e_{10} (M)	IMR (M+F)
Japan (1908)	68 (100)	157	10	70	National and very efficient	90	43	49	155
Italy (1901)	226 (300)	163	14	60	National and moderately efficient	30	43	51	174
England/Wales (1901)	551 (550)	169	54	15	Local and inefficient	95	45	50	154

Sources:

Income per head. S. Preston, *Mortality Patterns in National Populations* (New York, Academic Press, 1976). The figures are all expressed in terms of 1963 US dollars. The figures in parentheses acknowledge that in the case of underdeveloped rural countries like Japan and Italy in 1900 there is a substantial non-market sector of the economy whose contribution to national income is not included in official statistics based on market transactions. Suggested adjustment factors vary, but the lower the income the higher the proportional adjustment. The suggested adjustments in Table 3 give a simple, if crude, way of more realistically comparing the average incomes of each country.

Heights of adult men. These statistics are generally based on those taken from army recruits. The Japanese heights are found in C. Mosk, 'The decline of marital fertility in Japan', *Population Studies* (**33** (1980), p. 25). For Italy see R. Floud, 'The heights of Europeans since 1750', NBER Working Paper no. 1318 (1984), p. 26. For England see R. Floud, K. Wachter and F. Gregory, 'The physical state of the British working class 1870–1914', NBER Working Paper no. 1661 (1985), p. 21.

Per cent urban. For Japan and England/Wales see T. Wilkinson, *The Urbanization of Japanese Labor* (Amherst, University of Massachusetts Press, 1965). For Italy see J. deVries, *European Urbanization 1500–1800*. (Cambridge, Mass: Harvard University Press, 1984), Table 5.8. All statistics refer to cities of 20,000 and above.

Per cent primary industry. For Japan see C. Mosk with S. R. Johansson, *loc. cit.* footnote 1. For Italy see M. Livi-Bacci, *A History of Italian Fertility* (Princeton, Princeton University Press, 1977). For England see B. R. Mitchell and P. Deane, *Abstract of British Historical Statistics* (Cambridge, Cambridge University Press, 1962).

Public health. See discussion in text.

Education. The literacy statistics ae rounded figures based on discussions in sources cited above. For Japan see C. Mosk, *Patriarchy and Fertility* (New York, Academic Press, 1983). For Italy see Livi-Bacci, *A History of Italian Fertility*. For England see Floud, Wachter and Gregory, *loc. cit.* above.

Mortality. The life expectancy data come from the selected life tables in Preston, Keyfitz and Schoen, *Causes of Death: Life Tables for National Populations* (New York, Seminar Press, 1972). The infant mortality data for both sexes come from (1) Japan ('A brief report on public health administration in Japan', 1963, published by the Japanese government); (2) England and Italy, B. R. Mitchell, *European Historical Statistics* (New York, Columbia University Press, 1976).

grades. There was no system of universal, free and compulsory education in Italy, and, not surprisingly, illiteracy was much more widespread.

On the other hand by 1900, in both 'underdeveloped' Italy and Japan, the *national* government had been committed to the comprehensive public management of health for several decades. Because Japan's population was better educated, the efforts of its government in the public health sphere were probably intrinsically more efficient than those of Italy.[26] But in England and Wales at the turn of the century the state still allocated very little money to what to-day would be classified as public health expenditures, and there were no ministers or civil servants specifically assigned to the national management of health matters.[27] McKeown, approaching the matter from a medical perspective, has long argued that Britain's national public health efforts had relatively little impact on the decline of mortality during the nineteenth century. His views find support in the institutionally oriented analysis of Wohl, who argues that the management of public health was exceptionally backward in Great Britain throughout the nineteenth century. Neither of the two major political parties ever put forward an explicit philosophy of public health; nor was the regulation of public health an issue in national elections.[28] In England and Wales, public health was managed at the district level by elected officials who were expected to finance various reforms from locally collected taxes. Local autonomy in health matters produced a great deal of local variation in death rates.[29] Some of this variation was caused by the reluctance of ratepayers to finance measures which would benefit the non-taxpaying poor. Thus, McKeown may be correct in arguing that national public health measures were not very important in the reduction of mortality in England and Wales during the nineteenth century.

Japan's exceptionally strong commitment to national public health is examined in greater detail below, but we begin by translating the information in Table 1 into an analysis of why mortality patterns were so similar in three such different countries. In terms of the model developed in Figure 2 and Table 2, England can be characterized as a country with a highly urbanized population greatly in need of protection from exposure, particularly to crowd-type contagious diseases and polluted air and water. Since the majority of England's labour force were employed in industry, many workers also

[26] In many Italian cities there was a centuries-old tradition of public health management which the national government took over and tried to universalize. See C. M. Cipolla 'Four centuries of Italian demographic development' in *Population in History* (eds.), D. V. Glass and D. E. C. Eversley (London: E. Arnold, 1965), pp. 570–587. By the late nineteenth century national health authorities had become very efficient at identifying rural health problems, gathering the necessary data and trying (if not always succeeding) to solve the identified problems. See, M. Livi-Bacci 'Fertility, nutrition and pellagra: Italy during the vital revolution', *Journal of Interdisciplinary History*, **16** (1986), pp. 431–454.

[27] D. Allen, 'Health services in England', in *Comparative Health Systems* (ed.), M. W. Raffel (University Park: Pennsylvania State University Press, 1984), p. 201. Allen says that until 1907, when the administrative machinery for a school health service was created, the state contribution's to public health were limited to its provision for the care of lunatics and the support of hospitals for those with specific infectious diseases.

[28] There is a large literature on public health in Britain in the nineteenth century, almost all of which agrees that investment in the health of the public was one of the most underdeveloped aspects of this otherwise developed economy and society. For a comprehensive treatment of this literature and a general review of organizational shortcomings of Britain's nineteenth-century public health efforts see A. S. Wohl, *Endangered Lives: Public Health in Victorian Britain* (London: J. M. Dent and Sons Ltd, 1983). See Chapter 6, 'State Medicine', pp. 142–165.

[29] For example, in turn-of-the-century Cornwall, local death rates were still surprisingly variable. The towns with standardized death rates below average were almost always those vying for the tourist trade. Invariably they found the money to invest in a very comprehensive set of public health measures. Mining towns, which were still economically depressed as a result of the collapse of copper mining, were too poor to tax themselves for even the most basic health reforms. In consequence, their death rates were much above the national average. See, S. Ryan Johansson, 'The demographic transition in England: a study of the economic, social and demographic background to mortality and fertility change in Cornwall, 1800–1900'. Doctoral dissertation submitted to the Department of History, University of California, Berkeley, 1975.

experienced a high level exposure to toxic substances, lung irritants and/or carcinogens. Men were particularly vulnerable to exposure at the workplace, because they worked away from home most of their lives. But the level of protection from exposure that this highly urbanized, industrialized population received was generally inadequate and extremely uneven, partly for the financial reasons discussed above.[30]

Despite the fact that England's population was poorly protected from exposure, it was comparatively well off (by income standards of 1900) and well educated, with an average standard of living sufficient in our judgment to confer a 'high' ability to resist/recover from disease on its population. Thus, in terms of Table 2, its *low/high* combination of protection/resistance gives England and Wales an overall score of four, and thus a life expectancy at birth in the 40s at the turn of the century.

Japan, in contrast, was a country whose people were still naturally protected from a certain amount of exposure by their residence in largely rural localities. This natural protection was enhanced by the government's extreme commitment to public health and mass education. These three factors combined to give the Japanese people a 'high' level of protection from exposure, which effectively offset their very 'low' standard of living. This *high/low* combination also resulted in a life expectancy at birth in the 40s.

The Italians in 1900 are best thought of as a rural population whose protection from exposure and resistance to disease were both moderate. Their average income was intermediate between that of England and Wales and Japan. Although Italy's national government was fully committed to public health, its efforts were undermined by the fact that the Italian population was relatively uneducated. (Probably more than half of the women in 1900 were illiterate or nearly illiterate.) At any rate, a *moderate/moderate* score for protection/resistance would also produce a life expectancy at birth for Italy in the 40s.

Thus, the fact that mortality in a low-income country like Japan was similar to that of two countries much wealthier than itself was due to a particular combination of natural and investment-related advantages which gave its comparatively poor population an unusually high level of *protection from exposure*. This explanation acknowledges the uniqueness of Japan's mortality achievements at the turn of the century; but it also permits us to see those achievements as the product of choices made by its government. It is to the elaboration of this explanation that we now turn.

V. DISEASE AND MORTALITY IN JAPAN TO 1900

The commitment of the Japanese to the management of public health was rooted in a centuries-old tradition of strong central government. The Tokugawa rulers of Japan had long claimed the right to regulate information streams and constrain individual choice to a degree unknown in England and Wales after the restoration of the Stuarts in the seventeenth century. But in the decades before the Meiji restoration (1868) Japan's political traditions worked against the control of disease. Tokugawa officials were suspicious and hostile to almost all forms of Western influence on Japanese culture, and European medicine was no exception.[31] Nothing illustrates this better then two events which occurred in 1849. On the one hand, the government, urged by the demands of those Japanese physicians trained in classical Chinese medicine, forbade the study of European medicine (with the exception of surgery). It even gave permission to the

[30] Wohl, *loc cit.* footnote 28.

[31] The classic work dealing with the long struggle for acceptance of Western medicine in Japan is Genpaku Sugita's, *Rangaku Kotohajime* [The Dawn of Western Science in Japan], first published in 1815, a modern translation of which was published by R. Matsumota (Tokyo: The Hukuseido Press, 1969).

Igakukan (The Academy of Medicine of Yedo) to censor the publication of new medical books. On the other hand, it was in that very year that the first successful vaccine against smallpox was introduced into Japan.[32] Since smallpox was probably the leading cause of epidemic mortality among children,[33] this was an event of no small importance. But the acceptance of vaccination obviously entailed some recognition of the superiority of European medicine and its rapidly developing techniques for the control of epidemic disease.

With the Meiji Restoration (1868) the new government gave its full support to the study, importation and adaptation of European medical and public health techniques, particularly vaccination and large-scale quarantine to prevent the geographical spread of port-introduced diseases like cholera and plague. The government and people of Japan were 'fortunate' that smallpox and cholera were the two major forms of epidemic diseases in the late nineteenth century, since both could be controlled by relatively low-cost public health techniques which were most efficiently applied by governments determined to *prevent exposure* and capable of enforcing compliance at the local level, even in rural areas.

As late as 1876, smallpox was still a disease which killed tens of thousands of children in regularly recurring epidemics, but in 1874 the government, through its newly established Central Sanitary Bureau (part of the Department for Home Affairs), had begun to attack the problem by ordering local authorities to carry out mass vaccination campaigns.[34] By 1908, smallpox was a minor cause of death responsible for fewer than 100 deaths a year. It no longer took an epidemic form, because of at least 87 per cent of all children had been vaccinated at least once. The efficiency of the central government was such that in only one of the 47 prefectures were less than 80 per cent of its children vaccinated by 1908. In the urbanized prefectures 91 per cent compliance was achieved. Everywhere, when it was determined that vaccination had failed to 'take' in certain individual cases, second and even third vaccinations were arranged and recorded statistically by the local authorities.[35]

Cholera proved more difficult to control because of Japan's extensive coastline, and because her poorly nourished people were so susceptible to the ravages of the disease. Cholera is not endemic to Japan. It was first imported in 1822. As commerce with the outside world increased, the epidemics became more frequent and severe. In 1858, several hundred thousand people died from cholera. Beginning in 1874 the newly formed Central Sanitary Bureau began the fight to control cholera, relying basically on quarantine techniques patterned on those previously developed in Europe. These techniques involved identifying the sources of the continual re-introduction of the micro-organism and its spread within Japan, inspecting incoming ships and their crews for signs of the disease; preventing them from any contact with the local populace, if necessary, getting local authorities to report outbreaks quickly so that infected individuals could be isolated, and local quarantine measures imposed even on the neighbours of the infected parties.

Quarantine measures were also coupled with the forced inspection and compulsory cleaning of houses in which infected individuals had been reported and confirmed.

[32] F. Fujikawa, *Japanese Medicine*, trans. J. Ruhrah (New York: Paul B. Hoeber, 1934), p. 84. The chief rival of Western medicine was the Chinese medical tradition, which had a very different orientation to the explanation and treatment of disease, and was not strong on the control of epidemics.

[33] A. B. Janetta, 'Epidemics and child mortality in Tokugawa Janan'. Paper presented at the Social Science History Association meetings, Bloomington, Indiana, 1982.

[34] M. Takenaka and D. Kitagawa, *The Development of Social, Educational and Medical Work in Japan Since Meiji* (1954).

[35] See the *Annual Report* of the Central Sanitary Bureau, 1907–1908: (Tokyo: Imperial Japanese Government, 1910).

Surveillance, quarantine and compulsory disinfection are easy to write into law but difficult to enforce; they are not expensive (except to merchants whose business dealings are suspended). But to be effective they require a high level of local co-operation. Knowing this, the Japanese government conducted widespread educational campaigns to teach people about cholera and how their co-operation could help stop its spread.

Gradually the Japanese brought the worst outbreaks under control. Although they could not totally prevent its re-introduction from China and the Philippines, outbreaks in the 1880s which still resulted in over 150,000 identified cases and 100,000 deaths in the early twentieth century were reduced to fewer than 10,000 cases with 6,000 resulting deaths.[36] By the 1920s techniques for preventing the penetration and spread of cholera were sufficiently developed to remove it from the list of serious threats to health. In the meanwhile the Japanese were conducting independent research on the disease. They tried but failed to develop a vaccine against the disease, so that its control would become even simpler.

Not surprisingly, any attempt by the Central Sanitary Bureau to suppress communicable diseases involved a heavy emphasis on sanitation-based preventive measures. The Japanese people in general were relatively receptive to all preventive health measures which stressed cleanliness and sanitation in the home or immediate neighbourhood. Without acknowledging the importance of cultural support for cleanliness it would be difficult to understand how the government could enact and enforce the myriad invasive regulations directed at the individual and local level, requiring, for example, the inspection and forced cleaning (if necessary) of private dwellings. The Japanese equivalent of 'spring cleaning' was not an individual option; it was required by law.[37]

Despite the public health advances achieved on the home front, the 'real triumph of Japan', as Seaman put it, was in the sphere of military medicine. During the Sino-Japanese War of the 1890s, Japan lost four times as many men to infectious diseases as it did to deaths which resulted from battle casualties. This was the traditional historical ratio, but it was one that the Japanese government was not prepared to tolerate. In the interests of the most efficient use of its manpower, as well as the welfare of its soldiers, the Japanese government despatched teams to travel abroad and bring back the best methods available for preventing mortality from infectious disease in military camps. Observer teams recommended the adoption of the most advanced practices used in the German, Austrian and French military establishments. By 1905, as part of its preparations for war with Russia, all Japanese bases had been equipped with field hospitals and bacteriological laboratories. All medicines and other necessary equipment were supplied with great efficiency. For every division there was a sanitary detachment which carried water-testing kits. Handbooks were issued to every soldier explaining how to treat infections, sunstroke, frostbite and common injuries. All soldiers were instructed to boil local water before drinking it. Great attention was also paid to the standard military diet with particular attention being paid to the elimination of vitamin deficiency diseases like beriberi. Inspections were regularly carried out to ensure that all the regulations were being obeyed.[38]

As a result of this intensive effort (once again capitalizing on organization, information

[36] See R. Takano *et al.*, *Studies of Cholera in Japan* (Geneva: League of Nations Health Organization, 1926). It was not the case that the virulence of the disease was decreasing. The percentage of those who died after developing the disease remained stationary and fluctuated randomly around 60–70 per cent from the late nineteenth century to the first decades of the twentieth, p. 97.

[37] See the large number of sanitary regulations written into law by 1910 in the Central Sanitary Bureau's *The Sanitary Laws of Japan* (Tokyo: The Home Department, 1911).

[38] L. L. Seaman, *The Real Triumph of Japan* (New York: D. Appleton & Co, 1906).

and co-operation-related advantages) the Japanese were the first to reverse completely the usual historical ratio of battle deaths caused by infectious disease. They not only kept battle casualties during the Russo-Japanese war to a minimum, but deaths from infectious diseases were reduced to only one-fourth of that total. Seaman, an American officer, was convinced that by 1905 the Japanese practised the most advanced principles of military medicine in the world. He wrote his book in the hope of persuading the American military establishment (which he characterized as extremely backward) to follow the Japanese example.

Through creative adaptation of the type which the military health reforms exemplified, by the first decade of the twentieth century the Japanese had certainly equalled and probably surpassed the European countries which they had originally set out to follow in the practical application of all the relatively inexpensive forms of public health, that is, insofar as these involved protecting a still largely rural, non-industrial population from exposure to disease.[39] Certainly the cause-of-death patterns in Japan were definitely of the same type as those common in Europe at the turn of the century.

In Table 4, cause-of-death patterns for England and Wales, Italy and Japan at the turn of the century are compared. The classic epidemics had disappeared as leading causes of death in all three countries, and endemic infectious diseases dominated mortality patterns.

These cause-specific statistics are taken from Preston, Keyfitz and Schoen's compendium of national level statistics, *Cause of Death Life Tables For National Populations*. They are based on data provided by the governments of each country; but in order to be included in the volume, government-produced data had to pass certain tests for quality and completeness.

In admitting Japanese data from the turn of the century, Preston, Keyfitz and Schoen were acknowledging the high quality of Japan's statistics, a quality which has long been defended by Morita[40] and others who have examined the available data closely. A careful reading of Table 4, however, shows that a much larger percentage of Japanese deaths were attributed to the 'other and unknown' category than in England or Italy. The source of this difference cannot be attributed to the 'unknown' category. Very few Japanese death certificates were left blank. But a very large number of Japanese deaths were attributed to 'diseases of the sensory organs and nervous system'. This category was not used frequently in Western European countries, and we think its popularity with Japanese physicians may reflect the continuing influence of Chinese medical theories on Japanese practitioners (most of whom by 1900 had not been trained in Western style medical schools).[41] Had Western-trained physicians completed all Japanese death certificates, they would have probably attributed some/most of the observed deaths to the

[39] The question naturally arises what kind of life expectancy pay-off did Japan receive from the efficient control of epidemic disease in the last three decades of the nineteenth century. Answering this question requires a more reliable series of life expectancy estimates from the early nineteenth century than is presently available. Most of the existing estimates come from village-level studies, and they vary considerably both in level and in the quality of the data on which they are based. For the early Meiji period life expectancy estimates, produced by a still immature system of registration and enumeration, are almost certainly too high. The safest guess is that by 1870 life expectancy at birth in Japan was in the mid-thirties. By 1908 the efficient control of all the major epidemic diseases raised life expectancy at birth to the mid-forties. For a more detailed discussion of the existing pre-1900 estimates, see Mosk and Johansson 1984 *op. cit.* in footnote 1, Table 3.

[40] Y. Morita, 'Estimated birth and death rates in the early Meiji period of Japan', *Population Studies*, **16** (1962), pp. 33–56.

[41] Translated into Western cause-of-death terminology at the turn of the century such diseases were classified as 'ill defined' by Preston, Keyfitz and Schoen. Classical Chinese medicine emphasized the role of stress and other manifestations of nervous strain in causing morbid states which, in turn, led to premature death. See D. Eisenberg with T. Wright, *Encounters With Qi. Exploring Chinese Medicine* (New York: W. W. Norton, 1985).

Table 4. *Cause-specific death rates (per 100,000) of Men: Japan, Italy, England/Wales, 1900*

		Standardized death rates						
Country/date	Life expectancy (at birth)	All causes	Respiratory tuberculosis	Other infectious and parasitic diseases	Influenza pneumonia bronchitis	Diarrhoeal diseases	Other and unknown	Neoplasms
Japan/1908	43	20	*141*	156	281	133	*815*	47
Italy/1901	43	21	106	214	434	*358*	514	34
England/Wales/1901	45	19	135	*261*	*317*	177	416	62

Source: All rates from Preston, Keyfitz and Schoen (1972), *op. cit.* in footnote to Table 3, for the dates indicated. All the rates are age-standardized using the standard population (1).

other leading standard cause categories. In this way the apparent mortality advantage of Japan in all the water-borne and airborne infections (except for respiratory tuberculosis), might well have disappeared. But even redistribution would not have transformed the modern (for the period) character of the Japanese statistics. No amount of readjustment would make Japan look like India or other poor, largely rural Asian countries in 1900, where mortality was still dominated by chaotic epidemic diseases and periodic widespread famines.[42]

But if the beneficial forces unleashed by the determination of the Japanese government to pursue an aggressive policy of economic and social development had given Japan a life expectancy at birth by 1900 similar to that of much wealthier European countries, the continuing process of development was also undermining the advantages Japan had achieved in public health. Urbanization was decreasing the percentage of the population who lived in naturally protected rural areas. Industrial development was also increasing the overall volume of internal migration (including rural-to-village and rural-to-rural movements).[43] As thousands began to leave the agricultural sector and transfer their labour power to industry, they exchanged a comparatively benign environment and form of work for more highly paid but often hazardous jobs located in unhealthy, densely populated urban areas.[44] As they did so, their material standard of living rose from very low to low, but increasing real wages were not enough to offset the erosion of natural protection from exposure which traditional rural life had offered. Early twentieth-century Japan, having perfected public health techniques suitable for the management of epidemic diseases in a rural society, was now faced with the challenge of managing endemic infectious diseases in an industrializing and urbanizing society. During the first four decades of the twentieth century Japan did not appear to do very well. The life expectancy of Japanese men, particularly those over ten years of age, did not improve to any marked degree as shown in Figure 1 and Tables 1 and 3. England and Wales and Italy, however, by successfully reducing their death rates from the leading airborne and waterborne endemic infections, raised their life expectancies at birth steadily after 1910. Japan was left to fall further and further behind. It is to the explanation of this relative 'failure' that we now turn.

VI. DEVELOPMENT, DISEASE AND PUBLIC HEALTH STRATEGIES 1900–1960

In order to explain Japan's failure to keep up with England and Wales or Italy during the first half of the twentieth century we must further extend the biological framework used earlier in Figure 2 and Table 2. If we assume that the variables specified in Figure 2 are still operating and that they interact with each other to produce observed life expectancies in the manner described in Table 2, we can introduce a *time dimension* to show the life expectancy 'path' that each country took from 1900 to 1960, as is done in Figure 3.

[42] M. McAlpin, 'Famines, epidemics and population growth: the case of India'. *Journal of Interdisciplinary History*, **14**, 2 (1983), pp. 351–366. Life expectancy at birth in India in the late nineteenth century is usually estimated to be in the low 20s.

[43] Taeuber, *loc. cit.* footnote 3. See pp. 123–168 for an extended discussion of the increasing mobility of the Japanese population.

[44] C. Mosk and S. R. Johansson demonstrated in an earlier article that until about 1930 the high-income areas in Japan were almost always those which were urban and/or industrial in character. In either case high-wage areas were high-density areas where death rates (age-standardized) were almost always higher than in poorer but rural areas. As long as these traditional income–mortality relationships remained unaltered by health technology, transferring the population from the traditional to the modern sector of the economy actually threatened to raise, not lower mortality. See, *loc. cit.* in fn. 19.

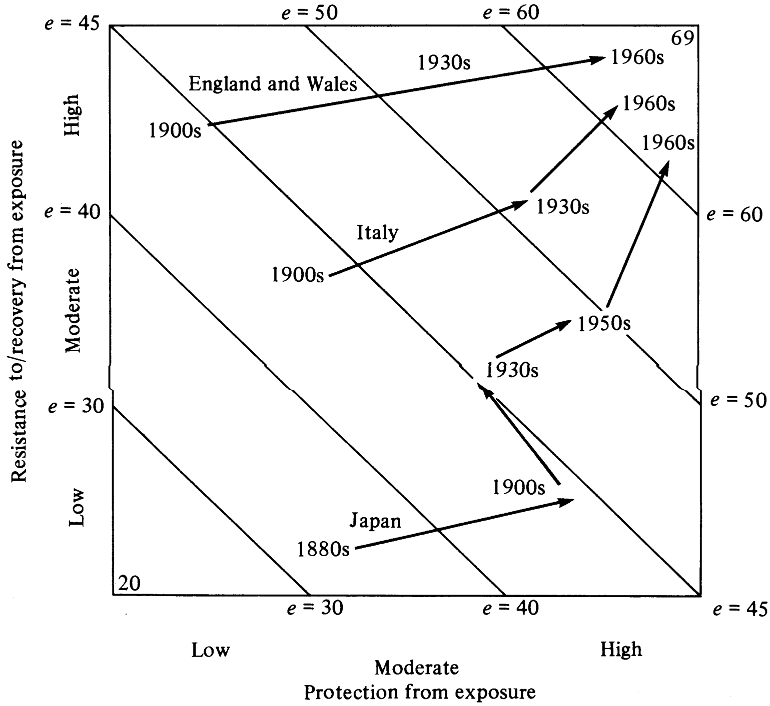

Figure 3. The path history of life expectancy at birth, in Japan, Italy, England/Wales graphed as an outcome of the differential contribution of resistance factors and/or exposure factors, 1900, 1930, 1960. Source: see text.

In Figure 3 the respective mortality histories of England/Wales, Italy and Japan are diagrammed using contour-map type techniques. (On this contour map the lines indicate life expectancy at birth levels in ten-year steps.) This type of presentation allows us to demonstrate that several countries, with the same level of life expectancy, can, nevertheless, occupy very different positions with respect to the relative contributions of protection from exposure compared with the enhancement of natural resistance in achieving that level. Moreover, each country can also take a different path from one level to the next. It is only when each country has reached a life expectancy at birth of 60 years or more, that the underlying mix of factors will be very similar. ('Similar' in this context means only that all will be above a minimum *threshold* with respect to income and public health.)

In the case of England and Wales, the twentieth-century ascent to a life expectancy at birth above 60 years is shown as depending primarily on increases in the level of protection from exposure to disease in a population which was already highly urbanized and industrialized with relatively high incomes. Although the twentieth-century expansion of the role of the government in the management of national health after 1900 has not been studied extensively, there is no doubt that the state took an increasingly vigorous role in investing in a wider and deeper range of public health services, and in seeing that they were delivered to every locality.[45]

Italy's historical path is one in which continued increases in its relatively low standard of living interacted with continued increases in public health investment (the efficiency

[45] B. Benjamin 'The urban background to public health changes in England and Wales, 1900–1950', *Population Studies*, **17** (1964), pp. 232–248.

Table 5. *Resistance, exposure and mortality in Japan, Italy, England/Wales 1930*

Period	Resistance proxies		Exposure proxies		Protection from exposure		Mortality/variables		
	Income per head	Adult height males (cm)	Urban (%)	Primary industry (%)	Public health type	Education, per cent literate	e_0 (M)	e_{10} (M)	IMR (M+F)
Japan (1926–33)	134 (200)	160	33	43	National and moderately efficient	95	45	48	124
Italy (1930)	342 (400)	166	30–40	52	National and moderately efficient	85	53	55	106
England and Wales (1930)	642 (650)	172	60	10	National and very efficient	95	58	55	60

Sources: see Table 3.

of these investments having been enhanced by more widespread basic education) to produce a balanced, protection/resistance ascent toward 60 years. However, throughout the early twentieth century Italy became less and less uniform with respect to its basic statistics and more like two contrasting regions. The North developed rapidly while the South stagnated. Italy's regional statistics reflect this divergence, and thus national aggregates become less easy to interpret.[46]

Japan's path towards a life expectancy at birth exceeding 60 years in Figure 3 begins in 1880 with a shift from moderate to high levels of protection from exposure achieved through the national government's successful campaigns to eliminate epidemic diseases. Subsequently, from 1900 to 1930 Japan lost ground on the exposure dimension, because rapid urbanization and industrialization were reducing its natural, rural type of protection from exposure, faster than an equal level of protection could be achieved through additional investments in urban public health. Life expectancy at birth would have fallen, were it not for the compensatory rise in income per head (from low towards more moderate levels) generated by economic development. The net result of this series of offsetting trends was to keep life expectancy at birth practically constant in Japan for almost four decades.

Each of the historical paths shown in Figure 3 are the result of imaginative speculation rather than precise measurement of the underlying levels of protection from exposure or resistance to/recovery from exposure. But in each case imagination was constrained by the data presented in Table 5.

In Table 5 it is evident that between 1900 and 1940 Japan became an industrialized country with one-third of its population living in fairly large cities (20,000 people or more) and over half of its male labour force moved out of primary industry (agriculture and forestry) to the manufacturing and service sectors of the economy. This effectively doubled Japan's income per head without substantially changing its level of mortality, or altering the cause-of-death patterns. Infants and small children benefited to some extent, while life expectancy of men, fell slightly despite the fact that their mean stature increased.

That rising income per head actually led to improved standards of living, can be substantiated from direct data on household level expenditures. The extensive studies of M. Shinohara have definitively established that economic progress at the national level was translated into substantially increased (price-adjusted) expenditures at the household hold level on food, clothing, fuel and light, and medical and personal care.[47] It also led to increased per head consumption of alcohol and tobacco. This could be interpreted as indicating that part of the failure to reduce adult men's mortality may be connected with sub-optimal choices made by the men themselves. (Adult men were almost certainly the principal consumers of these particular toxic substances.)

Relatedly, the Japanese people had a strong preference for eating white rice at practically every meal. Since the government had evidence to show that this habit contributed to certain vitamin deficiency diseases, they encouraged people to eat brown rice. But the public's preference for white rice remained strong.[48] Protein consumption

[46] See M. Livi-Bacci, *A History of Italian Fertility* (Princeton, Princeton University Press, 1977), p. 194. With respect to the role accorded to income change over time, in 1930 Italy was still below the necessary threshold level of income for that period, as determined by Preston. According to Preston's data a country with an income per head less than $600 dollars a year in 1930 could still achieve some mortality improvements from income increases alone. See Preston, *op cit.* in footnote 6, p. 67.

[47] *Personal Consumption Expenditures*, vol. 6 of *Long-Term Economic Statistics of Japan* (Tokyo: Keizai Shimposha, 1967), table 4, pp. 140–141.

[48] T. Saiki, *Progress of the Science of Nutrition in Japan* (Geneva: League of Nations, 1926).

per head, however, was increasing, and inadequate nutrition was probably not the basic cause of an apparent stagnation in life expectancy at the national level.[49]

The failure of Japanese men's life expectancy to rise in the face of improvements in the standard of living, indicates that inadequate investment in public health at the 'community' level was the fundamental cause of the observed stagnation. The Japanese failure to invest adequately in public health could have been due to several factors: the government could have suffered from a simple lack of knowledge about how to manage the major disease problems which remained after major epidemics had been eliminated. However, there is no evidence that Japan lacked any relevant information, in either medicine, biological science, or applied public health. In fact, as early as 1900, there were eminent bacteriologists like Shibasaburo Kitasato (Koch's most important pupil) who were already contributing advanced research to the world's pool of knowledge about infectious diseases, while other Japanese scientists were contributing to the frontiers of parasitology.[50]

Nor was the relative lack of progress in mortality due to some change in the government's *commitment to public health*. A healthy citizenry was treated as an intrinsic part of the government's plans to make Japan a world power. Attitudes were not the problem as they had been, for example, during the Tokagawa period when the government forbade the importation of dangerous foreign knowledge.

At the root of the failure to raise men's life expectancy substantially in the first four decades of the twentieth century were the government's imperial ambitions, which made increasing military strength the first priority of the top officials. Given that the Japanese were still a relatively poor nation, they could not commit their limited financial resources fully to public health while simultaneously investing heavily in a major military build-up. Thus the national government, acting under self-imposed financial constraints, continued its public health efforts by relying on traditional, fairly inexpensive strategies built around protecting the population from exposure.

But, during the early twentieth century, the most effective techniques for reducing mortality from endemic infectious diseases were fairly costly measures designed to assist an afflicted individual to recover from one or more diseases. By 1910 the cheap techniques used to control the classic epidemic killers could contribute to the maintenance of the mortality *status quo*, but not to the achievement of new breakthroughs in disease control. Although the government continued their campaigns to educate people about the importance of sanitation,[51] and initiated more sanitary inspection campaigns (including a greatly increased emphasis on the inspection of milk and other foods sold to the public) and continued to impose effective quarantines when any new contagious disease erupted, mortality stagnated. Aware of the limitations of their methods, the government sponsored research on the development of vaccines against the major infectious diseases in the hope that these would make it as cheap and easy to protect its citizenry as had been the case with smallpox. In short, the government continued its effort to control disease, but the exposure-oriented methods they used had reached the limits of their potential. As the volume of internal migration kept increasing and urbanization proceeded, it became more and more difficult to prevent widespread exposure to common airborne and waterborne infections.

In Table 6 we show the disease history of Japan during the twentieth century. While

[49] For protein consumption per head see Mosk, *loc. cit.*, footnote 25.

[50] M. Miyajima, *Robert Koch and Shibasaburo Kitasato* (Geneva: Sonar, 1931).

[51] In 1921 a giant exhibit was held in Tokyo war organized by the government that had over 30,000 educational and demonstration exhibits dealing with sanitation. See Y. Fujikawa, *Japanese Medicine*, p. 91.

some limited progress was made before 1945 with 'other infectious and parasitic diseases', 'influenza/pneumonia/bronchitis' and 'diarrhoea/gastritis/enteritis', all of which were among the ten leading (grouped) causes of death, respiratory tuberculosis remained as intractable as ever. In Italy and England death rates from these diseases had been greatly reduced in importance by the 1930s; in fact, it was the successful control which caused most of their rise of life expectancy between 1900 and 1940.

Table 6. *Age standardized death rates (per 100,000) for all causes combined and some cause-specific categories, Japan, 1908–1960*

	Infectious diseases							
	Airborne			Water-borne	Degenerative diseases			
Year	Respiratory tuberculosis	Other infectious and parasitic diseases	Influenza, pneumonia, bronchitis	Diarrhoea, gastritis, enteritis	Neo-plasms	Cardio-vascular diseases	Violence	Other unknown
1908	152	162	300	144	58	215	82	948
1920	155	186	596	242	70	236	87	692
1930	140	131	220	215	71	241	84	548
1935	152	141	236	185	77	259	86	372
W.W. II	—	—	—	—	—	—	—	—
1950	138	80	94	78	83	180	77	250
1960	32	78	57	32	95	202	67	121

Source: Mosk and Johansson, 'Death and development, mortality decline in Japan' (1984) *loc. cit.* footnote 1. Original data from Preston, Keyfitz & Schoen, *op. cit.* in note to Table 3.

The major techniques of disease control used in Western Europe after 1900 to reduce mortality from common lung infections frequently involved intensive medical care that could only be delivered in a hospital setting. This was particularly true of *respiratory tuberculosis*. Tuberculosis was strongly correlated with poverty, and particularly with poor nutrition. But even the most poorly nourished, badly housed person could not die from tuberculosis unless exposed to it first. The Japanese medical establishment believed that the steady rise of deaths from tuberculosis was basically due to increased exposure related to the mass migration of its people from the rural to the urban sector.[52] To prevent the exposure of future susceptibles, the government sponsored research during the 1920s on what ultimately became BCG vaccine.[53] In the meantime the pathological investigations of Professor H. Oka (based on extensive autopsies of people who had definitely died of respiratory tuberculosis) demonstrated that the death rate from tuberculosis was particularly high in the age group 15–25, because first exposure tended to occur at that age, and not because previously contained childhood infections were re-activated by the physical stresses of puberty or other extraneous forms of stress.[54]

While trying to develop a vaccine against tuberculosis, the Japanese passed laws requiring all places where the public gathered to provide frequently disinfected phlegm pots to control public spitting. Infected services workers with mild cases of tuberculosis were required to give up their jobs. The government also passed legislation mandating

[52] Miyajima, *op. cit.*, footnote 50, p. 98.
[53] T. Shimao, 'Side-effects of BCG vaccination', *Reports on Medical Research Problems of the Japan Anti-Tuberculosis Association*, **20** (1972), pp. 7–15.
[54] T. Shimao, 'Studies on the onset and development of pulmonary tuberculosis in Japan in recent years', *ibid.* **14** (1966), pp. 6–19.

protective measures to those in certain occupations, like textile workers whose lungs seemed particularly susceptible to the disease.

But the most effective way to control respiratory tuberculosis involved the construction of special hospitals (sanatoria) for people who were already infected. This was a very expensive form of preventing exposure and assisting the sick person to recover naturally. Since few ordinary individuals could afford extended hospitalization in private sanatoria, both the local and national government had to bear much of the cost of constructing public sanatoria, as well as provide financial assistance to those families who temporarily lost wage-earners.

The Japanese national government started by ordering the local health authorities in its largest and wealthiest cities to build tuberculosis hospitals very early in the twentieth century. But even these comparatively 'rich' cities claimed to be unable to afford the necessary capital outlays. As government officials realized how expensive it would be to control tuberculosis by subsidizing the construction of sanatoria, meeting their running costs and the other associated welfare payments, they stopped pressuring local officials to proceed rapidly. Until after the war there was a chronic shortage of tuberculosis beds throughout Japan, and many afflicted individuals were forced to rely on the assistance of family members and relatives.

The household level techniques recommended for dealing with tuberculosis also involved a high level of investment in the sick person. The patient was supposed to be isolated, fed a protein-rich diet, and kept clean and rested: in short, given a standard of living which was probably well beyond what the ordinary family could afford.

The lethal nature of other respiratory infections (pneumonia, etc.) was also dealt with in Europe by using modern forms of hospitalization. Despite the fact that a lifetime of undernutrition made death from influenza, pneumonia, or bronchitis, more likely, it was generally true that, given proper medical supervision and nursing care, even those who were dangerously ill could recover and return to a state approximating health.[55] But the construction of modern hospitals, particularly those offering free or inexpensive modern intensive care to the public, was another form of high-cost intervention which the Japanese could ill-afford. The typical institution which the Japanese government built and called a 'hospital' usually required one or more of the patient's relatives to move in and provide food and nursing care for the sick person. Although this kind of hospital was spread widely throughout rural areas, a substantial part of the financial burden for its users was placed on families in greatest need of pervasive medical intervention.[56]

In his study of a still traditional Japanese rural village of the 1930s, the anthropologist J. Embree observed that about half the residents still used a traditional folk healer in times of sickness, rather than a locally available, formally trained physician. They did not necessarily prefer the folk practitioner; but purchased his services because they were much cheaper than those of the local doctor. Japanese authorities, aware of this problem, did not outlaw the practice of folk medicine, but did make it a criminal offence for any person openly to disparage the superiority of modern Western medicine.[57]

One of the most expensive forms of public health a government could provide for its people was the delivery of piped, pure water. Again and again this was shown to reduce deaths from diarrhoeal diseases, but once more the Japanese lagged behind Western

[55] See, J. P. Peter, 'Disease and the sick at the end of the eighteenth century', in *Biology of Man in History* (eds.), R. Foster and O. Ranum, eds. (Baltimore: Johns Hopkins University Press, 1975). Peter says that eighteenth-century French doctors had discovered that the lethal nature of the common lung infections could be reduced by half, even among poorly nourished and illiterate French peasants, with proper medical supervision. This included discouraging the peasantry from resorting to sometimes harmful folk remedies (p. 115).

[56] Taeuber, *loc. cit.* footnote 2, p. 325.

[57] *Suye Mura, A Japanese Village* (Chicago: University Press, 1939).

Europe. By the 1930s, when 90 per cent of London's households were supplied with clean water, Tokyo's corresponding proportion was 70 per cent. Outside Tokyo and several other large comparatively rich industrial cities there was almost no provision of clean piped water. In total, about 26 per cent of all Japanese households were supplied with treated water by 1935, whereas at least 80 per cent of English households were connected to the modern water system.[58]

Table 7. *Mean values of public health and medical variables for groups of prefectures classified by their proportion in primary industry in 1930, (Japan, 1908–1960)*

Proportion in primary industry (%)	Houses supplied with pure water per 100,000 persons (1920–35)		Food examinations per 100,000 persons (1930–50)		Hospitals per 100,000 persons (1935–60)		Doctors per 1,000 persons (1907–35)	
Less than 30 (most developed)	70 (48)	102 (38)	29 (31)	56 (40)	5.4 (2.7)	6.6 (0.9)	0.8 (0.21)	1.1 (0.38)
30–50	14 (15)	36 (22)	10 (10)	31 (10)	3.7 (1.6)	6.7 (1.9)	0.7 (0.15)	0.7 (0.14)
50–60	5 (10)	19 (10)	12 (12)	28 (12)	3.5 (1.6)	6.8 (1.6)	0.6 (0.14)	0.6 (0.11)
over 60 (least developed)	4 (4)	13 (6)	5 (2)	32 (11)	2.3 (0.7)	5.9 (1.8)	0.8 (0.4)	0.6 (0.09)

Source: Abstracted from the full table presented in C. Mosk and S. Ryan Johansson, *loc. cit.* footnote 1. See Table 5.

What resources the government could spare for direct investment (or co-investment with local government) in high-cost public health interventions was almost invariably concentrated in the most urbanized and industrialized prefectures. (See Table 7.)

As Kingsley Davis has pointed out, the concentration of public health resources in the urban sector was a widespread phenomenon during the nineteenth and early twentieth centuries. Such concentration was related to the fact that it was/is easier and cheaper to provide both basic health services and information to spatially concentrated populations.[59]

By the 1930s enough concentrated investment in both low- and high-cost public health measures had taken place in the most urbanized and industrialized prefectures of Japan to give these areas, which had always been more wealthy, freedom from their traditional health disadvantages. This brought about what we have identified elsewhere as a shift to the second stage in modern mortality history - the stage in which the urban/industrial sector reaches effective parity with the rural sector. This important point in the mortality history of a country means that a developing nation stops paying a mortality penalty for transferring its citizens out of the lower-exposure rural sector into the higher-exposure urban sector.[60]

Japan had reached Stage 2 by 1935 when in Tokyo and most of the other large Japanese cities life expectancy had reached levels equal to that of the average rural prefecture. But the onset of the Second World War interrupted further progress. By the

[58] For Japan see Taeuber, *ibid.* For England see A. Daley and B. Benjamin, 'London as a case study', *Population Studies*, **17** (1964), pp. 249–263.

[59] K. Davis, 'Cities and mortality', *IUSSP, International Population Conference*, Liège, vol. 3, pp. 259–282.

[60] See Mosk and Johansson, *loc. cit.* footnote 19.

fifth year of the war the government estimated that life expectancy at birth for men had dropped to 24! In the catastrophic conditions of the last months of war, cholera and other classic infections began to emerge once more as genuine threats to public health, along with bombs, atomic and conventional.

By the end of the war Japan's economy lay in ruins, and its income levels had fallen below those achieved in the late 1930s. In these unlikely circumstances life expectancy at birth began to rise at a pace unprecedented in both Japanese and world history. By 1946 men's life expectancy at birth was back to 43. Within one year it rose by over six years to 50, and by 1948 it stood at 56. In 1951 men's life expectancy at birth had risen to 60 years, *despite the fact that income per head had not yet returned to pre-war levels.*

The fact that in five post-war years the Japanese had been able to raise life expectancy faster and further than during the previous five decades, was based on the simultaneous occurrence of three major factors. Foremost among them was the reduced cost and enhanced efficiency of disease control techniques based on several newly available 'miracle drugs'. The new antibiotics were both cheap and easily diffused to rural areas. By 1955 an effective form of BCG vaccine against tuberculosis practically eliminated the disease among children who had not yet been exposed to it, although it was not successful with the elderly.[61] The era of penicillin and other miracle drugs made it possible to cure the major common lung infections, and some of the other endemic infections, with unprecedented ease.

Secondly, as the costs of controlling infectious disease fell, the Japanese increased the level of their expenditures on public health. Despite the fall in national income per head, investment was no longer hindered by the 'necessity' of maintaining a large military establishment. By the 1950s the national government was spending 8 per cent of its revenue on public health (*c.* 85 million yen in 1955) and almost 12 per cent by 1963 (330,000 million yen).[62] As a result of increased funding, sanatoria were built so rapidly that there was a glut of tuberculosis beds by the early 1950s. A great deal of money and effort was also put into nutrition surveys, and subsequently into the relatively expensive delivery of community-sponsored food supplementation programmes to schools, hospitals and even factories.

Few interventions remained too costly to prohibit extensive investment, and even rapid geographical diffusion to all the prefectures. Since studies had shown that time spent travelling made rural mothers reluctant to take themselves and their children to subsidized urban maternity and child welfare clinics, like those which had been constructed in Tokyo as early as 1935, the government began to build rural health centres even in the most remote areas of Japan. In effect, the government was now willing to spend money in order to encourage people to take advantage of free basic health care.

But some public health measures remained too costly to be delivered easily to rural areas. By the early 1960s, 57 per cent of all Japanese households were supplied with treated water, but almost all were in urban areas. The delivery of piped, treated water to rural areas was, and still is, one of the most costly forms of public health.

A third factor was responsible for the unprecedently rapid rise in life expectancy during the post war years – urbanization. By 1950, Japan had entered the third stage of modern mortality history, the defining characteristic of which is that death rates in cities

[61] K. Misono, 'The future trend of tuberculosis and its control program in Japan', *Reports on Medical Research Problems of the Japan Anti-Tuberculosis Association* (13, December, 1965).

[62] A complete set of health expenditure statistics for the 1960s and early 60s can be found in the Ministry of Health and Welfare's *A Brief Report on Public Health Administration in Japan* (1963), pp. 21–23.

finally fall below those in most rural localities. Since Japanese cities remained the principal beneficiaries of both the older and newer forms of disease control and health promotion after the war, they rapidly achieved a marked mortality advantage over rural areas. Thus, the continuing transfer of the rural population to the urban sector of the economy (by 1950 over 40 per cent of the population lived in cities with 20,000 or more

Table 8. *Regressions on income levels and age standardized death rates at the prefectural leval, Japan 1908–1960 (males)*

Year	Diarrhoeal diseases		Influenza, etc.		Respiratory tuberculosis	
	Constant	Logarithm of income	Constant	Logarithm of income	Constant	Logarithm of income
1908	−54.3	38.0†	69.7	45.0†	−76.7	49.7*
	(−0.7)	(2.4)	(0.7)	(2.5)	(−1.4)	(4.7)
1920	158.6	24.5*	91.8	81.7*	130.3†	21.7†
	(1.6)	(1.5)	(0.8)	(4.3)	(1.9)	(2.0)
1935	306.0	−13.5	191.3‡	−5.1	141.7†	17.7†
	(3.2)	(−1.0)	(1.7)	(−0.3)	(2.2)	(2.0)
1950	298.9†	−31.4‡	137.9	−21.2	246.5*	−3.7
	(2.4)	(−1.6)	(1.0)	(−0.9)	(3.0)	(−0.3)
1960	100.1	−4.7	36.4	−9.8	263.9*	−23.2‡
	(0.7)	(0.3)	(0.2)	(0.5)	(2.8)	(−1.9)

Source: Abstracted from a more detailed table in Mosk and Johansson, (1984), Tables 4.2, 4.4, 4.6.
Notes: this table leaves out the coefficient estimates for 1930 and 1955. It also leaves out an agricultural dummy. Adjusted R^2 for the diarrhoeal diseases regression is 0.88; adjusted R^2 for the influenza, etc., regression is 0.96, and adjusted R^2 for the respiratory tuberculosis regression is 0.85.
* Significant at the 1 per cent level (two-tailed test).
† Significant at the 5 per cent level (two-tailed test).
‡ Significant at the 10 per cent level (two-tailed test).

inhabitants) was accelerating rather than retarding the decline of mortality, as had been the case before the war.

The impact of the beneficial effects of urbanization/industrialization on mortality can be demonstrated at the prefectural level by using age-standardized, disease-specific death rates. Table 8 shows how several leading (grouped) causes of death, diarrhoeal diseases, influenza/pneumonia/bronchitis and respiratory tuberculosis were affected by the differential impact of economic development and public health investment at the prefectural level between 1900 and 1960.[63] As can be seen in Table 8, at the beginning of the twentieth century all three cause-of-death categories were positively related to income at the prefectural level. Age-standardized death rates from the three major disease categories were highest in Japan's wealthiest (urbanized-industrialized) prefectures between 1900 and 1920; the lowest incidence of deaths assigned to these categories was found in the poorer agricultural prefectures. By 1930, mortality from the non-tubercular lung diseases, and the waterborne diarrhoeal infections reached the income-neutral stage (Stage 2), and by 1935 average age-standardized death rates from these causes were more likely to be lower in the wealthier, industrialized prefectures, where most of the expensive investments in the public health sector had been concentrated. By 1950, unequal levels

[63] Table 7 is a reduced form of results presented in much greater detail in Mosk and Johansson, *loc. cit.* in footnote 1, 1984. The complete table is based on cross-sectional, pooled data for the 46 prefectures of Japan in 1908, 1920, 1930, 1935, 1950, 1955 and 1960. While the results are based on the pooled case, they were duplicated in regressions for each single year, and in their associated scattergrams, which are reproduced in the NFS report.

of investment in the control of water pollution gave the industrialized/urbanized areas a very marked advantage over rural areas in terms of deaths from diarrhoeal diseases. In the case of the common lung infections differential access to hospitals and other forms of medical assistance also appeared to give a strong mortality advantage to the urbanized/industrialized areas by 1950. But by 1960 the aggressive diffusion of public health measures to the rural areas were causing the rural areas to 'catch-up' with the now advantaged urban areas.

The history of tuberculosis at the prefectural level is slightly different. Tuberculosis became income-neutral after the war, sometime during the late 1940s. Very swiftly, death rates from respiratory tuberculosis in the urbanized–industrialized prefectures fell below those of agricultural ones, in all probability as an almost immediate response to the BCG vaccination campaigns conducted through health centres and schools.

That these structural shifts in specific disease categories do not respond uniformly to income changes is another way of demonstrating the greater relative influence on mortality of health technology. While public health measures can act immediately to protect the population from exposure to certain diseases, the mortality effects of income increases are slower to act and more diffuse. Biologically the superior effectiveness of public health measures makes a great deal of sense. With few exceptions (like those involving the ever-present opportunistic infections) individuals cannot catch a specific disease to which they have not been exposed by contact with an infected person, animal, or an ingested/inhaled/injected/touched substance. Even among relatively malnourished populations, whose stature has been reduced by calorie and/or protein deprivation, those who survive to adult ages, may exemplify Seckler's modern 'short but healthy' individuals, whose otherwise precarious lives have been preserved by a high degree of collectively managed protective intervention.[64] Historically, the Japanese in 1900 may be a good example of what was at that time a population, which though small in stature, was relatively healthy.

On the other hand, since income and nutritional advantages do not automatically protect individuals from the deleterious health consequences of exposure to many diseases, the English may exemplify a high-income, tall, but (relative to their potential) unhealthy population whose life expectancy was lower than it would have been had its government been determined to purchase and diffuse speedily all the forms of protective health technology then available. This view receives some support in that by 1900, in England, there were already some very well-managed healthy rural and urban districts in which life expectancy at birth had reached 60 years.

VII. CONCLUSIONS

Mortality transitions, considered from a biological perspective, are a process in which gains in life expectancy are produced by the interaction of a large set of social and economic factors which prevent exposure and/or enhance natural resistance to disease. Depending on the time and place, sometimes on set of factors can dominate mortality changes and sometimes the other. England began to industrialize and urbanize during the late eighteenth century, when the technology for controlling epidemic and endemic infectious disease was crude and costly. Since its institutional and cultural traditions placed responsibility for health on local officials who were financially unwilling and frequently unable to take advantage of whatever health technology existed, rising living standards and better nourished, taller individuals were not associated with a rapid decline

[64] D. Seckler, '"Malnutrition": an intellectual Odyssey', *Western Journal of Agricultural Economics*, **5** (1980), pp. 219–227.

in mortality. Furthermore, since death rates in British cities were higher throughout the nineteenth century, the transfer of the population from rural to urban areas, slowed down the decline of mortality.

Japan, in contrast, began its economic development after a century of experimentation made it possible to import from Europe a set of theories and rudimentary techniques for managing epidemic disease. This information advantage, in combination with an institutional and cultural legacy which stressed the national government's right and duty to interfere with individual or local freedom in order to improve the collective welfare, enabled 'underdeveloped' Japan to attain a life expectancy at birth in 1900 which was only a few years lower than that of Great Britain, Europe's wealthiest and most developed country.

Despite the relatively low income per head which characterized Japan during the first half of the twentieth century, it could have probably preserved its 'premature' high life expectancy, if the government's imperial and militaristic ambitions had not prevented it from investing in the relatively expensive forms of public health used to control endemic infectious diseases before the invention of 'miracle drugs'.

After the Second World War, demilitarization laid the basis for new public health triumphs as the cost of disease control was lowered, and a much higher level of investment was directed towards the public health sector. Through unprecedently rapid increases in life expectancy at birth, Japan quickly rejoined the club of nations with high life expectancies, even though its income levels were still much lower than those common in Europe. (In 1960 the life expectancy at birth of Japanese men was 68, and its income per head was equivalent to $774.) In England and Wales income per head was double that figure, but men's life expectancy at birth was only 69.[65] With an average income more than three times that of Japan, life expectancy at birth for men in 1960 in the United States was one year lower.

The life expectancy history of such different countries demonstrates that no one, single, culture-free, time-free, narrowly economic or biological explanation of mortality change is possible. Mortality history is as complex as the biological, political, cultural, economic and technological forces which drive it. In short, it is as complex as the human beings who make it.

The mortality history of Japan is unique in many ways. One point, which has not been widely appreciated, is that Japan was the first country to use its cultural and political institutions to demonstrate what is observed in Costa Rica, Kerala State, China and several other areas to-day – above a certain fairly minimum standard of living threshold, the 'right' to live to old age, can be secured for the average citizen, even in low-income developing countries, if the government is dedicated to the efficient exploitation of existing public health technology and the population is educated, and co-operative.

[65] Preston, *Mortality Patterns in National Populations*, pp. 86–87.