
POPULATION

AND

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REVIEW

VOLUME 25 NUMBER 4
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Smallpox in Nineteenth-Century India

JAYANT BANTHIA

TIM DYSON

SMALLPOX IS ONE of the most terrible diseases ever to have afflicted humanity. Highly contagious, frequently fatal, and often very disfiguring of those who survived, it has been feared for centuries. By the early twentieth century because of widespread vaccination and other measures, the disease was largely absent from North America and Europe. But as recently as the 1960s the disease remained endemic in much of Africa and Asia. From around 1967 the World Health Organization coordinated a massive international campaign aimed at the global eradication of smallpox. The strategy involved the containment of outbreaks by isolating the affected area and the patients and then tracing and vaccinating all possible contacts and others at risk of contracting the disease. The campaign proved remarkably successful. The last naturally occurring case of smallpox happened in Somalia in 1977. In 1980 WHO declared that smallpox was finally eradicated from the world—a success that inspired thoughts of eliminating other diseases.

It is, however, an unfortunate fact that our interest in smallpox today cannot be merely historical. There has been a recent debate as to whether or not the two remaining official stocks of the smallpox virus—held at the Russian State Research Center of Virology and Biotechnology in Koltsovo, Novosibirsk, and at the United States Centers for Disease Control and Prevention in Atlanta, Georgia—should be destroyed. There is concern too that secret stocks of the virus may exist somewhere and could be released deliberately, either by a rogue nation state or by terrorists. It is also conceivable that live smallpox virus could emerge from a corpse which has been preserved in permafrost. Hence a recent editorial in *The Lancet* concludes that the threat of this disease still persists.¹ Moreover, humanity today is largely unprotected, because vaccination has not been practiced for two decades; and current global supplies of the vaccine are low and might take several

years to replenish. The editorial finishes with the sobering observation that declaring a disease eradicated does not consign it to history.

With this as background the present article aims to shed light on an important, but not well-documented part of the story of smallpox—namely the history of the disease in India during the nineteenth century. It is sometimes suggested that demographic data on causes of death do not exist for India before about 1880, when publication of the *Annual Report of the Sanitary Commissioner* starts providing information on registered births and deaths.² Moreover, because during the nineteenth century deaths were rarely classified by both the age of the deceased and the cause, scholars have tended to assume that little worthwhile cause-specific analysis of early Indian mortality patterns can be attempted.³

Such constraints have resulted in there being few adequate demographic studies of mortality patterns in British India during the nineteenth century. For example, while David Arnold's influential essays on cholera, smallpox, and plague examine colonial health policy and its political and cultural context, they do not examine the demographic impact of such diseases.⁴ Similarly, studies by Ira Klein and Sumit Guha have tried to explain why Indian mortality began to improve from around 1921, but they largely neglect the issue of mortality dynamics during the nineteenth century.⁵ Likewise, an early study of smallpox by S. P. James was confined to the late nineteenth century.⁶

In his classic 1951 book *The Population of India and Pakistan*, Kingsley Davis assessed the consequences of smallpox, cholera, plague, and malaria. His view too was that the available death registration data were not suitable for demographic analysis. Interestingly, he speculates that “[i]n nineteenth century India, this disease [i.e., smallpox] must have carried away huge numbers.”⁷ Again, nevertheless, Davis's book deals mostly with the twentieth century and is chiefly focused on the national level. Another study by Dyson used vital registration data for the province of Berar in central India to estimate long-term trends in fertility and mortality over the period 1881–1980. Touching upon the relative importance of different diseases in the late nineteenth century, Dyson remarks that smallpox appears to be fairly unimportant—on average accounting for between one and 3 percent of deaths.⁸

The result of this inattention to nineteenth-century circumstances and data has been that the history of Indian morbidity and mortality has often been characterized in terms of the decline of a few particular diseases during the twentieth century—notably malaria, plague, and cholera. Of course, there are constraints in studying trends in malaria mortality because the disease was usually not classified as a separate cause of death. Plague became a problem only after its probable reintroduction to India in 1896 and was largely controlled by the 1920s. This leaves cholera for longitudinal demographic study, but most studies of cholera have focused on aspects of

health policy. So despite the fact that the population of India suffered from several epidemic diseases in the nineteenth century, virtually no long-term demographic studies of cause-specific mortality pertain to that period.

The present study of smallpox in nineteenth-century India is a step toward filling this gap. We assemble authoritative data on the disease's case fatality and its prevalence and thereby assess the chances of dying from smallpox. We also quantify changes in the importance of smallpox mortality during the nineteenth century. In doing so we use some substantial (though neglected) historical data sources, including annual provincial vital registration reports. We explore variations in smallpox trends within India, both at the provincial level and among the presidency towns, in an effort to account for differences in observed smallpox mortality patterns. Above all, through two case studies we examine the role of a specific medical intervention—vaccination—in greatly reducing the number of smallpox deaths during the nineteenth century. Finally, our study underscores the scientific value of the various historical demographic data sets that exist for India.

Smallpox case fatality

We begin with the approximate case fatality rate for smallpox. The number of deaths from any disease depends upon that disease's case fatality rate (CFR) and its prevalence. The CFR is the ratio of the number of deaths from a disease to the total number of people contracting it; in other words, the proportion of people affected by the disease who die from it. Several problems are involved in determining a single case fatality rate for smallpox in nineteenth-century India. First, few people who were suffering from the disease were hospitalized in the small number of existing hospitals; this was partly because no cure for smallpox existed, and partly because most cases occurred in young children. Second, the protective status of India's population changed over time (notably, as vaccination progressed during the nineteenth century) and this status also varied from place to place.⁹ Finally, the CFR for smallpox may vary according to other factors, such as the age of the afflicted person, the specific type of smallpox virus, the clinical smallpox-type, and, of course, whether people have been vaccinated, revaccinated, or inoculated.¹⁰ Inoculation (mentioned in relation to Bengal below) was the practice of injecting dried smallpox scabs from a previously infected person with the aim of providing immunity by causing a mild form of the disease. In contrast, vaccination began with Edward Jenner's demonstration in 1796 that deliberate infection with vaccinia (cowpox) was an effective and safe prophylactic against smallpox. All these facts must be borne in mind when interpreting smallpox fatality rates.

Table 1 presents case fatality rates found for the Indian subcontinent during the nineteenth century. They vary between 20 and 50 percent. (Stan-

standard medical texts suggest a case fatality rate for smallpox of around 25–30 percent.¹¹) The data for Ceylon, the earliest in this series, are based on hospital records relating to an unprotected population. The data for Calcutta and Madras are also based on hospital records for unvaccinated persons. Although the Madras data pertain to a period of severe famine, the indicated level of smallpox case fatality from the famine hospital records is not particularly high. Non-hospital-based (i.e., survey) records for unvaccinated rural people are available for Moradabad and Gujarat. Although variations in recording no doubt existed, the data shown in Table 1 can be considered fairly reliable, being based on observations made by Civil Surgeons (in hospitals) and Superintendents of Vaccination during their rural inspections. CFRs could fluctuate considerably between districts and at different times of the year, reflecting fluctuations in the severity of the disease. Thus, observations on the virulence of smallpox in the Malabar region of Madras Presidency invariably described it as particularly fatal. Overall, the data in Table 1 suggest that smallpox CFRs in nineteenth-century India were high and broadly similar to those cited in standard medical texts.

In fact, in some circumstances the upper boundary clearly exceeded 30 percent. This is indicated, for example, by a long time-series from the Smallpox and Infectious Disease Hospital in the City of Bombay during the twentieth century (see Table 2). The CFRs recorded for unvaccinated people were quite stable, ranging between 35 and 40 percent.¹² The CFRs for people who at some time had been vaccinated (but probably not revaccinated) were

TABLE 1 Number of smallpox cases and number of deaths from smallpox based on reports by Civil Surgeons and Superintendents of Vaccination in the nineteenth century in Ceylon and various parts of India

Place/location	Year(s)	Smallpox cases	Deaths from smallpox	Smallpox fatality rate (percent)	Remarks
Ceylon	1800–02	2,110	473	22.4	Hospital records, unvaccinated people
Moradabad	1830	5,182	1,597	30.8	Unvaccinated people
Mangalore	1851–52	3,948	1,093	27.7	Protection status, perhaps mixed
Malabar	1852	7,166	3,502	48.9	Protection status, perhaps mixed
Calcutta	1878	355	148	41.7	Hospital records, unvaccinated
Madras	1877–78	1,090	233	21.4	Hospital records, during famine
Gujarat	1884	1,783	352	19.7	Rural population, unvaccinated

NOTE: The data for Moradabad, Mangalore, Malabar, and Gujarat come from surveys taken during epidemics. Moradabad is located in the north of India, Mangalore and Malabar in the south, and Gujarat in the west.

PRINCIPAL SOURCES: For Ceylon, T. Christie, *An Account of the Ravages Committed in Ceylon by Smallpox Previously to the Introduction of Vaccination*, Cheltenham, 1811. For Moradabad, W. Cameron, *Report on the State of Vaccination in Bengal*, Calcutta, 1831, p. 64. For Mangalore and Malabar, *Reports on the Progress of Vaccination in Madras Presidency, 1852* Madras, 1853, pp. 6 and 16. For Calcutta, *Report of the II nd Quarter of 1879 Calcutta Health Officers Report*, Calcutta, 1880. For Madras, *Annual Administration Report of Madras Municipality 1877–78*, Madras, p. 25. For Gujarat, *Annual Report of the Sanitary Commissioner*, Bombay, 1884.

TABLE 2 Case fatality rates among smallpox patients admitted to the Smallpox and Infectious Disease Hospital, Arthur Road, Bombay 1905–44

Years	Vaccinated patients			Unvaccinated patients		
	Admissions	Deaths	Fatality rate (percent)	Admissions	Deaths	Fatality rate (percent)
1905–09	1,385	222	16.0	914	374	40.9
1910–14	1,341	225	16.8	828	329	39.7
1915–19	2,492	311	12.5	1,612	582	36.1
1920–24	1,444	144	10.0	1,344	500	37.2
1925–29	1,564	85	5.4	1,578	615	39.0
1930–34	2,068	125	6.0	1,838	668	36.3
1935–39	2,474	111	4.5	1,689	699	41.4
1940–44	4,742	693	14.6	2,743	900	32.8
Total 1905–44	17,510	1,916	10.9	12,546	4,667	37.2

PRINCIPAL SOURCE: *Annual Administration Report of the Municipal Commissioner of Bombay, 1905–44.*

much lower. Comment is required on the representativeness of hospital CFRs—such as those in Tables 1 and 2—for smallpox case fatality among the general population. It is conceivable that hospital data may overestimate case fatality in the general population; for example, clinically less severe cases could have been underrepresented among patients. On the other hand, CFRs were probably highest for unvaccinated infants and very young children, an age group that was less likely to be hospitalized and is therefore underrepresented in hospital data. Also, it is known that clinically the highest fatality rates occurred among smallpox cases of the hemorrhagic type, which actually tends to mask the characteristic pustular symptoms of the disease.¹³ Therefore, again, hospital admissions of patients—which were based on external symptoms—may have understated case fatality for the general population. Finally, it has been claimed that CFRs for unprotected populations in eighteenth-century Europe ranged between 10 and 20 percent.¹⁴ Clearly case fatality in India was higher. One explanation for this difference may be that in India only the more virulent variety of the disease, variola major, was reported. Variola minor, which had a CFR of one percent or less, was not found in the Indian subcontinent. Therefore it is quite possible that the lower CFRs observed for European populations partly reflect the presence of variola minor.

Smallpox prevalence

Although lacking statistical precision, many descriptions made by early medical officers convey how widespread and destructive smallpox was in nine-

teenth-century India. Thus J. Moore, the Civil Surgeon of Joudpoor, stated in 1866 that:

Smallpox, I believe, numbers more victims in Marwar, than any other disease. . . . [R]oughly speaking, from the calculations based on counting when passing through the streets of Joudpoor and Palee, ten percent of the population appear to have totally lost sight of one or both eyes, or to have received greater or less permanent injury to organs. Of these afflictions the great majority may be traced to smallpox. From similar observations it would appear eighty percent are pitted by the disease.¹⁵

In another example, J. Pringle, the Superintendent of Vaccination for the North-Western Provinces, wrote in 1869 that: "In the Doab region lying between the Ganges and the Jumna rivers, with a population of upwards of 9,000,000 . . . 95% of the population have been attacked with smallpox at some period of their lives and that in 60% the traces of the disease are seen on the face."¹⁶

We now assess the credibility of these observations. Because hospital records provide little information on the proportion of the total population that contracted the disease, we must look elsewhere for information on prevalence. Surveys of pockmarks among various population groups are an important source of such information.

The statistics in Table 3 relate to surveys of prison populations. The data are based on the results of physical inspections and similar inquiries made by Civil Surgeons during the period 1848–72 in most regions of India. Those in jail were mainly male adults, who thus obviously represent survivors from previous exposures to smallpox. Although data on the age distribution of these prisoners are unavailable, we may reasonably assume that in most cases their average age was above 20 years. So the data reflect the disease experience of prisoners who were very young children during the early and mid-nineteenth century.

In interpreting Table 3 it must be borne in mind that the prevailing protection-status of different regional populations in India strongly conditioned the chances of contracting smallpox. In particular, the practice of inoculation was common in Bengal, where over 85 percent of people were inoculated (as suggested by figures for Chittagong, Ramganj Balueah, and Dacca in Table 3). As a result, fewer than 10 percent of prisoners in the districts of Bengal showed any sign of having contracted smallpox. Also, in Benares in eastern United Province, where inoculation and vaccination together covered roughly half the total population, only 46 percent of prisoners showed signs of the disease.

In most of northern and central India, however, smallpox was widely prevalent, with over 90 percent of jail populations showing signs of having

TABLE 3 Estimates of smallpox prevalence, and protection status, among imprisoned populations and students in different parts of India in the mid-nineteenth century

Location	Year(s)	Persons examined	Had smallpox	Inoculated	Vaccinated	Unprotected	Remarks
Chittagong	1848	1,000	91 (9.1)	871 (87.3)	2	36	Jail population
Ramganj Balueah	1850	730	50 (6.8)	632 (86.6)	1	47	Jail population
Dacca	1850	785	29 (3.7)	729 (92.3)	0	27	Jail population
North-Western Provinces	1861–72	268,445	228,964 (85.3)	4,223 (1.5)	2,553 (1)	12,215 (4.5)	Jail population
Lahore	1864	1,930	1,818 (94.2)	—	—	—	Jail population
Amritsar	1864	548	537 (98)	—	—	—	Jail population
Ambala	1864	598	520 (87)	—	—	—	Jail population
Nagpur	1862–63	1,309	1,195 (91.3)	—	—	—	Jail population
Madras	1864	7,396	3,112 (42)	0	3,140 (43)	1,144 (15)	Students
Madras	1865	11,108	4,747 (43)	0	4,550 (41)	1,811 (16)	Students
Benares	1869	900	414 (46)	162 (18)	0	324 (36)	Jail population
Oudh	1869	1,095	997 (91.8)	10 (1)	0	88 (8)	Jail population

NOTES: Figures in parentheses are the percentages in each category. For North-Western Provinces, Lahore, Amritsar, Ambala, and Nagpur the protection status of some people is unknown. Dash indicates data not available.

PRINCIPAL SOURCES: For data for Chittagong, Ramganj Balueah, and Dacca, J. Bedford in *Indian Annals of Medical Science*, 1853, Calcutta. For North-Western Provinces (NWP, United Provinces except Oudh), *Report on Vaccination in NWP 1873*. For Lahore, Amritsar, and Ambala, *Annual Administration Report of Punjab 1864*. For Nagpur, *Central Provinces Civil Secretariat Bundle Correspondence, General Department 1864*, Madhya Pradesh State Archives, Nagpur. For Madras, *Report on Vaccination, Madras Presidency 1864 and 1865*, pp. 22 and 65 respectively. For Benares and Oudh, R. Milne, *Report on the Practice of Inoculation, Benares Circle*, in *Selections from the Records of Government of North Western Provinces*, Second Series Volume, 1871.

contracted the disease (see Lahore, Amritsar, Ambala, Oudh, and Nagpur). The sample from North-Western Provinces (NWP), being particularly large, covering many districts and a period of 12 years, must be considered fairly representative for the province. Indeed, the wide prevalence indicated for NWP can be taken as broadly typical of what must have been experienced by unprotected populations elsewhere in India.¹⁷ The observations from Madras Presidency in the south covering 17 districts are also noteworthy. Based upon examinations of a younger population, namely students, they reflect a high prevalence of smallpox in the recent past.¹⁸ In conclusion, in

Table 3 regional variations in smallpox experience are discernible, reflecting different levels of population protection. It is also clear that in the absence of protection through inoculation or vaccination, the vast majority of people contracted smallpox.

Further evidence providing a rare cross-sectional view of smallpox prevalence during the early and mid-nineteenth century comes from the Census of Bombay City conducted in 1872. As part of this inquiry all inhabitants were categorized according to whether they had ever been vaccinated or had experienced smallpox. At this time the population of the town was growing as a result of in-migration from the countryside. Therefore to some extent the census data can be taken to reflect the prevalence of smallpox and vaccination in the wider Presidency.

TABLE 4 Population of Bombay in 1872 by age, and whether vaccinated, unvaccinated, or had experienced smallpox

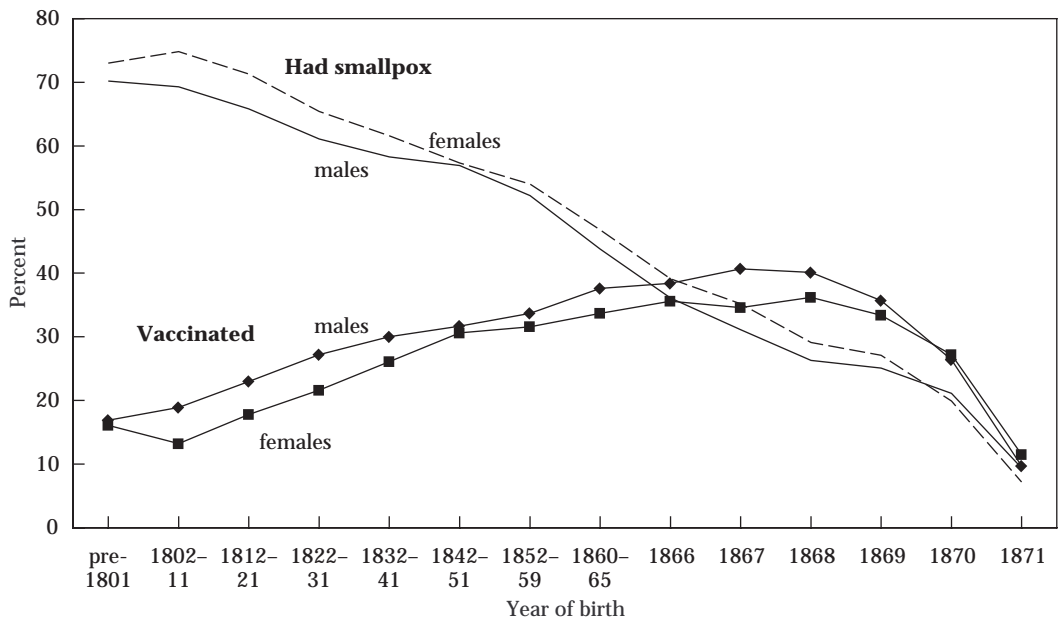
Age	Implied year of birth	Population	Proportion (percent)		
			Vaccinated	Unvaccinated	Had smallpox
1-30 days	1872	884	0.5	95.1	4.4
1-6 months	1872	6,355	9.5	82.6	7.9
7-11 months	1871	4,273	14.4	75.9	9.7
Total <1 year	1871	11,512	10.6	81.1	8.3
1 year	1870	11,240	26.8	52.7	20.5
2 years	1869	11,736	34.6	39.3	26.2
3 years	1868	11,692	38.1	34.2	27.7
4 years	1867	11,131	37.7	29.2	33.2
5 years	1866	11,694	37.4	25.2	37.3
Total 1-5 years		57,493	34.9	36.1	29.0
6-11 years	1860-65	60,758	35.8	19.0	45.2
12-19 years	1852-59	96,416	32.9	14.3	52.9
20-29 years	1842-51	169,628	31.3	11.6	57.0
30-39 years	1832-41	117,705	28.8	11.9	59.3
40-49 years	1822-31	68,791	25.2	12.2	62.7
50-59 years	1812-21	35,061	21.0	11.2	67.8
60-69 years	1802-11	19,193	16.2	11.9	71.9
70-79 years	1792-01	5,102	17.1	12.2	70.7
80-89 years	1782-91	2,168	16.5	11.1	72.4
90+ years	Pre-1781	578	10.7	11.6	77.7
Total all ages		644,405	29.6	16.2	54.2

SOURCE: Census of Bombay City 1872, Bombay.

Table 4 shows that even in 1872 over half (54 percent) of the total population of the city had experienced smallpox and only about 30 percent had been vaccinated. Of the 16 percent who were reported as unvaccinated, one can assume that many had not yet been exposed to smallpox because they were still very young.

Because they are cross-classified by age, the data in Table 4 can be subjected to “backward time-referencing,” so giving an indication of trends earlier in the nineteenth century. Thus children classified as currently aged less than one year (i.e., on 21 February 1872) must have been born on or after 22 February 1871. Following this procedure the implied years of birth are given in the second column of Table 4. As one goes back in time, the proportion of the population protected by vaccination declines, slowly at first, and then rapidly as we approach the beginning of the nineteenth century. This suggests a gradual progress of vaccination spread over a long period. More importantly, the proportion of the population recorded as having experienced smallpox rises slowly in the recent past, and then rapidly as we approach the start of the nineteenth century. For example, among those born during 1860–65 (corresponding to current age 6–12 years) 36 percent were vaccinated and 45 percent had experienced smallpox.¹⁹ In con-

FIGURE 1 Smallpox experience and vaccination status of the population by implied year of birth and sex, Bombay City 1872

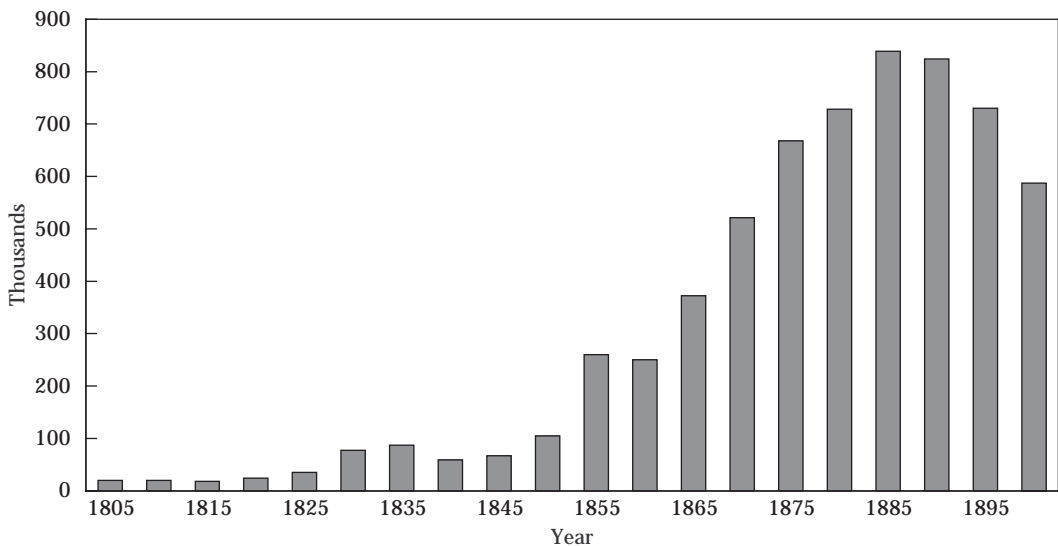


DATA SOURCE: Census of Bombay City 1872, Bombay.

trast, among those born during 1802–11, 16 percent were vaccinated and 72 percent had suffered from smallpox. These long-run trends of rising vaccination coverage and declining experience of smallpox are shown in Figure 1. Males were slightly more likely to be vaccinated and slightly less likely to have suffered from smallpox. The sex differentials in smallpox prevalence (and thereby mortality) appear to have been influenced primarily by differences in the vaccination rate. The disease itself was not sex selective.

These data from the 1872 Census of Bombay City provide strong statistical evidence of a close link between increasing coverage of vaccination and the decline in smallpox. They also enable us to state with confidence that smallpox was widely prevalent during the early nineteenth century and that it must have been a significant cause of death—especially among children—before the introduction of vaccination. In this context the progress of primary vaccination during the nineteenth century for Bombay Presidency is shown in Figure 2. Progress until the 1850s was clearly slow. Only in the second half of the century was a consistently high proportion of the Presidency’s population vaccinated against smallpox. The decline in vaccinations at the end of the century was temporary, reflecting the influence of plague in the city as people fled and health staff were diverted to plague-control efforts.

FIGURE 2 Annual number of primary smallpox vaccinations, Bombay Presidency 1805–1900



NOTE: For years before 1850 annual data on primary vaccinations are sometimes unavailable. Accordingly, for reasons of consistency above we show data for every fifth year throughout the period 1805–1900.

PRINCIPAL DATA SOURCES: General Department Number 108, 1853, Maharashtra State Archives, Mumbai; *Report on Vaccination, Bombay 1854–75*; and *Annual Report of the Sanitary Commissioner, Bombay*, various years.

Estimates of the unprotected population in early-nineteenth-century India

Vaccination was brought to India from England in 1802; prior to this year inoculation was the only form of protection available. We have already seen from Table 3 that inoculation was reasonably effective in protecting against smallpox. The question thus arises, what proportion of India's population enjoyed some form of protection against smallpox at the start of the nineteenth century?

To begin, how prevalent was the practice of inoculation in India prior to vaccination? In this context other work by the first author has shown that inoculation was largely restricted to Bengal Presidency, with isolated pockets of the practice also occurring in northern and western India.²⁰ For simplicity in the following calculations we used population totals from the 1872 census (when India's population was 206 million), on the rough but reasonable assumption that the population distribution between the various provinces was broadly the same then as at the start of the nineteenth century. At the beginning of the century inoculation coverage is estimated to be around 80 percent in Bengal Province (population, 34 million), while it was about 50 percent in Bihar and Orissa (combined population, 26 million). These figures give a total of about 40 million people protected through inoculation. Granting another 3 million people inoculated in other parts of the country, we conclude that very roughly 21 percent of India's total population had access to this form of protection against smallpox around 1802.

Thus it is reasonable to conclude that at the start of the nineteenth century about 80 percent of India's population was likely to contract smallpox. Universality of the disease for the unprotected, its high case fatality, and its wide geographical spread all resulted in smallpox being a major cause of death in most of India during the early nineteenth century and before.

Regional patterns of smallpox mortality

Systematic registration of deaths and births in India began in the 1860s. Although the vital registration system lay in the realm of the Medical Department, headed by the provincial Sanitary Commissioners, these officers had little control over the district- and village-level administrative apparatus that was used to collect data on deaths and births. The village officer usually charged with recording deaths (the village watchman, or *kotwal*) was an integral part of the Revenue Department that was headed by the District Collector (Deputy Commissioner). The degree of interest taken by a District Collector and his subordinate officers influenced the quality, coverage, timely reporting, and inspection of the vital statistics in a district. These factors varied considerably over time and between districts and provinces.

Initially many Indians viewed the recording of vital events—deaths and births—with suspicion.²¹ Underregistration was a recurring problem. In many cases the village watchmen were barely literate. Accordingly, it was decided that only basic information (e.g., the age and sex of the deceased) and relatively identifiable disease categories (smallpox, cholera, fevers, bowel diseases, and accidents) were to be recorded by the registration system.²² However, there is no doubt that the vital data still suffered from underregistration (for a variety of reasons) and from misrepresentation and misclassification of both the cause and age at death.

It is difficult to assess how these sources of error may have influenced collection and interpretation of smallpox mortality data. There were specific sources of underreporting for smallpox deaths. For example, infant and child deaths were especially underregistered and most smallpox deaths took place among infants and children.²³ In certain communities efforts were made to conceal an outbreak of the disease by people opposed to the British practice of vaccination. On the other hand, at least the diagnosis and classification of smallpox deaths were aided by a number of factors. Superintendents and Inspectors of Vaccination were especially interested in identifying smallpox deaths in order to ascertain the vaccination status of the deceased. This helped them both to assess the quantity and quality of vaccination and to persuade the general population of its efficacy. Also the public in general was familiar with the disease; and the onset of fever followed by the appearance of the characteristic red rashes on the body left little doubt about its presence. Furthermore, smallpox was deified. When it afflicted a family member, few would risk offending the smallpox goddess, Shitala, by failing to worship her—so making the presence of the disease known in the community. In addition, smallpox had a markedly seasonal distribution, with about three-quarters of all deaths occurring between February and June (see below). Finally, it was mainly a disease of early childhood, although deaths to older people were not unknown. For these reasons we can probably have considerable confidence in the classification of smallpox deaths.

It was only from 1870 that all provinces were included in the registered smallpox death total published for British India. Table 5 and Figure 3 summarize the data for the last 35 years of the nineteenth century.²⁴ Over 4 million smallpox deaths were recorded during this period, giving an average of just over 100,000 registered deaths per year. This average masks great fluctuations, however. Thus in 1884 a total of 327,774 smallpox deaths were registered, whereas in 1894 the number was only 37,575. Also noteworthy is the steep decline in the average number of deaths from smallpox that took place roughly around the mid-1880s. Thus whereas in 1875–79 an average of 175,000 deaths were registered annually, by 1885–89 the number had fallen to 78,000. By the end of the century registered smallpox deaths in the country had stabilized at a much lower level.

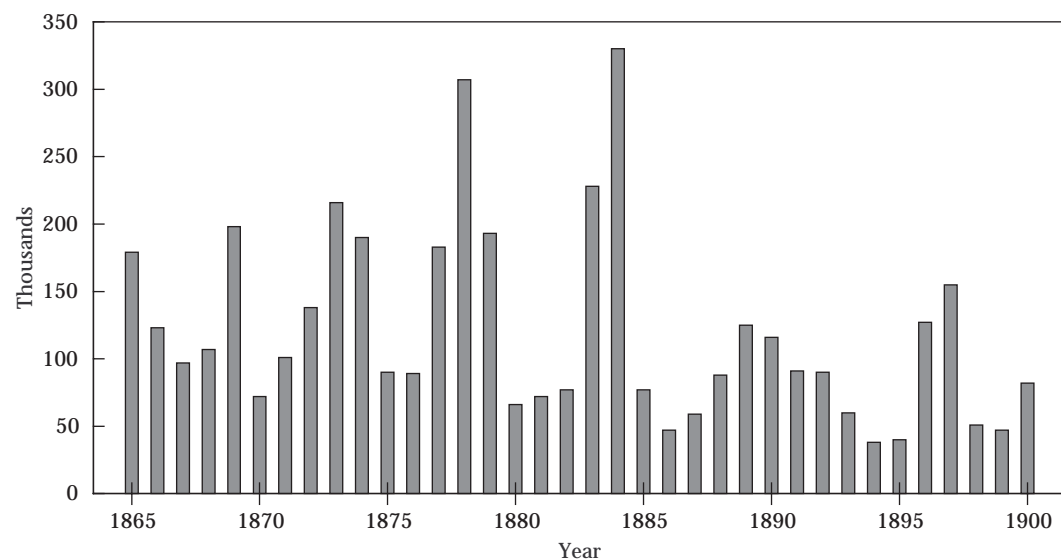
TABLE 5 Average annual registered smallpox deaths 1865–99 in British India and its major provinces by period

Period	British India	Bengal	United Provinces	Punjab	Central Provinces	Madras	Bombay
1865–69	140,797 (210/97)	—	66,979 (108/30)	38,455 (66/21)	7,700 (17/3)	25,542 (34/17)	9,381 (15/4)
1870–74	158,955 (237/83)	6,675 (12/1)	72,221 (119/35)	22,830 (27/12)	7,107 (18/1)	34,225 (52/11)	10,913 (27/4)
1875–79	174,628 (308/101)	9,330 (23/1)	70,472 (171/26)	25,184 (49/10)	13,700 (26/3)	42,153 (88/18)	9,656 (27/1)
1880–84	151,439 (333/70)	17,884 (24/10)	74,641 (203/8)	10,158 (16/6)	4,105 (5/2)	30,537 (64/15)	6,190 (14/2)
1885–89	77,642 (131/51)	6,534 (10/4)	21,363 (48/8)	11,919 (17/8)	7,553 (18/3)	24,865 (35/17)	3,592 (7/2)
1890–94	78,654 (120/44)	14,821 (22/8)	19,979 (55/4)	6,735 (11/4)	1,422 (2/1)	30,333 (44/11)	2,772 (4/1)
1895–99	83,790 (167/46)	14,690 (20/13)	27,276 (87/2)	15,928 (45/5)	4,138 (7/1)	14,735 (22/5)	3,271 (6/2)

NOTE: For concision, provincial maximum and minimum numbers of smallpox deaths (shown in parentheses) have been rounded to the nearest thousand. See also note 24.

SOURCE: *Annual Report of the Sanitary Commissioner*, various provinces, 1865–99.

FIGURE 3 Annual number of registered smallpox deaths, British India 1865–1900



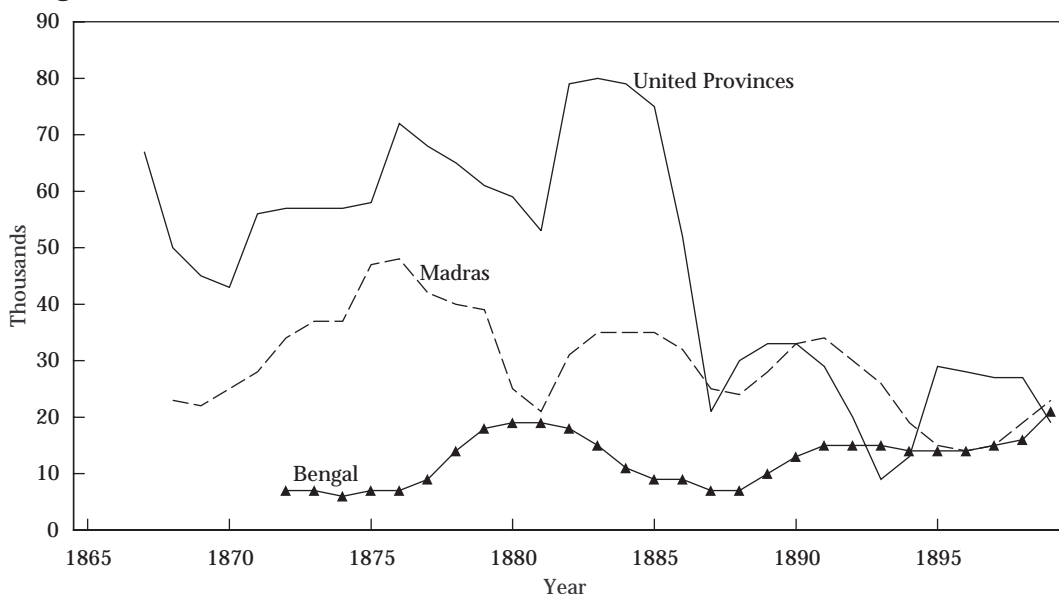
PRINCIPAL DATA SOURCES: *Annual Report of the Sanitary Commissioner*, various provinces, 1865–1900.

Table 5 also provides data for the six major provinces of British India, which together contained 95 percent of the total population. And Figure 4 plots five-year moving average curves (to assist interpretation) for three of these—Bengal, United Provinces (UP), and Madras. It is striking that Bengal, which had the largest population, did not even record 25,000 smallpox deaths in any year during this period. So smallpox was a minor cause of death in this province.

In contrast in UP, Central Provinces (CP), and Punjab smallpox was initially a major cause of death, although it declined sharply in importance by the end of the century. In CP the range of annual registered smallpox deaths varied from a high of 25,492 (in 1879) to a low of 874 deaths (in 1891). Similarly in Punjab the peak year was 1865, when 66,221 smallpox deaths were recorded, and the minimum was in 1891, when the figure was 4,085. The sharpest declines were observed for UP, where in 1884 a total of 202,541 smallpox deaths were registered compared to only 1,968 in 1895. In six years within the period 1865–84 UP registered more than 100,000 smallpox deaths, but during 1885–99 this figure was not recorded once. Clearly, during the last two decades of the nineteenth century smallpox was declining in all these provinces.

Of the remaining two major provinces, Bombay registered a comparatively small number of smallpox deaths throughout the 35 years, with, again,

FIGURE 4 Annual number of smallpox deaths, five-year moving average, Bengal, United Provinces, and Madras 1867–99



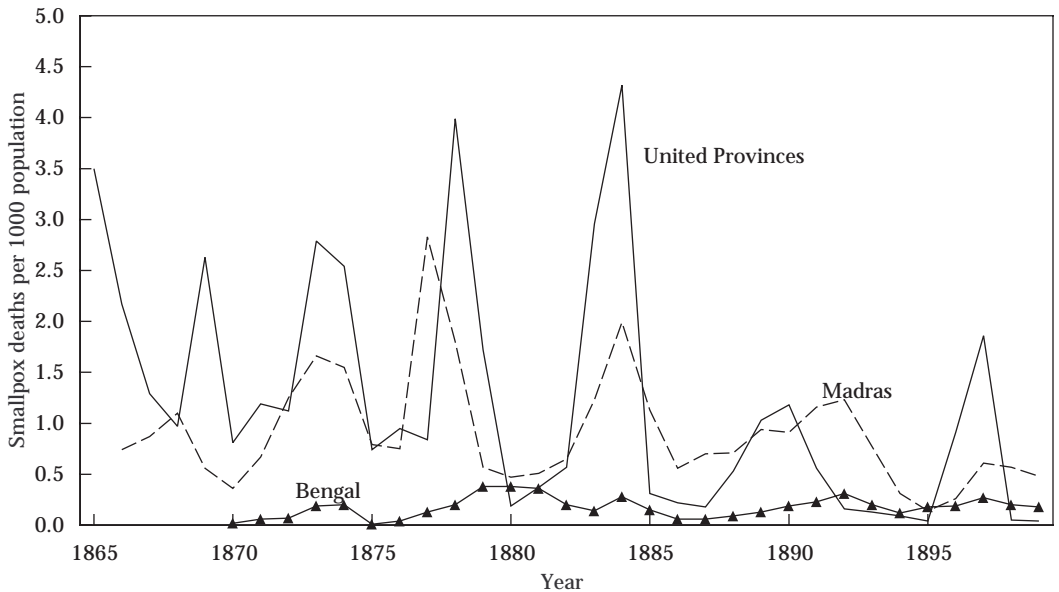
PRINCIPAL DATA SOURCES: *Annual Report of the Sanitary Commissioner, Bengal, United Provinces, and Madras*, various years.

a significant decline from around the 1880s. Madras registered a far higher annual number of deaths, although there was substantial fluctuation; for example, in 1877 and 1884 respective totals of 88,321 and 64,247 smallpox deaths were registered, whereas in 1895 and 1896 the figures were only 5,111 and 9,410. Madras too shows some indication of reduced smallpox mortality by 1895–99.

Thus at least three distinct types of trend in registered smallpox deaths are discernible at the regional level and illustrated in Figure 4: first Bengal, where the number of deaths was low throughout the period 1870–99; second UP, which recorded a large number of deaths at the beginning of the period 1865–99, followed by a sharp decline by the end; third Madras, which experienced a stable and moderately high number of smallpox deaths throughout most of the period.

To emphasize these points, Figure 5 plots the registered annual smallpox death rates for Bengal, UP, and Madras. Bengal exhibited a low smallpox death rate at the start of the period of death registration, and the rate remained low throughout the 30 years shown. UP experienced a high and violently fluctuating death rate until around the 1880s, after which a sharp decline occurred. Madras experienced a more moderate smallpox death rate throughout the period, with occasional peaks.

FIGURE 5 Annual smallpox death rates per 1000 population in Bengal, United Provinces, and Madras 1865–99



NOTE: Bengal Province includes Bihar and Orissa. United Provinces includes Oudh from 1869.
PRINCIPAL DATA SOURCES: *Annual Report of the Sanitary Commissioner*, Bengal, United Provinces (and North-Western Provinces), and Madras, various years.

So by the time death registration began in the late 1860s, smallpox was already a minor cause of death in much of eastern India. In northern and central India, however, it was important until the 1880s, after which a significant decline set in. Finally, in the southern presidency of Madras, smallpox remained a moderately important cause of death even in the last decade of the century. Therefore any study of mortality decline in India that begins in the twentieth century (or even the late nineteenth) would fail to capture the widespread devastation caused by smallpox earlier on. To get a better idea of smallpox mortality during the early and mid-nineteenth century, we now examine data for the major towns.

Evidence from the presidency towns

The earliest data on smallpox mortality in India are for Calcutta in 1832. The Superintendent of Police in the city kept a record of deaths from the early nineteenth century.²⁵ Later records of deaths in Calcutta were compiled by the Municipal Corporation. In 1848 in Bombay a systematic effort by Dr. A. H. Leith, modeled on the English civil registration system, began to record deaths by cause, age, sex, and race.²⁶ Then in 1865 the Bombay Municipal Corporation appointed an officer to report on the city's health and take responsibility for, and improve, the death registration system. Finally, Madras introduced registration of deaths in 1855, modeled on the Bombay system.²⁷ Thus records of urban smallpox mortality from three regions of India are available from the mid-nineteenth century or before (see Table 6).

In Calcutta during 1832–69 (excepting 1851–55) smallpox accounted for roughly 5 to 10 percent of deaths. In Bombay during 1848–79 the range was fairly steady at about 4 to 6 percent. In Madras during 1855–84 the range was between 3 and 11 percent. Very broadly, then, smallpox usually accounted for between 5 and 10 percent of total mortality in these presidency towns, before sharp declines set in at various times.

We conclude that smallpox remained an important cause of death in these towns, even though vaccination was introduced into each of them in 1802 and significant efforts subsequently were made to protect their general populations.²⁸ It seems inevitable to conclude therefore that smallpox must have been an even more important cause of death in urban populations that were totally unprotected.

Figure 6 plots smallpox death rates for Calcutta and Bombay.²⁹ The landmark epidemic years of 1865 in Calcutta and 1876 in Bombay (1884 in the case of Madras) led to remarkable changes in government policies and public attitudes toward vaccination. In Calcutta inoculation—long popular in Bengal—was alleged to have retarded the progress of vaccination and was judged to be responsible for smallpox outbreaks in the city.³⁰ So after

TABLE 6 Number of deaths attributed to smallpox as a percent of the total number of deaths by period, Calcutta, Bombay, and Madras 1832–99

Calcutta			Bombay			Madras		
Period	High/Low	Mean	Period	High/Low	Mean	Period	High/Low	Mean
1832–35	14.2/.2	6.9						
1836–40	—	4.1						
1841–45	18.3/.2	5.1						
1846–50	27.7/.3	9.8						
1851–55	1.1/.3	0.5	1848–54	8.6/1.3	5.0			
1856–60	20.0/.4	5.0	1855–59	12/1.2	4.9	1855–59	9.4/3.5	6.1
1860–64	—	—	1860–64	10.8/1.0	5.3	1860–64	7.0/.9	3.5
1865–69	22.0/.2	6.4	1865–69	9.7/2.0	5.9	1865–69	6.5/.3	2.6
1870–74	1.4/.2	0.7	1870–74	9.8/1.7	5.3	1870–74	7.3/.2	4.1
1875–79	9.4/.5	4.6	1875–79	15.3/1.3	4.3	1875–79	14.5/1.4	8.0
1880–84	3.8/.1	1.3	1880–84	6.2/.20	1.7	1880–84	20.2/2.5	11.0
1885–89	1.2/0	0.4	1885–89	2.2/.10	0.9	1885–89	.3 / 0	0.2
1890–94	4.3/.1	1.3	1890–94	2/.50	1.3	1890–94	.5 /.1	0.2
1895–99	8.2/.3	2.1	1895–99	2.1/.10	0.7	1895–99	.7 / 0	0.4

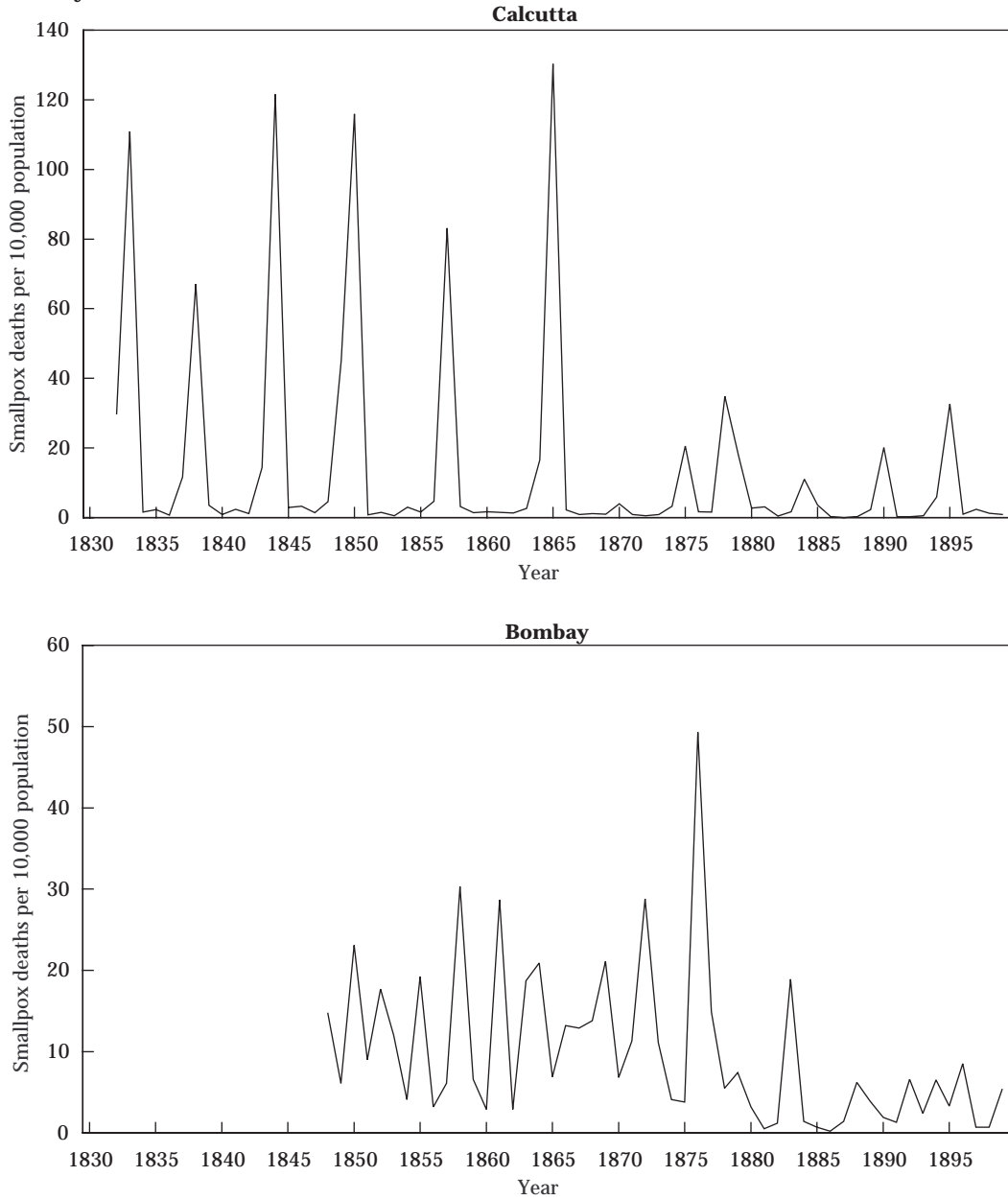
PRINCIPAL SOURCES: For Calcutta, *Report of the Health Officer, Calcutta Corporation 1895 and 1928*; “Vital statistics of Calcutta,” *Journal of the Royal Statistical Society of London*, 1850, p. 176; H. Macpherson, “On the mortality of Calcutta during the twenty years ending 31st December 1860,” *Indian Annals of Medical Science*, Volume XV, 1862, pp. 79–138 (National Library, Calcutta); *Report of the II nd Quarter, Health Officer Calcutta Corporation 1878*. For Bombay, 1848–66, *Deaths in Bombay and Annual Administration Report of the Municipal Commissioner of Bombay, 1867–99*. For Madras, *Deaths in Madras, 1855–67*; and *Annual Report of the Madras Corporation, 1868–99*.

many years of dither, in 1865 the Government of Bengal prohibited inoculation in and around Calcutta.³¹ At the same time it promoted vaccination by sanctioning more vaccinators and their supervisors. The results are reflected in the decline of smallpox after 1865: death rates were reduced, the disease accounted for a much lower proportion of deaths, and epidemics became less frequent.

Similarly in Bombay and Madras the epidemics of 1876 and 1884 forced the respective provincial governments to introduce Compulsory Vaccination Acts.³² This legislation resulted in greater vaccination coverage and it also meant that vaccinations subsequently occurred at younger ages, because parents now had to vaccinate their children before their first birthday. For Bombay Figure 6 shows that during 1848–76 smallpox epidemics occurred every three or four years; however, after the Act of 1877 death rates from the disease declined (though not as sharply as in Calcutta) and the interval between epidemics increased.

Table 7 shows changes in the proportions of vaccinations occurring before age one, for periods prior to and after the introduction of the Acts in Bombay (in 1877) and Madras (1884). In the city of Bombay following the legislation, three-quarters of primary (i.e., first) vaccinations were performed by age one. In Madras the shift was greater, rising from 18–28 percent dur-

FIGURE 6 Smallpox death rates per 10,000 population, Calcutta 1832–99 and Bombay 1848–99



PRINCIPAL DATA SOURCES: *Annual Administration Report of the Municipal Commissioner of Calcutta* and *Annual Administration Report of the Municipal Commissioner of Bombay*, various years.

TABLE 7 Primary smallpox vaccinations by age and period in the cities of Bombay and Madras, 1857–91

Bombay				Madras			
Period	Age at primary vaccination		Total primary vaccinations	Period	Age at primary vaccination		Total primary vaccinations
	Under 1 year	1 year and older			Under 1 year	1 year and older	
1857–61	19,289 (48)	21,054 (52)	40,343	1857–61	12,755 (28)	32,486 (72)	45,241
1862–66	15,868 (43)	21,419 (57)	37,287	1862–66	14,316 (27)	39,140 (73)	53,456
1867–72	23,109 (42)	31,275 (58)	54,384	1867–72	11,497 (18)	52,323 (82)	63,820
1880–84	64,848 (76)	20,069 (24)	84,917	1886–91	72,336 (69)	32,141 (31)	104,477

NOTE: Vaccination data for Bombay and Madras 1857–72 are for fiscal years. Those for Bombay 1880–84 are for calendar years. For Madras, the data for 1886 pertain to calendar year, while subsequently they are for fiscal years. Figures in parentheses show the proportion of primary vaccinations in the given age group as a percent of the total number of primary vaccinations.

PRINCIPAL SOURCES: *Report on Vaccination Throughout the Bombay Presidency*, various years; and *Annual Administration Report of the Municipal Commissioner of Bombay, 1880–84*. *Report on Vaccination in Madras Presidency, 1857–72*; and *Annual Administration Report Madras Municipality, 1886–91*.

ing 1857–72 to 69 percent in 1886–91. This increase in infant vaccinations had both an immediate and a long-term effect on the decline of smallpox. No doubt the resulting increase in the overall level of coverage played a beneficial role, but the compulsory vaccination of infants reinforced the effect by decisively reducing the numbers of susceptible infants and children. We conclude that a shift in government and public attitudes toward vaccination was the primary reason for the decline in smallpox before the end of the nineteenth century in the presidency towns.

Modeling smallpox mortality

Using the evidence provided above on case fatality and prevalence, we can estimate the proportion of total deaths attributable to smallpox under various assumptions and in populations that were either totally or partially unprotected. The following simple calculations are only broadly illustrative, because the situation and data do not merit a more refined treatment. We have already seen that case fatality rates in India were very high and that experience of the disease among unprotected populations was nearly universal. In what follows we make no assumptions regarding age at primary vaccination, the quality of the vaccination process, or the eventual decline in immunity following vaccination. Moreover, we assume no revaccination. Finally, we treat the smallpox experience of a birth cohort under various assumptions as to the prevailing level of early-age mortality. Average infant mortality rates in India during the late nineteenth century have been estimated at around 250 per 1000 births. Prevailing levels of child mortality were also high.³³

Our estimates of the eventual proportions of deaths attributable to smallpox that were probably representative of the conditions prevailing in eighteenth- and nineteenth-century India are shown in Table 8. We have deliberately chosen a modest, though plausible, range of CFRs between 20 and 30 percent. The smallpox prevalence range used is between 60 and 80 percent. Panel 1 simulates a situation where an entire birth cohort is exposed to smallpox before dying from any other disease. Under these circumstances and with smallpox prevalence of 80 percent, roughly 16 to 24 percent of all deaths would be attributable to smallpox. Relevant data by

TABLE 8 Calculations showing the eventual percentage of total deaths attributable to smallpox in India in the early nineteenth century under alternative assumptions of the smallpox case fatality rate, smallpox prevalence, and the level of infant mortality affecting the size of the population at risk in an initial birth cohort of 1000

Case fatality rate	Smallpox prevalence		
	60%	70%	80%
Panel 1: Population at risk 1000			
20%	12.0	14.0	16.0
25%	15.0	17.5	20.0
30%	18.0	21.0	24.0
Panel 2: Population at risk 750			
20%	9.0	10.5	12.0
25%	11.3	13.1	15.0
30%	13.5	15.8	18.0
Panel 3: Population at risk 650			
20%	7.8	9.1	10.4
25%	9.8	11.4	13.0
30%	11.7	13.7	15.6
Panel 4: Population at risk 550			
20%	6.6	7.7	8.8
25%	8.3	9.6	11.0
30%	9.9	11.6	13.2
Smallpox prevalence			
	5%	7.5%	10%
Panel 5: Population at risk 750			
20%	0.7	1.1	1.5
25%	0.9	1.4	1.9
30%	1.1	1.7	2.2

NOTE: See discussion in the text.

birth cohort are not available for India, but if an epidemic experience (i.e., strong period effect) is considered and converted into cohort experience, then panel 1 probably captures the essence of the situation. Such an experience may well be represented by epidemics in 1850 in Calcutta and 1884 in Oudh with proportional smallpox mortality of 47 and 27 percent respectively.³⁴

Although infants (i.e., those aged under one) were quite liable to die from smallpox, the calculations summarized in panels 2, 3, and 4 are conservative in assuming no infant deaths from the disease. Even so, smallpox remains a significant cause of death in these models. The lowest proportional smallpox mortality is about 7 percent (in panel 4) under the assumption of 20 percent CFR and 60 percent prevalence and allowing for a very high overall level of infant and child mortality, none of which is assumed to be attributable to smallpox. Smallpox was a significant cause of death in unprotected populations. The sort of contribution of smallpox to overall mortality shown by panels 2–4 was probably representative of that experienced in eighteenth- and early-nineteenth-century India.

Lastly, panel 5 addresses circumstances akin to those of Bengal, where inoculation was widely practiced until at least the mid-nineteenth century and consequently smallpox was a fairly minor cause of death. Panel 5 also appears to be a reasonable approximation of the low proportional smallpox mortality observed in many provinces of India during the last decades of the nineteenth century and much of the twentieth, when a sizable fraction of the population was protected, mostly by primary vaccination.

The impact of vaccination on smallpox mortality

The provinces of Oudh and Berar, located in northern and central India respectively, have special significance because their data provide a rare opportunity to examine the toll of the disease in an unprotected population and illustrate the decline of smallpox following the introduction of vaccination.

Oudh

Oudh, a medium-sized province consisting of 12 districts with Lucknow as its capital, retained a separate political identity until the British took control in 1856. In 1878 it was merged with North-Western Provinces. The mortality and vaccination statistics extracted for the districts of Oudh form the basis of this case study. The first sanitary report for Oudh (for 1868–69) contains the following telling observation: “Almost every native face is scarred by smallpox, whereas among Europeans this is an exception to the rule. . . . [S]o prevalent in short is the disease that all adult natives may be said to be survivors of smallpox.”³⁵

Death registration in Oudh started in 1869, and it is clear from inspection of the registered crude death rates that during the initial years deaths were especially underregistered. The level of registration seems to have improved, however, particularly following the inquiry into excess mortality associated with the so-called food scarcity of 1877–79.³⁶

Oudh experienced epidemics of smallpox in 1869, 1872–74, 1878–79, 1883–84, and 1889. Thus the population experienced an epidemic cycle of around four to six years, with smallpox accounting for at least 10 percent of registered deaths in each epidemic; in both 1878 and 1883–84 the figure exceeded 20 percent. Only toward the end of the nineteenth century did the share of smallpox in the province's total mortality decline. During 1869–73 smallpox accounted for 9.7 percent of all registered deaths; during 1874–78 it was 9.1 percent. This proportion was still as high as 7.3 percent during 1884–88, before finally falling to 2.5 percent in 1894–98.

In six years during the period 1869–90, registered smallpox death rates around or exceeding 200 per 100,000 population were recorded. Starting from around 1890 the province's smallpox death rate showed a perceptible decline, even though there was no fall in the overall registered crude death rate for Oudh.

Table 9 shows that roughly 90 percent of total smallpox deaths occurred among infants and children. Indeed, infants alone accounted for around one-third of deaths. Adults (aged 12 years and older) constituted only about 10 percent of smallpox mortality.

Figure 7 plots the proportion of the province's villages (which totaled some 25,000) that reported one or more deaths from smallpox during 1877–99. It shows that in an epidemic year 40–60 percent of all villages could be affected and underscores the sizable and complex administrative network required to offer protection to children living in a large geographical area.

Figure 8 depicts the seasonal pattern of smallpox mortality in Oudh. The peak month for deaths was usually May, while the minimum occurred

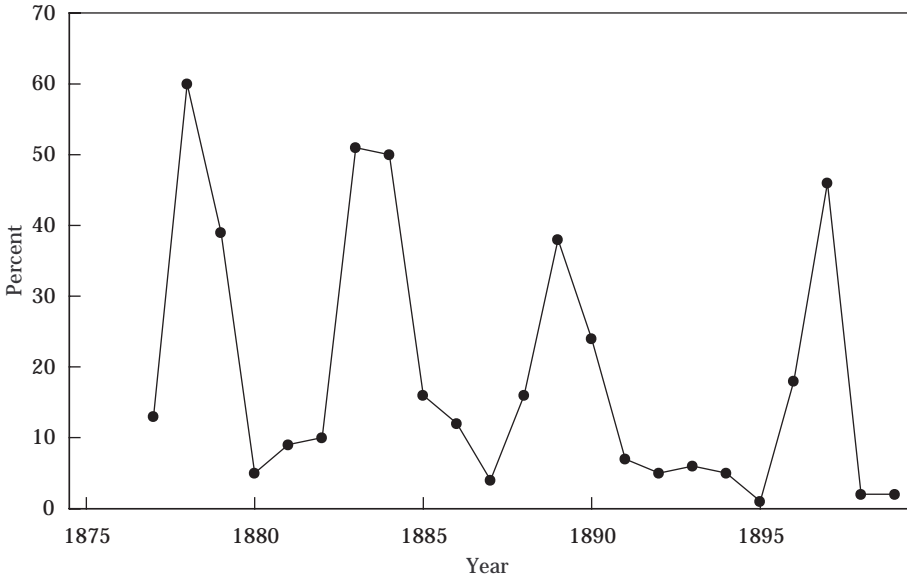
TABLE 9 Number and percentage distribution of smallpox deaths by broad age groups, Oudh 1885–99

Period	Under 1 year	1–12 years	Over 12	Total
1885–89	23,770 (35)	37,636 (55)	6,944 (10)	68,350 (100)
1890–94	10,363 (32)	18,808 (58)	3,281 (10)	32,452 (100)
1895–99	16,450 (32)	28,250 (55)	6,647 (13)	51,347 (100)
1885–99	50,583 (33)	84,694 (56)	16,872 (11)	152,149 (100)

NOTE: The precise age categories used varied slightly over time, but do not influence these results.

PRINCIPAL SOURCE: *Annual Report of the Sanitary Commissioner*, United Provinces, various years. Age reporting of smallpox deaths began in 1885.

FIGURE 7 Percentage of villages reporting smallpox deaths, Oudh 1877-99

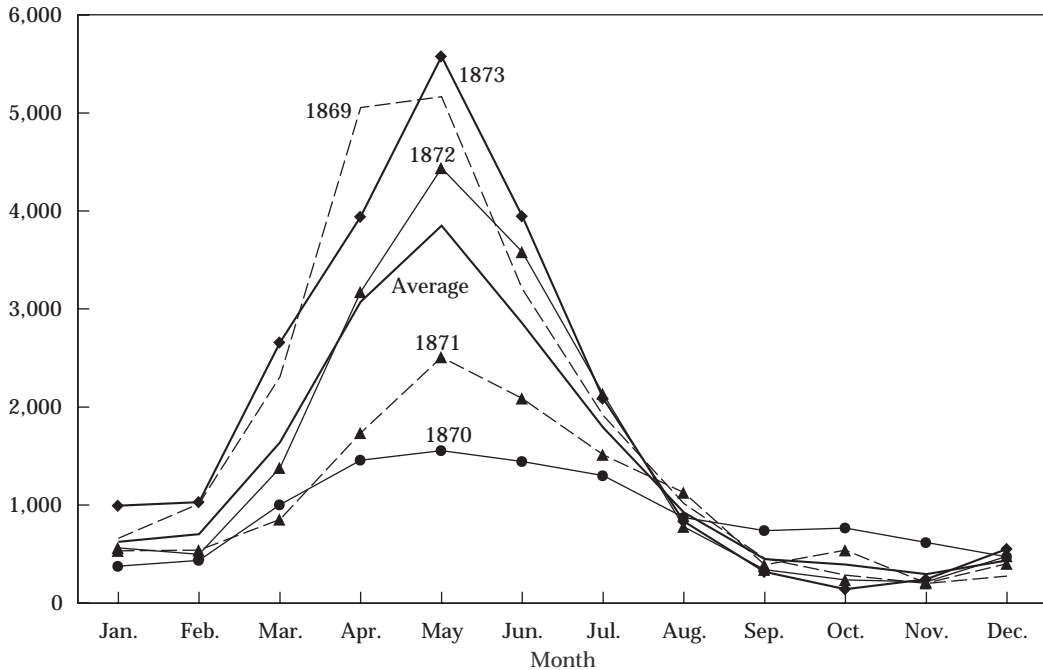


PRINCIPAL DATA SOURCES: *Annual Report of the Sanitary Commissioner, United Provinces, various years.*

around September/November. About three-quarters of all smallpox deaths occurred in the five-month period from March to July. Smallpox was clearly evident during the spring, reached its peak in mid-summer, and declined with the coming of the monsoon rains. This general pattern was found throughout the country.

The province's political independence until 1856 meant that it remained isolated from the progress of vaccination occurring in much of India.³⁷ The indigenous practice of inoculation was unknown in Oudh, in contrast to the neighboring regions of Kumaon and Benares where inoculation was practiced with varying degrees of acceptability.³⁸ Consequently many smallpox deaths continued to occur in Oudh, and neither the Nawab (Muslim prince) nor the general population made much effort to practice inoculation or establish vaccination. Early British Administration Reports for Oudh lamented the poor state of vaccination. In 1869 it was being practiced only in Lucknow (a city of about 300,000) out of a total provincial population of some 11 million. By 1872 vaccination was introduced to another 11 district headquarter towns and extended gradually to the vast rural population of the province.

Figure 9 shows the relationship between primary vaccination in Oudh and the smallpox death rate. Initially vaccination progressed slowly, and by 1875 only about 25,000 people were being vaccinated each year. Then 75,000 vaccinations were performed in 1882, but an official investigation

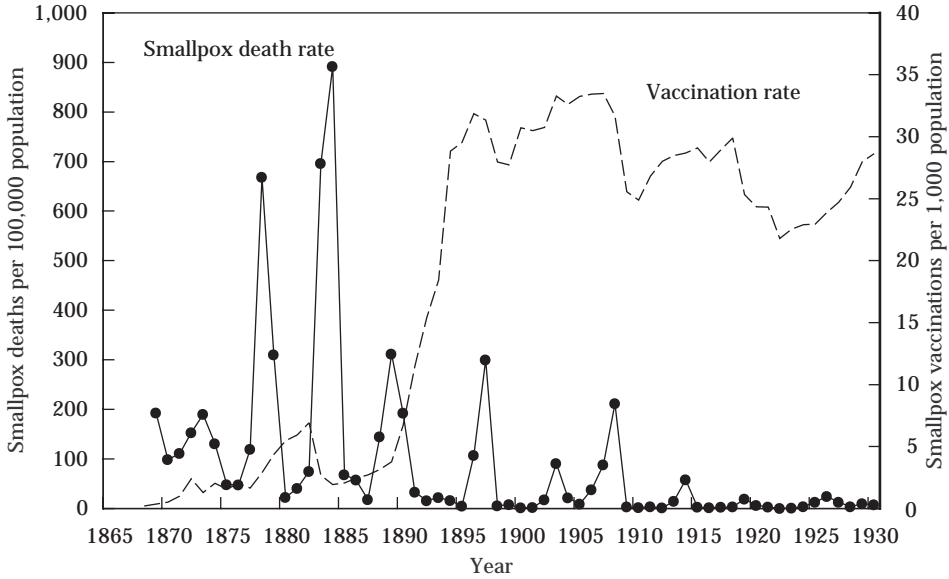
FIGURE 8 Number of smallpox deaths by month, Oudh 1869–73

PRINCIPAL DATA SOURCES: *Annual Report of the Sanitary Commissioner, Oudh, 1869–73.*

revealed that some records had been falsified in order to suggest improved performance. Punishment of the dishonest vaccinators followed, and the annual number of vaccinations recorded fell back to around 30,000. The slow progress of vaccination continued for some time, but its quality and coverage began to improve. The early years of the last decade of the nineteenth century saw very large improvement, with more than 350,000 primary vaccinations being performed annually.

Figure 9 also establishes the strong link between the increase in vaccination and the decline of smallpox. To achieve a lasting impact, primary vaccination coverage of at least 70 percent of annual births was required. This was finally achieved from 1891 and it produced a significant and permanent decline in smallpox deaths by the end of century. This level of vaccination coverage was sustained in the twentieth century, making smallpox a minor cause of death in Oudh. Nevertheless, a continued failure to vaccinate all infants, plus the fact that in some cases the procedure was delayed beyond age one, still left some children vulnerable. So occasional minor epidemics still occurred—for example in 1897 and 1908—usually associated with large-scale population movements and mixing of people (e.g., during famines), which exposed those unvaccinated to a greater risk of contracting the virus.

FIGURE 9 Smallpox vaccination rate and smallpox death rate, Oudh 1868–1930



PRINCIPAL DATA SOURCES: *Annual Report of the Sanitary Commissioner, Oudh and United Provinces*, various years.

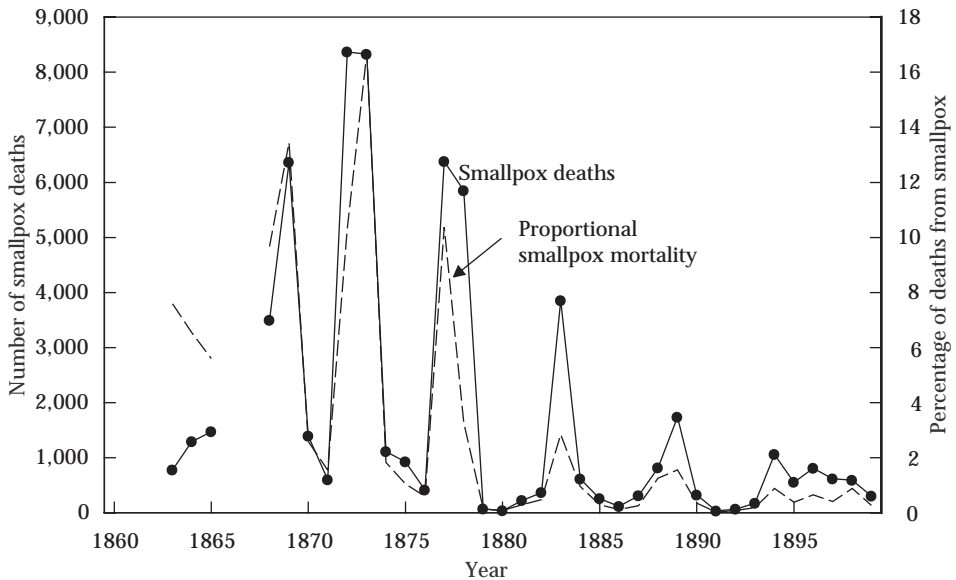
Berar

Famous for its cotton, Berar, a small, well-administered province in central India, came under direct British control in 1856 from the Nizam of Hyderabad. It consisted of six districts, with a combined population of 2.2 million in 1867. The historical demography of Berar has been studied by Dyson, who has shown that the vital registration data for years after 1881 were of high quality.³⁹ The present study reaffirms the uniqueness and utility of Berar’s registration statistics by analyzing mortality and vaccination data for years before 1881.

The first available mortality data by cause of death for Berar date from 1863, although we have been unable to find statistics for 1866–67. In the 1860s the province’s vital registration system was new and the coverage of events was improving from year to year. Figure 10 shows that smallpox was a significant cause of death in the 1860s and 1870s, contributing around 6–8 percent of overall mortality. In early epidemics it accounted for over 10 percent of deaths, reaching about 16 percent in the worst epidemic. But smallpox death rates and proportional mortality were declining during the last two decades of the nineteenth century.

The Sanitary Commissioner for Berar, appointed in 1869, was entrusted with establishing and extending vaccination throughout the province. Evi-

FIGURE 10 Annual number of smallpox deaths and its share in total mortality, Berar 1863–99



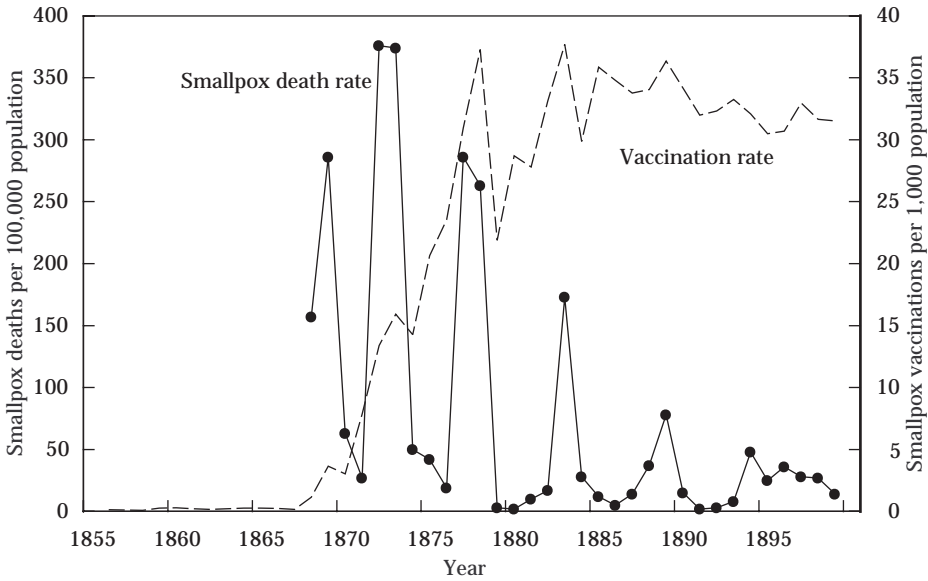
NOTE: Data for 1866 and 1867 are not available.

PRINCIPAL DATA SOURCES: *Annual Administration Report* and *Annual Report of the Sanitary Commissioner*, Hyderabad Assigned Districts, various years.

dence that only a tiny fraction of Berar's population was protected in the 1850s and early 1860s comes from the *Annual Administration Reports* for 1855–68.⁴⁰ The prominence accorded vaccination in these reports shows that top administrators were concerned with the high mortality attributable to smallpox. Nevertheless, resistance to vaccination was common, and it was difficult to recruit and retain vaccinators in these early years.⁴¹ Although the smallpox goddess, Shitala, was well known and worshipped throughout the province, inoculation was not practiced in Berar. Hence, the population was unprotected against the disease until vaccination was introduced.

Figure 11 underscores that until 1867 vaccination was barely practiced in Berar, with an annual coverage of less than 0.2 percent of the population.⁴² But in 1867 a full vaccination program was approved to cover the rural population of each district. Vaccination progressed rapidly thereafter, overcoming the widespread indifference of the rural people observed a decade earlier. In 1880 the Sanitary Commissioner of Berar recommended the introduction of a Compulsory Vaccination Act, particularly in the towns.⁴³ However, because the province's district officers feared adverse public reaction to compulsory measures, promulgation of the Act was withheld for over a decade.⁴⁴ Even so, by the mid-1880s over 80 percent of infants were

FIGURE 11 Smallpox vaccination rate and smallpox death rate, Berar 1856–99

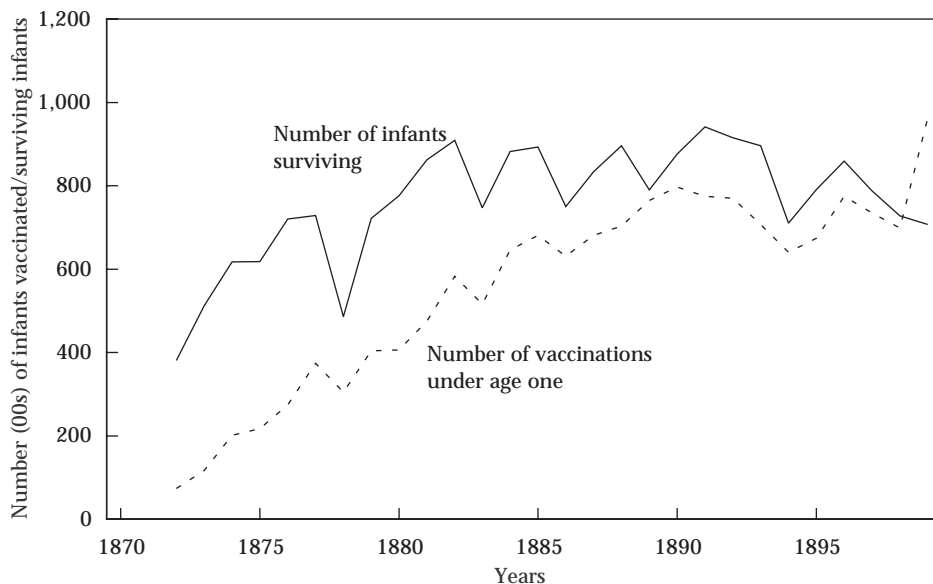


PRINCIPAL DATA SOURCES: *Annual Administration Report, 1855–67*; *Report on Vaccination*; and *Annual Report of the Sanitary Commissioner, Hyderabad Assigned Districts, various years*.

vaccinated (see Figure 12). The introduction of a Compulsory Act within rural areas was deemed unnecessary since it could only marginally improve coverage and, if it stimulated opposition, would do more harm than good. Figure 11 shows that when vaccination coverage was low, smallpox death rates were high. The smallpox death rate in Berar declined as vaccination progressed. Good vaccination performance in the province, which eventually stabilized at a high level, was maintained by sustained efforts from the administration aimed at ensuring that primary vaccination of young children became routine. Evidence that this success was firmly grounded is also provided by the fact that the smallpox death rate stayed low during the famines of 1896–97 and 1899–1900 despite a massive increase in overall mortality. Of no less significance was the change in the epithet that was reportedly used by the public to address the vaccinator—in the 1850s a “murderer”; in the 1890s the venerable “Devi Doctor.”⁴⁵

The Berar case allows us to reiterate three points. First, in the absence of protection through vaccination, smallpox was a significant cause of death. Second, if properly administered, the vaccination program caused a substantial decline in smallpox deaths within a short period. In Berar this happened between 1867 and 1884; the contrast with the far longer time re-

FIGURE 12 Number of smallpox vaccinations under age one and number of infants surviving, Berar 1872–99



NOTE: The number of surviving infants has been calculated by subtracting the number of registered infant deaths in a given year from the number of registered births in that year.

PRINCIPAL DATA SOURCES: *Annual Report of the Sanitary Commissioner* and *Report on Vaccination*, Hyderabad Assigned Districts.

quired in Madras Province is striking. Finally, compulsory vaccination measures were not resorted to if, through an efficient vaccination program, most infants could be protected early in life.

Conclusions

The following conclusions summarize the circumstances regarding smallpox in India during the nineteenth century.

First, about 80 percent of India's population was completely unprotected against smallpox in the eighteenth and early nineteenth centuries. Inoculation, an effective and indigenous form of protection, was largely restricted to Bengal Presidency—a fact that explains the low smallpox death rate registered there in the period before the early 1880s.

Second, case fatality in India from smallpox was high—in the vicinity of 25–30 percent in unprotected populations, higher than recent estimates for eighteenth-century Europe.

Third, evidence from pockmark surveys of adult jail populations and from the 1872 Bombay City Census indicates that in the absence of protec-

tion (or death while young from another cause) almost everyone in India contracted smallpox.

Fourth, although deaths (including those from smallpox) were generally underregistered, several considerations increased the accuracy of classification of smallpox: the disease was common, it had characteristic symptoms and distinct seasonality, and it mainly afflicted young children. The religious dimension—the existence of the goddess Shitala—was important too, as was the close monitoring of vaccination by supervisory staff.

Fifth, the early urban death registration data for Calcutta, Bombay, and Madras—whose populations were partly protected in the mid-nineteenth century—indicate that on average smallpox accounted for 5–10 percent of registered deaths. However, the early data for the unprotected rural populations of Oudh and Berar indicate a similar range of 6–10 percent. Comparison of these ranges, and estimates from our calculations (see Table 8, panels 2–4), suggest that the range indicated for the unprotected populations of Oudh and Berar may be low. The most plausible explanation for any discrepancy is differential underregistration of deaths at very young ages (in which smallpox featured prominently) in the early vital registration data for Oudh and Berar and possibly some misclassification of deaths.

Sixth, although smallpox was endemic to India, it also had a characteristic epidemic cycle usually in the range of four to seven years. In epidemic years smallpox could account for a third of all deaths—and then be barely noticeable for the next few years. This was probably due to a substantial diminution of the susceptible population during an epidemic year. It took several years for the pool of susceptibles to build up—through the occurrence of new births—until it reached a size that would sustain another epidemic.

Seventh, the available age data suggest that in unprotected populations 85–90 percent of all smallpox deaths occurred among infants and young children.

Eighth, the disease had a strong seasonality—with late winter and early spring heralding its arrival, peaking during the mid-summer, and then abating when the rains arrived.

Ninth, vaccination—introduced in 1802—was an effective prevention against contracting smallpox. However, in much of the country progress in spreading the practice was very slow until well after the 1850s. Only in the 1880s was vaccination's impact fully felt, and thereafter smallpox became a minor cause of death in India. The case studies of Oudh and Berar clearly demonstrate the close link between the progress of vaccination and the decline of smallpox. Therefore the role of medical intervention in the control and decline of a specific disease is clearly established.

Tenth, in the cities of Bombay and Madras a major part of the decline in smallpox deaths resulted from the introduction of Compulsory Vaccina-

tion Acts. In both cases a degree of legislative coercion produced a perceptible further decline in smallpox mortality, long after vaccination had been introduced.

Finally, although smallpox had its own epidemic cycle independent of famines, the mobility and congregation of people during food crises could help engender smallpox outbreaks. Nevertheless, the data for Berar in the 1890s show that with adequate vaccination coverage famines did not result in raised smallpox mortality. Similarly in the case of Oudh, smallpox death rates were much lower during the famines of 1897 and 1908 compared with the rates recorded in earlier food crises.

In conclusion, the introduction into India of primary vaccination against smallpox in 1802—and its subsequent establishment and spread—was eventually successful. The wide diffusion of the practice throughout the subcontinent took between seven and nine decades to achieve, but once it was properly established mass primary vaccination resulted in a major decline in smallpox mortality. Ironically during the very period that this happened—the 1870s, 1880s, and 1890s—the death rate in India suffered severe jolts from major famines and related epidemics. Yet the great importance of this specific medical intervention should not be underestimated. After a long and bitter fire-fighting operation, lasting most of the nineteenth century, smallpox in India was, like a fire, largely controlled but not extinguished. It was still capable of flaring up, as indeed sometimes happened in the twentieth century. Even as late as 1958 the disease claimed over 150,000 lives in India.

Nevertheless the crucial first stage of controlling smallpox and ensuring that it became generally a minor cause of death was achieved. Its final eradication—the last recorded case of smallpox in India occurred in Assam in 1975—required a different strategy, which included the revaccination of adults, the isolation of those infected, improved reporting of outbreaks of the disease, and even greater levels of infant primary vaccination.

Notes

This research was funded by a grant (No. 046622) from the Wellcome Trust. All the early historical records used in this article were located in either the Wellcome Trust Library or the India Office Library, London.

1 “Is smallpox history?” *The Lancet* 353 (9164) 1999: 1539.

2 For such a suggestion see, for example, D. Arnold, “Smallpox and colonial medicine in nineteenth-century India,” in D. Arnold (ed.), *Imperial Medicine and Indigenous Societies* (Manchester: Manchester University Press, 1988), p. 47.

3 Of course, age was usually recorded for registered deaths in India. However, except in the case of smallpox, it was not customary to publish deaths by both cause and age.

4 See, for example, D. Arnold, *Colonizing the Body: State Medicine and Epidemic Disease in Nineteenth-Century India*, (Berkeley: University of California Press, 1993).

5 I. Klein, “Population growth and mortality in British India,” *The Indian Economic and Social History Review* 26(4) 1989 and 27(1) 1990; also S. Guha, “Mortality decline in twentieth century India: A preliminary enquiry,”

The Indian Economic and Social History Review 28(4) 1991.

6 S. P. James, *Smallpox and Vaccination in British India* (Calcutta: Thacker, Spink, 1909).

7 See K. Davis, *The Population of India and Pakistan* (Princeton: Princeton University Press, 1951), pp. 33 and 47.

8 See T. Dyson, "The population history of Berar since 1881 and its potential wider significance," *The Indian Economic and Social History Review* 26(2) 1989: 182–186.

9 This article addresses the impact of primary vaccination. In India revaccination began only in the 1870s and remained at a low level for the rest of the nineteenth century.

10 Variola major and variola minor were the two types of smallpox virus. Clinically, however, there were five types of smallpox cases. In decreasing order of severity and case fatality they were hemorrhagic, confluent, semi-confluent, modified, and discrete. On the factors influencing case fatality see F. Fenner et al., *Smallpox and Its Eradication* (Geneva: World Health Organization, 1988), pp. 175–178.

11 See Fenner et al., cited in note 10, p. 178.

12 By the early twentieth century a larger proportion of people who were unvaccinated contracted the disease at older ages, and at such ages case fatality rates were generally higher than at ages 1–10 years. This accounts for the higher case fatality of unvaccinated people shown in Table 2.

13 See Fenner et al., cited in note 10, p. 37.

14 See P. Sköld, *The Two Faces of Smallpox: A Disease and Its Prevention in Eighteenth- and Nineteenth-Century Sweden* (Umeå: Demographic Data Base, Umeå University, 1996), p. 72.

15 See W. J. Moore, "Marwar: The land of death," *Indian Annals of Medical Science*, Calcutta, 1866, Vol. XX, pp. 526–529.

16 See R. Pringle, "On smallpox and vaccination in India," *The Lancet*, January 1869, pp. 44–45.

17 Vaccination in the North-Western Provinces began to gain ground only in the 1860s.

18 There is evidence that smallpox was more prevalent in parts of Madras Presidency prior to 1850. An examination of 843 prisoners at Coimbatore in 1855 found that 596 (i.e., 71 percent) had distinct smallpox marks, while only 70 (8 percent) had vaccination marks. See *Report on Vaccination in Madras Presidency 1855*, p. 13.

19 For survey data on smallpox experience and vaccination status for a large rural child population in Bombay Presidency that show very similar results to these for the city of Bombay, see *Report on Vaccination in Bombay Presidency 1865*, p. 3. These survey data support our contention that the city census data are fairly representative of the experience of the wider presidency.

20 J. Banthia, "The practice of inoculation in nineteenth century India," Working Paper, Department of Social Policy, London School of Economics, 1999.

21 For example, registration was sometimes viewed as a way of controlling the practice of female infanticide indulged in by some higher castes.

22 See Government of India, *Annual Report of the Sanitary Commissioner*, 1868, Appendix to p. 98.

23 Most Sanitary Commissioners felt that registered smallpox mortality was understated rather than overstated. Thus the Sanitary Commissioner for Oudh observed in 1875, "Smallpox ought not [to] present any difficulty in recognition, its characteristic being well known, though the number may be understated through extreme laxity in reporting, especially as children are the greatest sufferers." See *Annual Report of the Sanitary Commissioner*, Oudh, 1875, p. 9.

24 In both Table 5 and Figure 3 the statistics for British India prior to 1870 are influenced by changes in territorial coverage; thus the data for the provinces of Bombay, Punjab, and North-Western Provinces (part of United Provinces) start from 1865; those for Madras from 1866; for Central Provinces from 1867; and for Berar (not shown separately in Table 5) from 1868.

25 D. Stewart, *Report on Smallpox in Calcutta 1833–34, 1837–38, 1843–44 and Vaccination in Bengal from 1827 to 1844*, Calcutta, 1844.

26 Data on registered deaths first appeared in *Deaths in Bombay 1848*.

27 Data on registered deaths first appeared in *Deaths in Madras 1855*.

28 See W. Seton-Karr (ed.), *Selections from Calcutta Gazettes for the Year 1802*, Calcutta, 1864. Vaccination first reached Bombay from Europe in June of 1802. It arrived in Madras in September via Colombo, finally reaching Calcutta in November.

29 Partly because of denominator problems and also for reasons of space Madras is not shown in Figure 6.

30 See *Report of the Smallpox Commissioners*, Calcutta, 1850. A committee was appointed by the Government of Bengal to inquire into the 1849–50 smallpox epidemic at Calcutta; it recommended a ban on inoculation, holding it responsible for epidemics.

31 By Act V of 1865, the government was authorized to ban inoculation in any part of Bengal provided that simultaneously it made vaccination available to the people.

32 A Compulsory Vaccination Act was first promulgated in India in Bombay in 1877. Children born within the city limits were required to be vaccinated within six months of birth, failing which their parents could be prosecuted.

33 See T. Dyson, "Infant and child mortality in the Indian subcontinent, 1881–1947," in A. Bideau, B. Desjardins, and A. Pérez Brignoli (eds.), *Infant and Child Mortality in the Past* (Oxford: Clarendon Press, 1997).

34 See *Report of the Smallpox Commissioners*, Calcutta, 1850, p. 13; and *Annual Report of the Sanitary Commissioner*, United Provinces, 1884.

35 *First Sanitary Report for Oudh 1868–69*, p. 5.

36 *Report on the Scarcity and Relief Operations in the North-Western Provinces and Oudh During the Years 1877–1878 and 1879*, Allahabad, 1880.

37 The neighboring towns of Kanpur, Allahabad, Agra, and Bareilly practiced vaccination from the early nineteenth century.

38 See *Sanitary and Vaccine Report for the Province of Oudh*, 1869; *Report on Vaccination 1869–70*, p. 2.

39 See Dyson, cited in note 8; also T. Dyson, "The historical demography of Berar, 1881–1980," in T. Dyson (ed.), *India's Historical Demography: Studies in Famine, Disease and Society* (London: Curzon, 1989).

40 See *Report on the Hyderabad Assigned Districts 1855–56*, Appendix No. XVII, which states that "Two Brahmin vaccinators with 4 peons were appointed in 1854 to travel village to village for six months."

41 See *Report on the Hyderabad Assigned Districts 1857–58*, p. 79, which mentions the "difficulty of finding suitable persons as vaccinators and . . . their lack in experience, [the] time required for their instructions . . . the frequency of their resignations of the department, [the] prejudice of the people and [the] difficulty in exercising any direct supervision over the vaccination."

42 Primary vaccinations conducted during 1856–67—as reported in the *Annual Administration Reports*—were 365, 304, 181, 577, 608, 544, 436, 582, 692, 678, 605, and 386 respectively.

43 *Annual Report of the Sanitary Commissioner*, Hyderabad Assigned Districts, 1890, p. 16.

44 In Berar the Compulsory Vaccination Act was introduced in 1893 in towns only.

45 *Annual Report of the Sanitary Commissioner*, Hyderabad Assigned Districts, 1896–97 pp. 8 and 9.

The Global and Regional Impact of Mortality and Fertility Transitions, 1950–2000

PATRICK HEUVELINE

DURING THE SECOND half of the twentieth century, the world population, and even more so the population of the less developed regions, experienced demographic changes at an unprecedented pace. According to United Nations (1999) estimates, the world's population was 2.521 billion in 1950 and it will be 6.055 billion in mid-2000. This represents a mean annualized growth rate of 1.75 percent per year; the corresponding figure for less developed regions is 2.09 percent per year. The reasons for this unprecedented world population increase are well known, but the numbers remain striking. Global average life expectancy at birth increased by 9.5 years in just 15 years (from 46.5 years in 1950–55 to 56.0 years in 1965–70), while the average life expectancy at birth gained 11.3 years in less developed regions (from 40.9 years to 52.2 years; United Nations 1999), almost certainly the fastest pace in human history (Durand 1967; Coale 1974). During the same period, world average fertility remained stable, as total fertility rates merely declined from 4.99 to 4.91. But in the following 30 years substantial fertility declines occurred in many parts of the world, and, where they did, the pace of the decline was again rapid. The average total fertility rate declined by half in less developed regions, from 6.01 births per woman in 1965–70 to 3.00 births per woman in 1995–2000 (United Nations 1999).

These changes in life expectancy at birth and in total fertility rates transformed the “average” life course, especially in less developed regions. These major changes in demographic regimes also have long-lasting effects on population size, growth, and structure that have been extensively studied and debated during the past 50 years (e.g., Bogue and Tsui 1978 and 1979; Demeny 1979a and 1979b). Interest typically concerns the long-term implications of mortality and fertility trends into the twenty-first century. Fewer attempts are made to look back and assess how different is today's world

population as a result of past changes. In a recent exception to the norm, White and Preston (1996) measured life expectancy gains in the United States from 47.3 years in 1900 to 75.7 years in 1994 and estimated that about one-half of the population of the United States in the year 2000 owes its existence to the twentieth-century reduction of mortality.

Expanding their approach, this article evaluates the impact of demographic changes in the second half of the twentieth century on the end-of-century world population (hereafter referred to as today's population). The impact of the mortality reduction of the past 50 years on the size, growth, and age structure of today's population is first assessed for the world and broad geographic regions. The impact of fertility declines is similarly addressed, and the joint impact of these massive changes in demographic processes is then discussed. To disentangle the respective or joint impact of mortality and/or fertility changes, the different assessments rest on similar comparisons between prevailing demographic characteristics and the outcomes of counterfactual projections that simulate population from 1950 to 2000 had some demographic rates been different.

The magnitude of demographic changes during the past 50 years suggests that today's world population is profoundly different from what it would have been had demographic rates remained unchanged during that period. To a large extent, the expectation is confirmed by the results presented below. The assessment of mortality reduction in the second half of the twentieth century suggests that 25 percent of today's world population is alive because of this reduction. Correspondingly, today's world population size represents only 73 percent of what it would have been had fertility not declined in the past 50 years. Because mortality and fertility declines have varied in scope and timing across the world, certain changes have partially offset others, as have trends in different parts of the world. What emerges from these simulations is a more complex picture than anticipated, with an aggregate world population surprisingly little different at the end of the century from what it would have been had demographic rates remained constant over the past 50 years.

Data and methods

The impact of past changes is measured by comparing prevailing demographic characteristics with the outcomes of retrospective counterfactual projections.¹ Such projections appear only sporadically in the demographic literature (Coale 1956; Hermalin 1966; White and Preston 1996). As seemingly gratuitous exercises, retrospective counterfactual simulations may appear difficult to justify, but they can show the implications of real demographic trends by depicting the difference from what actually happened. In this instance, forward projections from 1950 on that maintain mortality and/

or fertility rates constant at their 1950–55 levels are used to depict the consequences of the actual course of mortality and fertility changes.

Projections were prepared following the female-dominant cohort-component approach (Shryock and Siegel 1975; Keyfitz 1968), a methodology formulated by Cannan (1895) and gradually developed by Whelpton (1928 and 1936) that has since become the standard practice for population projections. Age- and sex-specific survival ratios are applied to a population by age and sex, and age-specific fertility rates are applied to the female population by age. Net numbers of migrants by age and sex (i.e., number of immigrants minus number of emigrants) are also added throughout the projection interval. This approach implicitly restricts the heterogeneity of populations to two dimensions: age and sex.

From the perspective of world population projections, it is also necessary to account for the geographical heterogeneity in demographic rates. When different subpopulations grow at different paces, projecting the aggregate population at constant fertility and mortality rates ignores such heterogeneity and yields an incorrect estimate of the growth of the aggregate population because it amounts to maintaining the subpopulations in fixed proportions, even while the share of faster-growing subpopulations actually increases over time. In 1950, age- and sex-specific fertility and mortality rates varied greatly by area of residence; therefore, projecting the world population over a 50-year period first requires a breakdown of the world population into more homogeneous regions.²

Accordingly, in the present exercise the world population was divided into regions, each of which was projected separately. These regions were identified so as to reduce within-region heterogeneity, but in the interest of simplicity the number of regions was limited to eight. Regions of roughly equivalent population sizes were preferred, and geographical coherence was maintained as much as possible. Clearly, such an exercise is constrained by the availability of data; the United Nations (1999) global population estimates covering the period starting with 1950 provide a valuable resource. The United Nations estimates present demographic data for the world, both the more developed regions (hereafter MDRs) and less developed regions (hereafter LDRs),³ as well as major areas and countries. The smallest geographical unit is thus the country, but for our purposes only the two “demographic giants”—China and India—are large enough (respectively, 21 percent and 17 percent of today’s world population) to justify a separate projection as a region; other regions were constituted by grouping the remaining countries. Among these, the dichotomy between MDRs and LDRs captures much of the demographic heterogeneity within the global average, and the first division was drawn along this line. Within the LDRs, sub-Saharan Africa and Latin America and the Caribbean each represent about 10 percent of the world population, and the two regions stand out for their

distinct demographic regimes. Each was projected as a separate region, leaving a long stretch of less developed countries and territories from Northern Africa to Asia (less China and India) and Oceania comprising 24 percent of the world population in the year 2000. This large area was divided into two regions, East and West of India. In the rest of the article, the two regions are referred to as “Other LDRs-East” and “Other LDRs-West.” Finally, the MDRs, where 22 percent of today’s world population live, were also divided into two smaller regions: Europe constituting one region and “Other MDRs” (i.e., Northern America, Japan, Australia, and New Zealand) another.

United Nations data provide estimates of the population by sex and by five-year age groups⁴ at mid-year, for every five years between 1950 and 1995; and estimates of total fertility rates and life expectancy at birth by sex in each five-year interval from 1950–55 to 1990–95. Projections provide similar data up to 2050.⁵ China, India, Latin America and the Caribbean, and Europe are countries or regions featured in the United Nations database, and therefore for these geographic units the estimates necessary for carrying out the projections in the present exercise are directly available from that source. For the other four regions, the estimates are obtained by combining different United Nations areas or countries, as described in the Appendix (Tables A-1 and A-2). These estimates are treated as accurate even though total fertility rates and life expectancies at birth in the 1995–2000 period are in part estimates based on extrapolation. Obviously, the degree of accuracy of the population size estimates as well as the fertility and mortality estimates relating to the years between 1950 and 1995 can also be questioned, but a specific discussion of this issue is not undertaken here.

Preparing female-dominant cohort-component projections also requires assumptions about the sex ratio at birth, net migration rates by age and sex, and age-specific fertility and mortality rates in each five-year interval from 1950–55 to 1995–2000. These additional parameters have been estimated from available ancillary data and finalized through forward projections aimed at reproducing United Nations population estimates for every five years between 1950 and 2000. Although the outcomes of these forward projections based on actual mortality and fertility levels are not identical with United Nations estimates, they are extremely close⁶ and below are taken as accurate representations of demographic trends between 1950 and 2000.

The impact of changes in demographic regimes between 1950 and 2000 is then evaluated by comparing the outcomes of retrospective counterfactual projections (alternative projection scenarios) and the above-described forward projections incorporating actual mortality and fertility levels (the reference projections called scenario (a) in the tables). United Nations estimates were not used directly because those estimates are compiled from different data sources and are not necessarily internally consistent for past periods. Comparing the outcomes of different forward projections based on

alternative assumptions to reference projections describing the actual course of events allows any difference to be attributed precisely to the modification introduced in the fertility and/or mortality parameters, net of potential accounting discrepancies in the United Nations database. Retrospective counterfactual projections were prepared starting from the same 1950 population figures but then introducing specific assumptions as to the course of the 1950–2000 fertility and/or mortality rates (e.g., by stipulating that age-specific fertility or mortality rates remain constant at their 1950–55 values). Although population is projected between 1950 and 2000, demographic rates for the 1950–55 interval are the same in all scenarios. As a result, the 1955 population is identical in each scenario, and the comparison between the counterfactual projections with constant rates and the reference projections accounts for the effects of only 45 years of fertility and mortality change.

Preparing these different projections presents many technical issues. Perhaps the most delicate aspect of assessing the impact of past changes is of a different nature, however, and concerns interactions between demographic parameters. The simpler assessment is to simulate one parameter change holding other parameters constant. This is the approach followed, in particular, by White and Preston (1996: 416), who point out that it then accounts only for the “first-order effects” of these changes. A full assessment of the impact would require estimating the effect the change in one parameter might have on other parameters, for instance whether fertility would have declined and at what pace had mortality remained constant. Such issues of demographic interactions have long concerned demographers (see for example Preston 1978 and Montgomery and Cohen 1998). Quantifying the interaction on a regional basis was clearly beyond the scope of the present article. A simpler strategy had to be followed here.

Specifically, the impact of mortality changes is assessed by comparing two pairs of scenarios. In the first of these the reference scenario (incorporating actual fertility and actual mortality) is compared with a counterfactual scenario combining actual fertility with constant mortality. The second comparison involves projections both of which incorporate constant fertility but combine that assumption in one instance with actual mortality and in the other with constant mortality. These comparisons can be thought of as representing two extreme situations, one in which mortality has no effect on fertility and one in which fertility does not decline until mortality declines first. Results of these stylized comparisons are reassuring to the extent that absolute impacts vary much as expected (actual—that is, lower—fertility implies smaller numbers of people “at risk” of mortality). Impacts measured in relative terms (as the percentage difference between the projections compared) are much closer.

The impact of fertility change is similarly assessed by comparing the reference scenario with a projection combining actual mortality with con-

stant fertility, and by comparing projections both of which incorporate constant mortality but combine that assumption in one instance with actual fertility and in the other with constant fertility.

As to migration, although it is highly improbable that migration would not have been affected by different mortality and fertility assumptions (e.g., through their effect on population growth in sending countries), migration flows do not represent an important contribution to the long-term growth of any sending region (see Table A-3). The highest contribution to growth (as measured by the crude rate of net migration) is for the receiving region “Other MDRs,” where it reaches nearly a quarter of a percent per year, on average, between 1950 and 2000. In the interest of simplicity, migration was kept identical across all scenarios.

Past changes in demographic regimes and world population in 2000

Year 2000 populations that result under the four alternative scenarios (one of which, scenario (a), reflects the actual course of fertility and mortality change) are shown in Table 1. Figure 1 traces the population trajectories of these scenarios between 1950 and 2000. Comparing scenarios (a) and (b), on the one hand, and (c) and (d), on the other, illustrates the pronounced impact on world population size of mortality improvements that have occurred since 1950–55.

Today’s population is at least one-third larger than it would have been without mortality changes after 1950–55 (see Table 2). The estimated absolute impact depends on the assumption about concurrent fertility levels, from 1.5 billion assuming fertility that actually prevailed (no interaction) to 2.2 billion with fertility also kept constant at 1950–55 levels. The difference

TABLE 1 World population size (millions) in the year 2000, by age, projected from the population in 1950 according to four scenarios of fertility and mortality change

Age	Actual mortality and actual fertility: scenario (a)	Actual fertility; mortality constant at 1950–55 levels: scenario (b)	Actual mortality; fertility constant at 1950–55 levels: scenario (c)	Mortality and fertility constant at 1950–55 levels: scenario (d)
Under 15	1769.7	1225.2	3453.1	2343.3
15–29	1569.4	1190.2	2103.9	1578.4
30–44	1293.1	1036.4	1332.4	1067.4
45–59	810.6	662.2	810.6	662.2
60 and older	604.8	422.3	604.8	422.3
All ages	6047.7	4536.4	8304.9	6073.7

NOTE: Scenario (a) adapted from United Nations estimates (see Appendix).

TABLE 2 Impact of mortality change 1955–2000 on world population size in the year 2000, by age (in millions)

Age	Assuming actual fertility		Assuming constant fertility at 1950–55 levels	
	Absolute impact (a)–(b)	Relative impact [(a)–(b)]/(b)	Absolute impact (c)–(d)	Relative impact [(c)–(d)]/(d)
Under 15	544.5	44.4%	1109.9	47.4%
15–29	379.2	31.9%	525.5	33.3%
30–44	256.8	24.8%	265.0	24.8%
45–59	148.4	22.4%	148.4	22.4%
60 and older	182.5	43.2%	182.5	43.2%
Total	1511.3	33.3%	2231.2	36.7%

Scenarios:

(a) Actual mortality and actual fertility (United Nations estimates)

(b) Actual fertility; mortality constant at 1950–55 levels

(c) Actual mortality; fertility constant at 1950–55 levels

(d) Mortality and fertility constant at 1950–55 levels

between the two estimates owes much to the larger size of the population under age 45 had fertility remained constant. In relative terms, the impact of mortality decline varies much less, from 33.3 percent with prevailing fertility to 36.7 percent with constant fertility. The slightly higher impact with constant fertility even in relative terms reflects the fact that mortality gains since 1950–55 have been relatively more important for the youngest age groups, as is also evident in Table 2.

To reverse the perspective as do White and Preston (1996), the 1.5 billion people who would not be alive had mortality remained constant (all else equal) represent 25 percent of today's world population owing their existence to the reduction of mortality in the past 45 years. Although it may appear of a similar magnitude, this proportion reveals a stronger impact than the 50 percent in the past 100 years found for twentieth-century reduction of mortality in the United States. The reason is that the impact of changes is cumulatively compounded over time so that 50 percent in 100 years is achieved with considerably less change than 25 percent in any 50-year period. The impact on the 1940 population size of the 1900–40 mortality decline was less than 14 percent in the United States, and comparable 40-year mortality impacts diminished gradually throughout the century (calculated from data presented by White and Preston 1996: 421).

It is well known that mortality declines have been strongly differentiated by age, with the largest absolute gains at the youngest ages and the largest relative gains at both the youngest and oldest ages. This translates into an uneven age distribution of the population “added” by the reduction of mortality since 1950–55 (Table 2). Estimated with prevailing fertility, 545 million people under age 15 are alive because of mortality gains (both sexes),

and the estimate is twice that (1.110 billion) with constant fertility rates. In relative terms, mortality declines increased the size of the population under age 15 by nearly one-half (some 44–47 percent) but increased the size of the population aged 60 and older by nearly the same proportion (43 percent).

Although more recent, the impact of fertility change since 1950–55 on today's world population size is equally impressive. In Figure 1 the relevant comparisons showing this are between scenarios (a) and (c), on the one hand, and (b) and (d), on the other. With prevailing mortality, today's world population would be estimated to have 2.3 billion more people had fertility rates not changed since 1950–55 (see Table 3). Again, the assessment of the absolute impact of fertility change depends on the assumption about concurrent mortality levels, but the relative impact is slightly above 25 percent in either of the two scenarios considered here (it being somewhat higher with prevailing mortality, i.e., positing no effect of fertility on mortality, perhaps a more appealing assumption than in the case of the reverse interaction).⁷ The impact of fertility change is obviously differentiated by age, as changes since 1955 affect only the population under age 45 today. Since fertility changed little up to 1970, the actual effect is concentrated in the population under age 30. The reduction by about a quarter of the size of the 15–29-year-old age group reflects the onset of many fertility transitions 15 to 30 years ago, while the reduction by nearly one-half of the population under age 15 reflects both the continued fertility reduction and the smaller size of the cohorts entering their reproductive years in the past 15 years.

FIGURE 1 World population size under four scenarios, 1950–2000

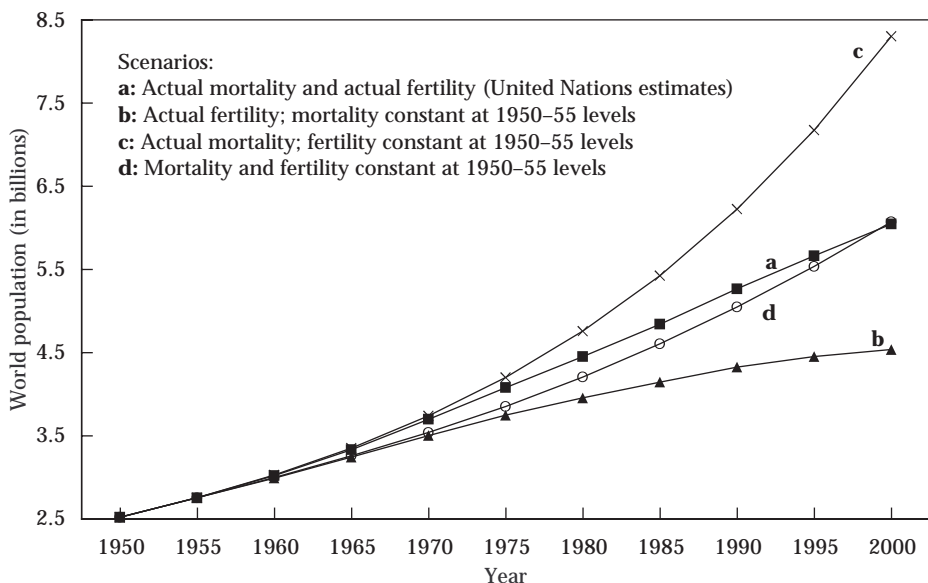


TABLE 3 Impact of fertility change 1955–2000 on world population size in the year 2000, by age (in millions)

Age	Assuming actual mortality		Assuming constant mortality at 1950–55 levels	
	Absolute impact (a)–(c)	Relative impact [(a)–(c)]/(c)	Absolute impact (b)–(d)	Relative impact [(b)–(d)]/(d)
Under 15	-1683.5	-48.8%	-1118.1	-47.7%
15–29	-534.5	-25.4%	-388.2	-24.6%
30–44	-39.3	-2.9%	-31.1	-2.9%
45 and older	0.0	0.0%	0.0	0.0%
Total	-2257.2	-27.2%	-1537.3	-25.3%

Scenarios:

- (a) Actual mortality and actual fertility (United Nations estimates)
- (b) Actual fertility; mortality constant at 1950–55 levels
- (c) Actual mortality; fertility constant at 1950–55 levels
- (d) Mortality and fertility constant at 1950–55 levels

Interestingly, the impacts of these two demographic forces—mortality and fertility—on today’s world population size largely offset one another. The projections with both mortality and fertility rates constant at 1950–55 levels (scenario (d)) yield a world population size marginally higher (26 million) than the actual world population size (scenario (a)). The declines in fertility and mortality occurred at different times and at varying paces so their relative impact on world population size changed during the second half of the twentieth century, incidentally balancing each other at the end of the century (see Figure 1). Because mortality began to decline even before the period under discussion here, the impact of mortality change increased steadily throughout this period. Conversely, the impact of fertility change on world population size is hardly noticeable between 1950 and 1975, but it increases faster than the mortality impact after 1975. Initially, the impact of mortality decline has thus exceeded that of fertility change, and population has grown faster than it would have had mortality and fertility rates jointly remained constant. The absolute difference increases up to 245 million people in 1980 (or 5.5 percent of the world population size at the time) but contracts thereafter. With a difference in timing, fertility declines at the close of the century have just begun to compensate for the impact of mortality declines since 1950–55.

While fertility and mortality declines suggest a compensatory impact on today’s world population size, their impact on the age structure is more visible. Although mortality declines sharply increased the number of persons in the youngest age groups, the depleting impact of fertility decline dominates under age 15, and the number of persons under age 15 would have been greater by 574 million (2343.3 – 1769.7; see Table 1) had both rates remained constant (nearly a third of today’s population under age 15). The

joint impact on the size of the 15–29-year-old age group is almost nil, while at older ages the joint impact is just about the same as the separate impact of mortality, that is, the size of the older age groups would have been smaller had rates remained constant.

The net impact of these changes is that about 574 million fewer people under age 15 have been “replaced” by about 557 million more people aged 30 and older. The drastic changes in demographic regimes of the past 45 years have thus left the size of today’s world population almost unchanged but have shaped a quite different age structure. The implication of these structural shifts for population growth in the twenty-first century is unambiguous. Had vital rates not changed, world average total fertility rates would not only be twice as high at the outset of the twenty-first century (4.99 in 1950–55 and 2.51 in 2000–05 according to United Nations estimates), but the number of females under age 15 would also be 32 percent higher. While the size of the hypothetical population with constant rates is hardly distinguishable from the actual world population size today, the difference would become quite significant very soon. By the mid-twenty-first century, the world population size would be projected above 15 billion with fertility and mortality rates still constant at 1950–55 levels, in contrast to the current United Nations (1999) projections of slightly under 9 billion for the same date.

Nevertheless, it remains puzzling that during the past half-century the world population size stayed quite close to what it would have been without fertility and mortality declines. At the world level, it may seem that the dramatic mortality reductions and fertility reductions have responded to each other to keep population dynamics nearly unchanged, almost in equilibrium. It must be noted, however, that 1950–55 is used as the benchmark period because demographic data are hardly available for all regions of the world before 1950, but from the standpoint of the mortality and fertility transitions the choice of this period is arbitrary. The immediate post-World War II years do not represent any pretransitional equilibrium. This is obvious for MDRs because of the baby boom, but it applies as well to those LDRs where mortality transitions started well before 1950, with a marked acceleration since about 1930, as is reflected in their already high rates of population growth in the 1950s. Latin America and the Caribbean in particular was growing at an average 2.8 percent per year during 1950–55, while on average LDRs were growing at 2.0 percent per year. The 1950–2000 period is thus much too short for expecting to find a return to some post-transition demographic equilibrium worldwide. In a broader perspective, these transitions may be seen as spread over four centuries (from the early eighteenth century to the late twenty-first century), and the second half of the twentieth century is not necessarily the most salient phase of these processes. This period is exceptional because it marks the onset of the decline in global population growth after a prolonged increase, and the window 1950–2000 is almost exactly centered on this inflection point.

Contrasted regional trends

Does the surprisingly small joint impact of mortality and fertility declines on global population size over the past 50 years reflect any “homeostatic” link between mortality and fertility declines? If so, similar results would be expected at the level of the regions delineated for the purpose of these projections. (The year 2000 regional populations that result from the projections are shown in Table 4.) But instead, the effects are very different across regions. The mortality and fertility impacts for each region are presented in Table 5, with the mortality impact measured with constant fertility and the fertility impact measured with prevailing mortality so that the two can be directly added together to assess the joint impact of these changes on regional population size. As mentioned above, and to a variable degree across regions, the assessment of the impact of mortality declines is partially truncated where mortality decline began before mid-century.⁸

As expected, demographic trends had more moderate impacts in MDRs than in LDRs. The most important change in MDRs since 1950–55 is the

TABLE 4 Regional population size (millions) in the year 2000, projected from the regional populations in 1950 according to four scenarios of fertility and mortality change

Region	Actual mortality and actual fertility: scenario (a)	Actual fertility; mortality constant at 1950–55 levels: scenario (b)	Actual mortality; fertility constant at 1950–55 levels: scenario (c)	Mortality and fertility constant at 1950–55 levels: scenario (d)
Europe	722.9	667.4	853.4	788.8
Other MDRs	460.4	421.3	630.2	579.7
Total MDRs	1183.3	1088.7	1483.6	1368.5
China	1275.2	814.4	2335.9	1457.0
Other LDRs-East	598.8	424.1	816.3	570.4
Total LDRs-East	1874.1	1238.5	3152.2	2027.5
India	1006.0	705.4	1311.5	899.2
Other LDRs-West	839.1	610.6	993.7	716.1
Total LDRs-West	1845.1	1316.0	2305.2	1615.3
Sub-Saharan Africa	617.9	467.3	636.5	479.3
Latin America and the Caribbean	527.3	426.0	727.4	583.1
Total LDRs less China	3589.1	2633.4	4485.4	3248.2
Total LDRs	4864.3	3447.7	6821.3	4705.2
Total world	6047.7	4536.4	8304.9	6073.7

NOTE: Scenario (a) adapted from United Nations estimates (see Appendix).

fertility impact in the “Other MDRs,” reducing today’s population size in these regions by 170 million people, or by some 37 percent. In relative terms, the impact in these regions is no less than the worldwide impact (2.257 billion) that also amounts to 37 percent of today’s world population. This result might appear counterintuitive but is in fact consistent with stable population theory, which indicates that growth rates depend on the natural logarithm of total fertility rates (TFRs) so that, all else equal, a TFR decline from 3.5 to 1.75 reduces the rate of population growth as much as a TFR decline from 6 to 3. Demographic trends in MDRs were dominated by the fertility decline from post–World War II baby-boom levels, and, on average, these regions would have increased their rate of population growth had they maintained their 1950–55 vital rates. The population size in these regions would be 300 million larger had fertility remained constant at the 1950–55 level, while mortality decline only added 115 million people to their population.

On the contrary, the positive impact of mortality reduction on the size of today’s LDRs populations exceeds the symmetrical negative impact of

TABLE 5 Impact of mortality and fertility change 1955–2000 on regional population size in the year 2000, by age (in millions)

Region	Mortality impact assuming constant fertility at 1950–55 levels (c)–(d)				Fertility impact assuming actual mortality (a)–(c)			
	Under age 15	15–44	Age 45 and older	Total	Under age 15	15–44	Age 45 and older	Total
Europe	16.2	19.5	28.9	64.6	–87.4	–43.1	0.0	–130.5
Other MDRs	13.7	13.9	22.9	50.4	–98.7	–71.0	0.0	–169.7
Total MDRs	29.9	33.4	51.8	115.1	–186.2	–114.1	0.0	–300.3
China	434.3	321.4	123.2	878.9	–749.4	–311.3	0.0	–1060.7
Other LDRs–East	122.4	87.2	36.3	245.9	–179.8	–37.7	0.0	–217.5
Total LDRs–East	556.7	408.6	159.5	1124.8	–929.2	–348.9	0.0	–1278.2
India	220.1	145.4	46.8	412.3	–241.1	–64.5	0.0	–305.6
Other LDRs–West	143.9	97.5	36.1	277.6	–143.5	–11.0	0.0	–154.6
Total LDRs–West	364.0	242.9	82.9	689.8	–384.6	–75.5	0.0	–460.1
Sub-Saharan Africa	85.8	55.3	16.1	157.2	–25.9	7.3	0.0	–18.6
Latin America and the Caribbean	73.4	50.3	20.5	144.3	–157.5	–42.6	0.0	–200.1
Total LDRs less China	645.7	435.7	155.8	1237.2	–747.9	–148.4	0.0	–896.3
Total LDRs	1080.0	757.1	279.1	2116.1	–1497.3	–459.7	0.0	–1957.0
Total world	1109.9	790.5	330.8	2231.2	–1683.5	–573.8	0.0	–2257.2

Scenarios:

(a) Actual mortality and actual fertility (United Nations estimates)

(b) Actual fertility; mortality constant at 1950–55 levels

(c) Actual mortality; fertility constant at 1950–55 levels

(d) Mortality and fertility constant at 1950–55 levels

fertility change by 159 million people (2.116 billion less 1.957 billion, Table 5). But even within these regions, the results show a marked contrast. China and Latin America and the Caribbean would each have a larger population today had vital rates remained constant at 1950–55 levels (182 million and 56 million respectively). The respective trends in the two regions are quite distinct, however. In Latin America and the Caribbean, the mortality impact (+144 million) was fairly small compared to the other LDRs, in part because mortality decline started earlier and ran some of its course before 1950. The impact of fertility decline in the region (–200 million), in proportionate terms about average among LDRs, was thus sufficient to more than compensate for the mortality impact on today’s regional population size. In China, on the contrary, both mortality and fertility impacts are spectacular (+879 million and –1.061 billion) even accounting for the large population size of the region (21 percent of today’s world population). China accounts for 39 percent of the impact of mortality change and 47 percent of the impact of fertility change worldwide. Today’s population in China is thus the product of two massive transformations, the mortality and fertility impacts representing respectively +69 percent and –83 percent of today’s population of China.

The other four LDRs would have smaller populations had vital rates remained constant at 1950–55 levels (altogether 397 million fewer people). The larger increases in population size attributable to demographic changes since 1950–55 are in sub-Saharan Africa and in the “Other LDRs-West,” with 139 million and 123 million people added to their respective populations. In each of these four regions, mortality reduction had a significant impact, if perhaps not as impressive as in China. More variation is observed with respect to the impact of fertility change. The lack of fertility impact even on the youngest age groups sets sub-Saharan Africa apart, suggesting that the region’s population growth will continue to exceed that projected with constant 1950–55 vital rates for several decades into the twenty-first century.

The regional breakdown thus demonstrates that the nearly balanced impact of fertility and mortality declines on today’s world population size is largely a coincidence, resulting from divergent regional trends worldwide. Aggregate fertility may seem to have declined in “response” to aggregate mortality decline, in a way that maintained population growth from 1950 to 2000 at what it would have been with 1950–55 vital rates. But regional trends do not support this “homeostatic” view of demographic change. While today’s “Other MDRs” population would be 26 percent larger and that of China 14 percent larger, today’s “Other LDRs-West” population would be 15 percent smaller and that of sub-Saharan Africa 22 percent smaller had vital rates remained constant at their 1950–55 levels.

The picture of regional diversity is confirmed by a further breakdown of the mortality and fertility impact on population by age and sex (Table 5). The result that mortality decline increased the adult and elderly population

applies to all regions and in proportionate terms to a roughly similar extent across regions. On the contrary, the finding that the population under age 15 decreased as the depleting impact of fertility change on that age group exceeded that of mortality does not apply across regions, because of very different magnitudes of the fertility impact. Without detailing the specific structural changes of each region, it is worthwhile noting that the disproportionate contribution of China is even more visible in the population under age 15. In China alone the impact of fertility decline on the population under age 15 (–749 million) exceeds the impact of mortality decline (+434 million) by 315 million and by merely 102 million in the other five LDRs combined (646 million less 748 million, Table 5).

The change in today's population age structure in the LDRs less China highlights the long-term implications of past mortality declines. The number of people under age 15 in these regions is smaller by 102 million because of the changes in vital rates that prevailed since 1950–55 but the main impact is the increased size of the cohorts now in reproductive ages (15–44)—an increase by almost 300 million (+436 million less 148 million, Table 5). Actual population growth in the LDRs is expected to be slower in the first part of the twenty-first century than would have been the case had rates remained constant at their 1950–55 levels, but only because of lower future fertility rates. The age structure of today's population in these regions is in fact conducive to faster population growth than would have been the case had vital rates remained constant. A summary indicator for the present age-structure contribution to future growth is the population momentum, the factor by which population size would increase before stabilizing if fertility rates were to decline to their replacement level immediately and remain there indefinitely. Population momentum thus expresses how much past mortality and fertility levels and changes, through their influence on the present age structure, will contribute to future population growth irrespective of future vital rates. Population momentum would be lower had vital rates remained constant at 1950–55 levels in all LDRs but China. In the LDRs less China, the present population momentum is 1.31 instead of the 1.04 that would have resulted with constant vital rates (data not shown, computed from formula in Preston and Guillot 1997: 21). The past 45 years of demographic changes in these regions thus imply that population would grow by an additional 27 percent even if fertility were to sink to replacement level instantaneously and thereafter remain there. On the other hand, past fertility declines brought current fertility levels closer to this replacement level than they were 45 years ago. In any event, from this perspective, the expected further fertility declines hardly seem cause for alarm as a so-called population implosion (Wattenberg 1997) remains unlikely for the LDRs in the foreseeable future.

In sum, results at the world level are somewhat deceptive. Even at the still highly aggregated level of the eight regions presented above, variations

appear that are at odds with what world average trends might suggest and for two reasons. First, fertility levels have not systematically adjusted to declining mortality rates to keep population growth from accelerating. Already by the year 2000, regional population size in two of the eight regions considered here differs by more than 20 percent from what it would have been with unchanged 1950–55 vital rates. Second, the potential for future growth has not been uniformly reduced. This phenomenon has been largely limited to the more developed regions and to China.⁹

Conclusions

World average mortality has declined at an unprecedented pace during the past 50 years. This impressive decline can be summarized using the abstract construct of the life tables' "synthetic" cohort, by stating that each person born at the end of the twentieth century could expect to live about 18 years longer, on average, than if born at mid-century. Another way to express the same decline, in perhaps more concrete terms, is that one-fourth of today's world population is alive because of mortality improvement in the second half of the twentieth century. Meanwhile, recent fertility declines have also been impressive on average and, indeed, much faster than predicted only a decade or two ago. In terms of their impact on today's world population size, the aggregate effect of individual decisions to bear fewer children almost exactly offsets the upward pressure of increased survival probabilities.

World average trends are deceptive, however. Whereas the respective effects of mortality and fertility on world population size nearly balance out, the regional level reveals a variety of distinct situations. Changes in demographic regimes slowed population growth in the more developed regions because the impact of mortality gains after 1950 was modest and fertility declined from its exceptional baby-boom levels. In the less developed regions, mortality declines had a strong acceleration effect on population growth in the second half of the century, generally exceeding the impact of later fertility declines except in two of these LDRs but for different reasons. First, Latin America and the Caribbean experienced earlier mortality declines than most other LDRs (by 1950–55, life expectancy at birth was about ten years higher than in Africa or Asia), so that the impact of mortality changes after 1950 was more limited. Second, China's well-known fertility decline reversed the momentum set by the previous mortality declines. In the remaining LDRs, population growth has actually been higher during the second half of the century than it would have been had fertility and mortality rates remained constant at their mid-century levels. Substantial variations were also found within these regions, most significantly in sub-Saharan Africa, where the impact of fertility declines has been minimal.

This review of the demographic consequences of changes in mortality and fertility regimes during the past 50 years leads to three conclusions.

First, it places recent fertility declines and the prospects for future fertility declines in perspective. A cursory reading of public debates over demographic issues during the past few years may leave the impression that contemporaneous demographic changes have permitted us to avoid a world population explosion but that the “over-correction” of fertility rates may precipitate instead a world population implosion. That population growth has been no slower than if demographic rates had remained constant at their 1950–55 levels may then surprise many. In most of the developing world, the current population momentum is even greater than would have been the case had there been neither mortality nor fertility transitions in this half-century. Taking a slightly longer view on retrospective population changes provides a corrective for the fashionable present-day interpretation of current and expected fertility declines in these regions.

Second, the balancing out at the world level should not support a fatalistic view of short-term population growth either. Population growth during the past 50 years has been largely consistent with growth implied by mid-century vital rates in spite of dramatic subsequent changes in such rates, but the modest combined impact of mortality and fertility transitions during the last 45 years reflects the very significant but compensating impacts of both mortality and fertility changes. Recent fertility declines did reduce the size of today’s world population by a quarter, but these declines occurred against a background of earlier mortality improvements that sharply increased the number of people reaching reproductive age. Recent fertility declines will have an even greater impact on future growth as they have reduced the size of the world population under age 15 by nearly 50 percent (Table 3).

Finally, although on average fertility declines have followed mortality declines and kept population growth in check, regional diversity cannot support a homeostatic view of recent transitions in LDRs. For instance, while the mortality impact has been less in sub-Saharan Africa than in the other LDRs except Latin America (24.4 percent of today’s population in the region is alive because of mortality reduction since 1950–55), fertility declines have been modest in the region. By the time mortality decline had the same impact on population size in China, 23.5 percent of the 1985 population (calculation not shown), a swift fertility decline was already underway and population was back to the size projected on the assumption that both mortality and fertility rates remained constant. Regional contrasts suggest that fertility change is not a necessary “response” to mortality change, or at least that their respective timing can be such as to allow a long period of sustained growth. That mortality declines preceded fertility declines is possibly the only universal trait linking recent transitions across the world (Hirschman 1994), but both the magnitude and the timing of fertility declines relative to the mortality declines were diverse.

Appendix: Parameters of the reference projections

For China, India, Latin America and the Caribbean, and Europe, the 1950 population by sex and five-year age groups was taken directly from United Nations (1999) data. Simple sums and differences in the population by sex and five-year age groups in the constituent United Nations areas or countries were the source of the 1950 population in the other four regions. The population of sub-Saharan Africa is simply the difference between the populations of Africa and Northern Africa.¹⁰ The population of the “Other LDRs-West” is the sum of the populations of Northern Africa, Western Asia, and South-and-Central Asia, less the population of India. The population of the remaining LDRs constitutes the population of the “Other LDRs-East,” that is, the difference between the total population of the LDRs and the sum of the populations of China, India, “Other LDRs-West,” sub-Saharan Africa, and Latin America and the Caribbean. Similarly, the population of the “Other MDRs” is the difference between the total population of the MDRs and the population of Europe.

While total fertility rates are available for United Nations areas and countries in each period, age-specific fertility rates are not. Initial age patterns of fertility were obtained from either vital statistics (United Nations 1997 and earlier) or model age patterns of fertility (published in the 1973 revision of United Nations biennial projections). These initial patterns were gradually calibrated to best match the United Nations estimates of the number of persons under age five years in each region and at every five years. Age-specific fertility rates for the composite regions were computed from the finalized rates in each of their constituent areas in the following manner. For each region, period, and age group of women of childbearing age, the age-specific fertility rates multiplied by the average number of women in the period provide the number of births by maternal age in the constituent areas. Simple sums and differences give the corresponding number of births by

APPENDIX TABLE A-1 Total fertility rates by region (five-year averages), 1950–2000

Period	Europe	Other MDRs	China	Other LDRs-East	India	Other LDRs-West	Sub-Saharan Africa	Latin America and the Caribbean
1950–1955	2.57	3.21	6.22	5.92	5.97	6.48	6.50	5.89
1955–1960	2.59	3.16	5.59	5.94	5.92	6.53	6.57	5.94
1960–1965	2.56	2.90	5.72	5.90	5.81	6.58	6.69	5.97
1965–1970	2.36	2.42	6.06	5.50	5.69	6.44	6.72	5.55
1970–1975	2.14	2.05	4.86	5.20	5.43	6.25	6.69	5.03
1975–1980	1.97	1.81	3.32	4.46	4.83	6.00	6.68	4.49
1980–1985	1.87	1.79	2.55	3.96	4.47	5.73	6.61	3.86
1985–1990	1.83	1.83	2.46	3.38	4.07	5.08	6.34	3.35
1990–1995	1.57	1.86	1.92	2.90	3.56	4.19	5.93	2.97
1995–2000	1.42	1.82	1.80	2.54	3.13	3.80	5.51	2.70

Source for Europe, China, India, and Latin America and the Caribbean: United Nations 1999. Total fertility rates for other regions were calculated from age-specific fertility rates and computed as described in the text.

maternal age in each region. In turn, these numbers of births and the average number of women in the region and period provide the age-specific fertility rates for that region and period. Resulting total fertility rates are shown in Appendix Table A-1. For each region, a constant value of the sex ratio at birth for the entire 1950–2000 period completes the fertility parameters. Selected values range from 1.03 in sub-Saharan Africa to 1.07 in China.

A similar approach was followed for mortality parameters. In each period, life expectancies at birth by sex are available for United Nations areas and countries, and were used for China, India, Europe, and Latin America and the Caribbean. As was the case for fertility, age patterns of mortality are described at the country level but are not provided for regions. For each of the above four regions and each constituent area of the remaining four regions, a single age pattern of mortality for the period 1950–2000 was selected from model age patterns. From United Nations life expectancies at birth and these model age patterns, a full life table can be computed (computations were carried out using MortPak, United Nations 1988). Survival ratios for a composite region are then obtained from the number of births by sex and survival ratios in the constituent areas in the following way. For each region, period, and sex, the number of births and the population by age at the beginning of the period are survived forward until the end of the period in each constituent area. Sums and differences then provide the number of survivors by age in each region. These numbers are subsequently combined with the number of births and the population by age in the region at the beginning of the period in order to compute survival ratios for that region. This approach amounts to taking as survival ratios the weighted averages of the survival ratios from the constituent areas with the weights equal to the population of the appropriate area and age group at the beginning of the period (for a discussion of several approaches, see Lutz and Scherbov 1992).

These life expectancies by sex were used for the composite regions; yet a single age pattern of mortality for the entire period 1950–2000 was selected from model

APPENDIX TABLE A-2 Life expectancy at birth, by region (both sexes, five-year averages), 1950–2000

Period	Europe	Other MDRs	China	Other LDRs-East	India	Other LDRs-West	Sub-Saharan Africa	Latin America and the Caribbean
1950–1955	66.2	67.4	40.8	42.8	38.7	41.9	36.6	51.4
1955–1960	68.3	68.9	44.6	45.6	42.6	44.6	38.7	54.3
1960–1965	69.8	69.8	49.5	48.4	45.5	47.2	40.7	56.8
1965–1970	70.4	70.8	59.6	51.2	48.0	49.5	42.7	58.8
1970–1975	70.8	72.1	63.2	54.1	50.3	51.7	44.6	60.9
1975–1980	71.2	74.0	65.3	57.0	52.9	54.0	46.2	63.1
1980–1985	71.9	75.3	66.6	61.2	54.9	56.5	47.5	64.9
1985–1990	73.0	75.9	67.1	64.4	57.6	59.6	49.7	66.7
1990–1995	72.6	76.9	68.4	66.6	60.3	61.9	50.8	68.1
1995–2000	73.3	77.6	69.8	69.1	62.6	63.9	51.8	69.2

Source for Europe, China, India, and Latin America and the Caribbean: United Nations 1999. Life expectancies for other regions were calculated from sex- and age-specific survival ratios and computed as described in the text.

age patterns rather than from the pattern derived from the computed survival ratios in each period. Life expectancy at birth for both sexes is shown in Appendix Table A-2. Age patterns of mortality were taken from Coale and Demeny's (1983) model life tables for Europe and "Other MDRs" (West), as well as for sub-Saharan Africa (North). United Nations (1982) model life tables for developing countries provided the patterns for China, "Other LDRs-East," "Other LDRs-West" (General), India (South Asian), and Latin America and the Caribbean (Latin American).

International migration estimates are not available from United Nations data. While the average net number of migrants can be computed from population change and the average number of births and deaths in a five-year interval, estimates derived in this fashion are not satisfactory since they do not sum to zero worldwide between 1950 and 1980. An examination of these data and figures in Zlotnik (1994) led to initial estimates of the number of migrants by region, period, and sex. These were gradually adjusted to sum to zero and to reduce the difference between the projected population by age in the reference projections and in the United Nations data. The resulting annual numbers of migrants per region and

APPENDIX TABLE A-3 Annual net numbers of migrants (five-year averages) and crude rates of net migration (CRNM, five-year averages) by region, 1950–2000

Period	Europe	Other MDRs	China	Other LDRs-East	India	Other LDRs-West	Sub-Saharan Africa	Latin America and the Caribbean
Annual net numbers of migrants (thousands)								
1950–1955	-66	82	8	-136	27	50	16	18
1955–1960	-31	69	-57	-67	31	76	4	-25
1960–1965	9	91	-15	-44	-25	46	-3	-60
1965–1970	-16	124	-19	-20	-11	5	-4	-59
1970–1975	91	236	-55	-56	-24	-52	-80	-60
1975–1980	70	240	-58	-130	-5	-11	-27	-79
1980–1985	49	154	-19	-131	55	-21	12	-100
1985–1990	171	205	73	-194	-17	-124	-20	-95
1990–1995	198	298	-9	-259	-18	-122	-5	-84
1995–2000	126	240	-32	-180	-24	-38	-14	-79
CRNM (percent, per year)								
1950–1955	-0.06	0.15	0.02	-0.38	0.02	0.07	0.03	0.04
1955–1960	-0.03	0.11	-0.14	-0.16	0.02	0.09	0.01	-0.05
1960–1965	0.01	0.14	-0.03	-0.09	-0.02	0.05	0.00	-0.11
1965–1970	-0.01	0.18	-0.04	-0.04	-0.01	0.00	0.00	-0.09
1970–1975	0.07	0.33	-0.09	-0.09	-0.01	-0.04	-0.09	-0.08
1975–1980	0.05	0.31	-0.09	-0.19	0.00	-0.01	-0.03	-0.10
1980–1985	0.04	0.19	-0.02	-0.17	0.03	-0.01	0.01	-0.11
1985–1990	0.12	0.24	0.08	-0.23	-0.01	-0.08	-0.02	-0.10
1990–1995	0.14	0.34	-0.01	-0.28	-0.01	-0.07	0.00	-0.08
1995–2000	0.09	0.26	-0.03	-0.18	-0.01	-0.02	-0.01	-0.07

NOTE: The net numbers represent the parameters used in all projections. As discussed in the text, they were derived to reduce potential discrepancies between the outcomes of our projection with actual mortality and fertility rates (scenario (a) or reference projections) and the United Nations estimates and are not an attempt to represent the best possible estimates of actual migration. The crude rate of net migration was computed assuming a constant instantaneous growth in each five-year interval to estimate the number of person-years (PY) lived in the interval and using the following formula (Preston, Heuveline, and Guillot, forthcoming): $CRNM(t,t+5) = NM(t,t+5) / (PY(t,t+5))$

period are shown in Appendix Table A-3. To allow a better match with the population age structures estimated by the United Nations, the numbers were not forced to zero within each age group. Although this is of course inconsistent, releasing this constraint allows the correction of the age patterns of mortality in case they differ from the selected model. In the interest of simplicity, a single model age pattern of mortality has been selected in each region for the entire projection period (1950–2000), but a single pattern is not necessarily valid throughout the period. Forcing the number of migrants to sum to zero for all ages combined, but not in each age group, amounts to a redistribution of the total number of deaths by age, but holds the total number of deaths unchanged.

Notes

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1 We label such projections retrospective because they refer to the past as opposed to, for instance, projections with indefinitely constant fertility in the future. The label does not refer to the technique of projection, which is here forward projection, not back-projection.

2 For instance, Lutz and Prinz (1991) found that projecting the world population over 110 years (1990–2100) as the sum of six regions with constant fertility and mortality rates resulted in a population size 50 percent greater than the world population size had world average fertility and mortality rates been assumed constant.

3 The United Nations defines the "More Developed Regions" as Europe (including the territory of the Russian Federation), Northern America, Japan, Australia, and New Zealand.

4 The open-ended age interval is 100 years and older in the most recent United Nations estimates. Projecting this age group poses additional difficulties when using conventional model life tables (see Heuveline 1997 for a discussion); 80 years and older was preferred here as the open-ended age interval.

5 The 1995–2000 figures incorporate available data as of 1998, complemented by projections. In the rest of the article, I refer to the United Nations estimates for the entire 1950–2000 period.

6 The parameters of the reference projections are described in the Appendix to this article. An additional appendix comparing the results of these projections with the United Nations estimates is available from the author upon request.

7 There are some well-documented health benefits to both mother and child of longer birth intervals (in turn leading to lower total fertility), but past mortality declines appear more independent of prior fertility change than past fertility declines of prior mortality change.

8 In the MDRs, the majority of the impact of mortality decline results from changes before 1950. For instance, White and Preston (1996: 422) found that for the United States "[m]ortality reductions during the first half of the century had a much larger impact on population size in 2000 than did reductions during the second half."

9 Many of the regional differences described above can be explained by the different timing and pace of fertility declines as compared to the timing and pace of mortal-

ity declines. An additional section analyzing the impact of mortality changes during the last 45 years in three sub-periods (1955–70, 1970–85, and 1985–2000) and the impact of hypothetical delays in fertility declines is available from the author upon request.

10 The United Nations also defines a sub-Saharan Africa region, but that definition is slightly different from the one used here.

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The Persistence of Outmoded Contraceptive Regimes: The Cases of Mexico and Brazil

JOSEPH E. POTTER

IN THE LAST several years, spurred in large part by Susan Watkins's persuasive argumentation and the rigorous analytic formulations of John Casterline, Mark Montgomery, and Luis Rosero-Bixby, there has been a resurgence of interest in the roles of social networks and interpersonal communication in fertility transitions and in the spread and changing composition of contraceptive practice.¹ By and large, these authors have concentrated on the exchange of information and ideas among prospective parents or contraceptive users, and they have focused on the beginning and middle parts of the process rather than its later stages. Moreover, they have generally viewed networks and the transmission of information across them as positive phenomena that should be taken advantage of in the design of public policies. In this article, I argue that there is ample reason to explore the problems as well as the opportunities that networks and diffusion pose and to consider the role of the providers of contraceptive services both as brokers of information between users and as agents who control or at least influence the choice of reproductive and contraceptive technologies. In so doing, I look at the later as well as the earlier stages of the fertility transition and point to some of the contradictions and dilemmas that these matters pose for emerging norms regarding reproductive health and quality of care.

What might be the problematic aspects and consequences of social interaction? While there is no doubt that the interpersonal exchange of information across networks can speed the fertility transition, it is also responsible for the inertia that makes introduction of new contraceptive technologies difficult. Less recognized is the inertia that may be encountered in the later stages of the fertility transition wherein individuals and institutions may become committed to a reduced set of contraceptive practices that may be

far from optimal for most if not all women. I argue that the tendency to become accustomed to a reduced range of methods and particular ways of practicing them results from the various sorts of positive reinforcement that contraceptive choices are subject to, and follows the logic of path dependence.

I illustrate the ways in which contraceptive regimes that evolved in one set of circumstances can persist long after they no longer make sense with experiences drawn from Mexico and Brazil, countries that have experienced substantial declines in fertility, but that have had widely different experiences in the realm of population policy. Mexico illustrates how government policies and styles of implementing them may outlive the conditions for which they were originally designed, while Brazil shows how a far more laissez-faire approach can also yield perverse, unwanted outcomes.

The stylized facts

Writing in this journal, Bongaarts and Watkins (1996) have provided a comprehensive review of the empirical evidence regarding the timing and pace of contemporary fertility transitions. As did demographers familiar with the history of the demographic transition in the West, they show that contemporary transition characteristics do not follow directly from either levels or rates of change of “conventional measures of development,” and that “once a country has begun a transition, further declines follow almost invariably.” Using countries as the units of analysis, they find large differences in levels of fertility and socioeconomic conditions prevailing at the onset of the transition, and little or no correspondence between the pace of the ensuing change in fertility and change in socioeconomic conditions (at least as reflected in the human development index, or HDI). They do, however, determine that the onset of fertility decline within countries in a macro-region can be predicted quite well on the basis of the level of development and the time elapsed since the first country in the region entered the fertility transition. Having established these features of contemporary fertility transitions, they proceed to suggest that much of the unexplained variation in contemporary fertility transitions, as well as in earlier ones, can be accounted for by the transmission of information and ideas regarding fertility and its control, and that “social interaction . . . accelerates the pace of transition” (p. 669).²

The argument that I make in this article is not that these facts and inferences are incorrect. Rather than question the importance of a diffusion process at work, my goal is to broaden the discussion of its consequences to include the problems that may be associated with the choice and practice of methods of birth control. To lay the basis for my suggestions as to how the scope of thinking about social interactions should be expanded, I draw at-

tention to the “stylized facts” pertaining to the contraceptive use associated with contemporary fertility transitions.

Wide variations in method mix

Perhaps the most striking aspect of contemporary contraceptive practice is the wide variation that exists across populations. The magnitude of this variation can be seen in Table 1, which shows contraceptive use by method for 26 countries selected from among those for which the United Nations (1996) has compiled this information. The percentages highlighted in bold print are for the most prevalent methods practiced in the country. While the cases have been selected to emphasize the diversity in world experience, the picture presented in the table is nonetheless striking. In many of the countries, the bulk of contraceptive use is concentrated on one or two methods rather than being spread over a larger number. Second, the most prevalent methods are not the same across these countries. For example, while female sterilization is an important method in about half of the countries shown in Table 1, its prevalence is below 5 percent in seven of the countries, all of which have a relatively large percentage of married women practicing contraception. Male sterilization is less frequently practiced than female sterilization among these countries, but is an important method in Nepal, Korea, and the United States. Other methods also show a wide range in prevalence: use of the pill ranges from less than one percent in Vietnam and Japan to 46 percent in Belgium, injectables from 15 percent in Indonesia to less than 2 percent in 16 countries, the condom from 48 percent in Japan to 3 percent or less in 17 countries, vaginal barrier methods are used by more than 2 percent of married women only in the United States, rhythm is practiced by 21 percent of married women in Peru and is an important method in Japan and Sri Lanka, and, finally, withdrawal is the most widely practiced method in Turkey, the Czech Republic, and Romania.

Each of these societies has a particular history, culture, medical system, and set of relations with other societies, and explanations for the individual patterns can be sought in those particularities.³ In an era of globalization in which goods and ideas are thought to travel more freely than ever before, however, such variation in the methods of contraception used in different countries has to command our attention. Simple appeals to variations in the preferences of individuals and couples—perhaps reflecting patriarchy or prevailing sexual practices—do not seem convincing, nor do explanations based solely on programmatic fiat or market restrictions. Also, there is no correlation between average levels of income or education and the prevalence of certain methods. Indeed, the most striking aspect of these data is how little use is made in so many places of the contraceptive technology that is available today.

TABLE 1 Percent of married women of reproductive age using contraception, by method, 1980s and early 1990s, selected countries

Country and year	Female sterilization	Male sterilization	Pill	Injectable	IUD	Condom	Vaginal barrier	Rhythm	Withdrawal	Any method
Egypt 1992	1.1	0.0	12.9	0.5	27.9	2.0	0.4	0.7	0.7	46.2
Kenya 1993	5.5	0.0	9.5	7.2	4.2	0.8	0.1	4.4	0.4	32.7
Bangladesh 1993	8.2	1.1	17.7	4.5	2.1	3.0	0.0	4.9	2.5	45.1
Hong Kong 1987	22.9	0.9	16.4	2.5	4.5	26.0	1.8	5.4	0.5	80.8
Indonesia 1991	2.7	0.6	14.8	14.8	13.3	0.8	0.0	1.1	0.7	49.7
Jordan 1990	5.6	0.0	4.6	0.0	15.3	0.8	0.6	3.9	4.0	35.0
Nepal 1991	11.0	6.8	1.0	2.3	0.2	0.6	0.0	0.5	0.4	22.7
Philippines 1993	11.9	0.4	8.5	0.1	3.0	1.0	0.0	7.3	7.4	40.0
Korea 1991	35.3	12.0	3.0	0.1	9.0	10.2	0.1	7.0	2.7	79.4
Sri Lanka 1987	24.8	4.9	4.1	2.7	2.1	1.9	0.0	15.0	3.4	62.0
Thailand 1987	22.4	5.5	20.0	9.2	7.2	1.2	0.0	1.0	0.9	67.5
Turkey 1993	2.9	0.0	4.9	0.1	18.8	6.6	1.2	1.0	26.2	62.6
Vietnam 1988	2.5	0.3	0.4	0.0	31.0	1.1		7.5	6.6	53.2
Colombia 1990	20.9	0.5	14.1	2.2	12.4	2.9	1.7	6.1	4.8	66.1
Dominican Rep. 1991	38.5	0.2	9.8	0.2	1.8	1.2	0.1	2.0	2.2	56.4
El Salvador 1993	31.5	0.4	8.7	3.6	2.1	2.1	0.0	3.0	2.0	53.3
Brazil 1986	26.9	0.8	25.2	0.6	1.0	1.7	0.5	4.3	5.0	65.8
Mexico 1987	18.7	0.8	9.8	2.8	10.2	1.9	0.6	4.4	3.5	52.7
Panama 1984	32.4	0.4	11.8	0.8	6.0	1.6	1.2	2.3	1.4	58.2
Peru 1991	7.9	0.1	5.7	1.9	13.4	2.8	1.0	20.7	3.9	59.0
Japan 1992	3.2	0.8	0.8		3.1	48.0	0.8	10.6	4.9	64.0
United States 1988	23.4	12.9	15.1		1.5	10.6	5.6	2.1	2.0	74.3
Belgium 1991	11.4	7.6	46.4		5.0	4.8	0.0	2.1	2.0	79.4
France 1988	6.7	0.0	29.7		25.9	4.3		6.4	6.6	81.2
Czech Rep. 1993	2.7	0.0	8.0	0.0	15.3	18.8	0.2	1.9	22.1	68.9
Romania 1993	1.4	0.0	3.1	0.0	4.2	3.9	1.9	8.5	34.4	57.3

NOTES: Blanks in the table correspond to methods for which prevalence estimates are not available and use is known to be either negligible or very small. The figures shown in the method columns do not always sum to the "Any method" percentage because of the use of methods that have been classified as "other methods" or "not stated," as well as resort to prolonged abstinence, none of which are shown.

SOURCE: United Nations (1996: Table A.6). The highlighted methods are either the most prevalent method, a method for which the prevalence is at least 60 percent of that of the most prevalent method, or a method with a prevalence greater than 10 percent.

The persistence of collective and individual contraceptive choices

When viewed in a longer-term, dynamic perspective, the evolution in patterns of contraceptive use is perhaps even more anomalous than the cross-section shown in Table 1. While there is often an understandable trend away from the use of traditional methods and toward the use of modern, more medicalized methods, what is surprising is the persistence of a particular mix and the tendency for the distribution of use to become more concentrated through time. In Mexico, as will be seen below, a tendency toward increased prevalence of the IUD and sterilization in recent years has come at the expense of the use of the pill and injectable contraceptives. The use of the IUD has diminished sharply in some countries such as the United States. In many countries such as Brazil, the tendency is toward reliance on just two methods, the pill and sterilization, with sterilization occupying an increasingly large share over time. There is no widely accepted explanation as to why the method mix does not become more diverse as more methods become available, or why the methods used in one country frequently do not become popular in neighboring countries.

The tendency toward a persistent, narrow distribution of use by method at the aggregate level has a parallel at the level of the individual. The relatively small number of studies that have looked at sequences of use among individuals display high stability in a woman's choice of methods. That is to say, there is relatively little switching. This conclusion was drawn early on with respect to the United States by Ryder and Westoff (1971) and by Michael and Willis (1975), both using data from the 1965 National Fertility Survey (NSF). When the latter authors examined successive segments of use, they found that about three-quarters of the couples who were using either the diaphragm, condom, or withdrawal in the first segment were using the same method in the following segment. Survey data have also provided strong evidence of stability among women in Malaysia (DaVanzo, Ann, and Othman 1986; Reboussin et al. 1987). Reboussin et al. noted that "couples used the same method of contraception both before and after 84 percent of the pregnancies in our sample" (p. vi). They concluded that the trend toward the use of modern methods of contraception apparent in the aggregate method mix was not the result of individual women substituting modern for traditional methods. Rather, those women who were using traditional methods continued to do so, while new cohorts of previous nonusers began practicing modern methods.

Further evidence of the tendency of women to continue using a method that they have already chosen is provided in studies of who accepts new methods of contraception when they are introduced. Michael and Willis used the 1965 NSF to study adoption of the pill when it was first introduced, and found that, as in Malaysia five to ten years later, women who

had not used a method were more likely to adopt the pill than women who had previously used another method. Results concerning the likelihood of adopting the subdermal contraceptive implant when it was first introduced are also available for Malaysia and the United States (Molyneux 1997; Mellor 1997). Here again, previous nonusers were more likely to adopt the new method than were women who had previously used another method.

How and why contraceptives are chosen

The standard conceptual formulations regarding contraceptive choice are closely related to familiar models of consumer choice theory wherein an individual takes into account the various attributes of a method such as its cost, including the time involved in acquiring the method, its ease of use, effectiveness, reversibility (in the case of sterilization), and possible side effects (Bulatao 1989). People start with a utility function, or set of preferences; they are subject to constraints with respect to their time and income; they encounter a specific set of prices (in terms of both money and time) for different methods; and they eventually select the method that is best for them (maximizes their utility). Perhaps the most familiar type of logic related to the application of this model of contraceptive choice is that “spacers” will give less weight than “limiters” to the effectiveness of a method. The model leads, in the absence of complications, to a felicitous outcome: individuals and groups of individuals choose the methods that are best for them.

The model has been extended in an attempt to account for the low frequency of method switching. Michael and Willis (1975) and Mellor (1997) have suggested substantial “fixed costs” attached to contraceptive practice as an explanation for the large fraction of couples who continue to use the same contraceptive method over time, and the large percentage of the adopters of new methods constituted by individuals who were not previously using a method. The fixed costs that inhibit people from switching methods are not well investigated, but are supposed to include monetary, psychic, information, and health costs. Monetary costs might include expenditures for consultations with physicians, as well as the expense of the method. Information costs refer to all efforts to gather information at the time of method selection, and fixed health costs are those incurred by using a method only once. Others have suggested directions in which to expand the dynamic aspects of the model (Mundigo, Phillips, and Chamrathirong 1989) so as to incorporate the learning that occurs as couples gain experience with individual methods.

Most recently, as noted at the outset, attention has been focused on social learning: individuals are seen as depending on others for information about the existence of new technologies and about the risks and conse-

quences of adopting them (Montgomery and Casterline 1996; Kohler 1997a and 1997b). In the remainder of this section, I first highlight two aspects that have not been given their due emphasis in most discussions of diffusion and social learning with respect to contraception, and then discuss the properties of a model of contraceptive decisionmaking that incorporates these extensions and considerations.

Fear of health consequences

The uppermost concern that women and sometimes couples have regarding modern medical contraceptive methods is that they will be damaging to their health. Modern medical methods include hormonal contraception, the IUD, and surgical sterilization—the contraceptives that have accounted for the bulk of contraceptive use in contemporary fertility transitions. The concern involved may range from well-informed, scientifically based fear of contracting pelvic inflammatory disease from using an IUD to a general worry that use of any of these methods will prove to be life-threatening based on a cognitive model of the body at some distance from the Western model and based on rumors afloat in the community.⁴

One of the most compelling descriptions of the role that fear plays in contraceptive decisionmaking is found in an article by Shedlin and Hollerbach (1981).⁵ Their subjects were women living in a rural community outside the city of Toluca, Mexico who had an understanding of reproductive processes based on “traditional,” non-Western conceptions, and ample experience with the consequences of using traditional means of avoiding or ending pregnancies. The dilemma facing women seeking to limit their fertility is to choose the least dangerous of the available options. The traditional methods present threats that are well known, while new methods such as the pill seem frightening both because they seem designed to interfere with the body’s natural functions and because stories circulate in the community about side effects. There are conflicting authorities regarding medical matters. Traditional practitioners and midwives seldom endorse the new methods but continue to provide the old ones, while the young and often ill-prepared interns in the nearby government health post often fail to present a convincing case for the methods they offer.

Shedlin and Hollerbach’s account is based on extensive anthropological fieldwork by one of the investigators. It is reflective of a large literature on the conflict between modern and traditional medical systems and the resistance to modern contraceptives in communities in which the modern medical paradigm is not dominant. But fear of contraceptive methods is not restricted to traditional populations; it is also found in the most highly medicalized of societies. The perennial concern for the health consequences of the pill in the United States and Britain, the backlash against the IUD

that resulted from the legal proceedings of the late 1980s in the United States, and the recent wave of Norplant® removals in the United States are, in all likelihood, reflections of this underlying phenomenon. Work in cognitive psychology points to fear of severe or life-threatening outcomes, even when such outcomes are statistically remote, and suggests that it is human nature to attribute great importance to such outcomes in forming impressions and making choices. Montgomery (1996) has surveyed this literature with a view toward understanding the problem that individuals and populations may have in perceiving the mortality changes that are occurring in their communities. Citing the review by Camerer (1995), Montgomery concluded that individuals tend to employ relatively simple learning strategies, and that they “consistently make fundamental mistakes in probabilistic reasoning, tending to assign too much weight to certain types of evidence and not enough to others” (p. 15).

The “mistakes” people are apt to make are of the very sort that would lead them to assign “too much weight” to severe or life-threatening outcomes resulting from the use of technologies such as contraception. There are several ways in which this may come about. First, individuals may give less weight to events that do not occur than to events that are noteworthy, because they have a differential proclivity to retain the information. In this instance, the notion is that people have a greater capacity to retain information about someone who develops a serious illness while using a contraceptive method than about someone who has used a method uneventfully. Second, individuals tend to give more weight to a small sample of evidence with which they are directly familiar than to a statistical portrait of the experience of the larger population. Third, “people are highly sensitive to variations in the extremeness of evidence and not sufficiently sensitive to variations in its credence or predictive validity . . .” (Griffin and Tversky 1992: 413, quoted by Montgomery 1996: 19–20). Moreover, they are likely to pay more attention to negative events and information than to positive information and to be especially attuned to the occurrence of events that are both highly undesirable and not easily prevented or controlled.

If the psychological literature reviewed by Montgomery suggests that people are especially sensitive to information about highly deleterious or possibly lethal consequences of using contraceptives, it also suggests that they will pay special attention to events that befall members of their immediate families and communities, and thus provides support for the idea that social interactions are vital to decisions regarding contraceptive use. Indeed, in the light of this literature, the quintessential social interaction related to contraception is rumors circulating through a community about someone who suffered a serious illness as the result of having used a method. A last finding from the psychological literature that adds further importance to such rumors and echoes Shedlin and Hollerbach’s emphasis on cognitive

models of human reproduction refers to “the importance of pre-existing beliefs and theories about causation, which function as mental frameworks through which new evidence is interpreted” (Montgomery 1996: 24). Thus, if a woman’s mental model of the menstrual cycle and the uterus is such that she believes inserting an IUD would have severe consequences, then it will take a great deal of personally verified information to the contrary for this person to be willing to accept this method.⁶

The role of medical practitioners

At least in part because of the importance of the fear of health consequences, doctors trained in Western medicine have played an important part in shaping patterns of contraceptive practice. Often they either constitute or control the sources of new contraceptive methods, and they are the authority that must attest to their safety and efficacy. They may prescribe, recommend, or offer a contraceptive method or surgical sterilization to their patients.⁷ This prescription or recommendation may specify the exact brand or dosage, as well as the timing and manner of its use or execution. In so doing, the medical practitioner or his or her superiors may be singling out one technology, such as a specific kind of IUD or manner of performing a sterilization, from an array of possible choices. These choices are not normally left to individual patients.

Once a method has been prescribed or recommended, the medical practitioner explains how the method works, how it should be used, and what side effects to expect. He or she may also provide information and assurance as to the safety and effectiveness of the method. The final role of the doctor or medical practitioner is to monitor use of the method by the acceptor. The doctor may have to check that there are no complications from use such as pelvic inflammatory disease in the case of an IUD, to provide explanations and assurances regarding the “normality” of certain relatively benign side effects such as increased menstrual bleeding, and to propose the use of an alternative method should the acceptor be dissatisfied or suffer serious complications of use.

In these functions and exchanges between a physician and a patient, there is a widely recognized difference between the two parties. As Kenneth Arrow wrote nearly four decades ago with regard to medical care more generally: “Because medical knowledge is so complicated, the information possessed by the physician as to the consequences and possibilities of treatment is necessarily very much greater than that of the patient, or at least so it is believed by both parties” (1963: 951). It is this asymmetry in knowledge that makes “the setting up of a relationship of trust and confidence” so important to both patients and doctors (1963: 965). In the realm of contraceptive counseling, patients’ fears of contraceptive methods and sometimes

wavering motivation to use them provide ample scope for a doctor to play a large role in guiding individuals through the process of adopting and practicing a method.⁸

The second general feature of medical care and the role of physicians that is relevant to contraceptive adoption also stems from the complexity of medical knowledge and technology and the uncertainty that surrounds them. In making recommendations concerning contraceptives, doctors face a wide range of choice. Moreover, with regard to the safety and efficacy of different contraceptives, the professional literature is too large to master,⁹ and it would be difficult for a single practitioner to accumulate enough patients accepting a new contraceptive method to be able draw his or her own inferences about how well it works. Here, as in many other areas of medicine, “The inference problem confronting doctors who wish to determine the efficacy of any specific intervention is hellishly complex . . .” (Phelps 1992: 34).

Phelps has argued that an important consequence of this contextual feature of medical practice is that doctors tend to conform closely to “local patterns of practice.” On the one hand, “In this model, when ‘schools of thought’ get established in a specific locality, the costs of gathering relevant evidence to alter those beliefs will often be large, if not prohibitive. Thus, local ‘schools’ can emerge and persist that hold different beliefs about the efficacy of an intervention” (1992: 31). On the other hand, conforming to local patterns is an excellent defense against charges of negligence, a standard commonly applied in malpractice law. What is surprising, though, is the enormous variation across communities and countries in the frequency with which a wide variety of medical procedures are performed. Such variation cannot be explained by plausible differences in demand, and authors such as Scitovsky (1992) and Phelps (1992) can only account for it in terms of incomplete diffusion of information. Seen in this larger context, the wide variation in contraceptive use patterns shown in Table 1 seems less anomalous.

Social interactions, positive feedback, and path dependence in models of contraceptive adoption

I now consider the nature, extent, and consequences of the various positive feedback loops that are present in the broad process of contraceptive adoption. If multiple and forceful sources of positive reinforcement are operating in this process, then it becomes easier to understand why societies have arrived at such widely varying method mixes.

The recent economic literature on increasing returns and path dependence suggests at least four possible sources of positive feedback in adopting new and competing contraceptive technologies (Arthur 1983, 1989, 1993; Bikhchandani, Hirschleifer, and Welch 1998; David 1985, 1993; Dosi 1991). First, spillover effects known as *coordination externalities* provide in-

centives for agents to adopt the dominant technology and do whatever other agents are doing. If, say, the pill is the dominant method, a prospective user can count on a large number of outlets that stock adequate supplies, as well as availability of trained professionals able to recognize and treat the method's side effects. The same reasoning holds for doctors. As more and more of their colleagues prescribe or provide a method, they can draw on the experience that these doctors have in supervising the use of the method or performing the requisite procedure.

A second source of positive reinforcement derives from *learning*. The more experience is gained with a contraceptive technology, the more it is improved. That is, the technology itself changes for the better the more it is used.¹⁰ Learning is perhaps most obvious with respect to providers. For example, the more practice providers gain inserting IUDs, the more skillful they become with the procedure; the more experience they have prescribing pills, the more they learn about varying the dosage to relieve specific side effects. But there is also learning by producers and users of contraceptive methods that leads to improvement of the technology. Examples are found in the evolution of formulations for the pill from high to very low doses of estrogen, and in the improvements in the design of IUDs.

The third source of positive reinforcement arises not from any concrete aspect of the technology itself but from *information* about its use. This is the positive feedback that lies at the heart of most accounts of diffusion and social interaction; it has particular relevance to technologies that are perceived to be risky.¹¹ The information in question is not simply about the existence of a technology but also about the risks and consequences of adopting it (Montgomery and Casterline 1996). The need for information concerning the practicality, safety, and effectiveness of new contraceptive technologies is felt not only by prospective acceptors but also by the medical practitioners who provide these technologies (Phelps 1992). From either perspective, however, the more widely a method is used, the more will be known about how it fares in practice. Other things equal, risk-averse persons may be expected to opt for a technology that their peers have used successfully. On the other hand, as more women adopt a new method, the number of individuals who experienced or are perceived to have experienced an undesirable health outcome from using the method may also increase, leading to rumors that may have a strong adverse effect on a method's acceptability.¹²

Social influence is one further source of increasing returns. Montgomery and Casterline (1996) suggest that, through peer group pressure, women may feel obliged to do what everybody else in their social network does. Incentives to conform may be even stronger for medical practitioners than they are for women. As noted above, according to Phelps, "local patterns of practice" are often the standard against which the actions taken by an indi-

vidual physician are compared in the event that he or she is being evaluated or that an inquiry is held to determine negligence (1992: 35).

To summarize, the process of adopting new contraceptive technologies involves four distinct but complementary sources of increasing returns: coordination externalities, learning, information, and social influence. Moreover, each of these operates with respect to the providers as well as the users of contraceptive methods. What can be said about a process of technology adoption that contains such sources of positive feedback? A general answer is available from the literature on increasing returns, path dependence, and information cascades. In theoretical models and simulations, “the economy, under circumstances of increasing returns, can become ‘locked-in’ to a future technological path that is neither guaranteed to be efficient nor entirely predictable in advance” (Arthur 1983: 14). In these models, which are said to be path-dependent and non-ergodic (David 1985), relatively small disturbances or chance events become magnified by the positive feedbacks, and there is no sure way to predict the technology that will come to dominate the market. Rather, history matters, sometimes more than underlying preferences, endowments, and opportunity sets.

The transformation of the meaning and nature of a technology

There is a striking similarity between the issues raised in Arthur’s and David’s discussions of the implications of positive feedbacks and those that anthropologists have brought up in their critique of diffusion. Kreager (1993), in his succinct review of the debates on this subject that have occurred since the 1890s, warns that in their enthusiasm for the concept of diffusion in population studies, contemporary analysts would do well to avoid past mistakes. Drawing on Dosi’s review of a number of studies of innovation diffusion (1991), Kreager argues that there is more to the adoption of new technologies than individual choices based on instrumental factors. He observes that “decisions are the outcomes of collective processes”; and that, in the course of adoption, “technologies and practices acquire a range of new and culturally-specific meanings” (1993: 315). He quotes Malinowski’s statement that “whenever one culture ‘borrows’ from another, it always transforms and readapts the objects or customs borrowed. . . . In this process of readaptation the form and function, often the very nature, of the object or idea is deeply modified—it has to be, in short, reinvented” (1993: 315).

The conclusion in this discussion is similar to that drawn from the analysis of increasing returns: the adoption process is both cumulative and open-ended. The anthropological critique, however, introduces the additional dimension of *meaning*, with the attendant anthropological discourse concerning culture as the “tacit knowledge that enables people to make active responses

to changing circumstances as they arise, successively reinterpreting the meaning of those circumstances and the several courses of behaviour that count as a response to them” (Kreager 1993: 319; Hammel 1990). The implication for contraceptive choice may be clarified by way of an example. The condom is now being promoted around the world as a means of accomplishing two distinct objectives: the prevention of pregnancy and the prevention of sexually transmitted diseases. Forty years ago in South American countries such as Argentina condoms were generally available in the bathrooms of bars to men who might be considering having sex with a prostitute. Condoms were seen as a response to the health risks entailed in such encounters. They were not seen, or considered acceptable, as a means to prevent pregnancy within marriage. Argentinean couples in the 1950s, like those in much of Europe a few decades earlier, attained quite low levels of marital fertility while relying on withdrawal rather than the condom. A different outcome evolved at about the same time in Japan, where the condom came to be the principal means of preventing pregnancy within marriage (Coleman 1981).

The question of scale

Where does this discussion of the literature on contraceptive choice, cognitive psychology, and path dependence lead us? The process of adopting new contraceptive technologies involves a variety of positive feedback loops for both clients and their doctors. This reinforcement means that what happened some time ago has a determinant bearing on what takes place in the present, even when there has been a major change in the environment. There may also be specificity in the way that methods are actually practiced due to adaptations that have been made over time of particular contraceptive technologies, and the meanings that they have acquired.

The scale of the community within which these choices and adaptations are made, however, will depend on communication between agents. Bongaarts and Watkins (1996) stressed that social interactions related to fertility change occur at a variety of levels, not only within localities but also across large territories, including national boundaries. On the other hand, much of the impetus and underpinning for theorizing about the role of networks in contraceptive choice has been the persistence of otherwise unexplainable differences in method mix across communities (Rogers and Kincaid 1981; Entwistle et al. 1996). Indeed, the first attempt to explicitly model contraceptive adoption as depending on word-of-mouth communication across networks focused on replicating the persistence of “village-level” variation in method mix (Kohler 1997a, 1997b). In this study, Kohler showed that, under a series of possible conditions concerning the precision of the information exchanged, decision rules, and the role of social influence,

word-of-mouth communication leads to path-dependent adoption of contraceptive methods within communities. Here, the method mix that a community becomes committed to is heavily influenced by the initial conditions and “does not converge to the socially optimal adoption level” (pp. 91–92).

Broadening the conceptualization of adoption to include the choices made by doctors as well as users, and considering interactions beyond those based on word-of-mouth communication, lead to the expectation that the respective networks range well beyond villages or local communities. While broader ties may help to explain the speed and reach of the contraceptive adoption process observed in recent years (Bongaarts and Watkins 1996), they also raise the possibility that the commitment or “locking-in” to particular configurations will have wider and more serious consequences. In the remainder of this article, I review the history of the promotion and adoption of modern contraceptive methods in Mexico and Brazil from this perspective. In each case, I consider what happened in the early stages of adoption and then assess the problematic aspects of contemporary contraceptive practice that had their origin in the earlier period. In both countries, doctors appear to have played an important role in the choice process and to have been heavily influenced by the behavior of their peers.

Mexico

Extending the national family planning program to rural areas: 1977–86

The Mexican government launched a population policy in 1973 with a view toward reducing the rate of population growth, but not until 1977 was a concerted decision made to promote family planning in the rural areas of the country.¹³ The rural population had much higher rates of fertility and much lower contraceptive prevalence than the urban population. Although rural fertility was very high with a total fertility rate of about 7.4 births per woman (CONAPO 1997), it had declined slightly from the peak levels it had reached by the start of the decade. Contraceptive practice, which was virtually nil as late as 1970 (García 1976), had increased to the point where 14 percent of married women were using some kind of method. Rural Mexico was characterized by widespread poverty, a virtual absence of employment in nonagricultural activities, and dispersed villages. Most outside observers as well as those involved in implementing the population policy regarded the task of promoting increased contraceptive practice and lower fertility in rural areas as a major challenge (Alba and Potter 1986; Jain 1998).

The public health institutions to which this task was delegated embarked on a major initiative to extend their reach into rural areas. The Min-

istry of Health's (SSA) Rural Health Program began by recruiting community health workers in over 11,000 communities (Elu de Lenero 1982). In the later years of the 1976–82 administration of President Lopez Portillo, after an unforeseen change in the cabinet, this program gave way to a much better-endowed rural health program administered by the Mexican Institute of Social Security (IMSS). Instead of relying on the existing infrastructure as the SSA program had, this initiative involved building over 3,000 rural health clinics and some 73 regional hospitals (Alarcon and Martinez 1986). Drawing on the regular IMSS infrastructure, but targeted toward people living in places with fewer than 2,500 inhabitants who were not yet served by any of the public institutions, the IMSS-COPLAMAR¹⁴ program greatly increased the number of physicians—for the most part interns performing their required year of social service—practicing in rural Mexico.

In these rural programs, SSA and IMSS each placed strong emphasis on family planning, intending to make services and supplies available in the villages and promoting their use (Alarcon 1982; Potter, Mojarro, and Nuñez 1987). To motivate the doctors, nurses, community health workers, and *parteras* (traditional birth attendants) to recruit new acceptors of hormonal methods, the IUD, and female sterilization, the administrators assigned hospitals and clinics monthly targets for new acceptors. These targets were usually method-specific, and, especially in the IMSS program, the highest priority was assigned to the IUD and female sterilization. The critical statistic for public hospitals and maternity clinics was the percentage of mothers who accepted one of these methods immediately following delivery.

To get a perspective on how providers responded to the program, in 1984 colleagues at IMSS and I visited a representative sample of villages with fewer than 2,500 inhabitants in the 1970 census that had fallen within the sampling frame of the 1981 Rural Survey of Family Planning. Most of the doctors and nurses and many of the midwives providing maternal and child health services to the selected villages were interviewed, irrespective of whether they practiced in the village or in a nearby town, or whether they were in the public or private sector. We were interested in learning how these providers perceived their own situation vis-à-vis the program, how they viewed their clients, and what they did to recruit acceptors. The information obtained in this survey provides a glimpse into the early history of the spread of modern contraceptive practice in rural Mexico.

For the large majority of doctors in the public health institutions whom we interviewed, people's fear of modern methods was the greatest obstacle to recruiting contraceptive acceptors. In the perception of doctors, resistance to family planning derived much more from rumors concerning the health effects of contraception than from lack of motivation to regulate fertility. Fully 90 percent of the doctors and 94 percent of the nurses in our sample believed that their patients were afraid to use particular methods. They were

especially emphatic with respect to the fear that women had of the IUD, and fear, rumors, and misinformation were the main reasons they gave for the lack of demand for the method.¹⁵ Ninety-one percent of the doctors and 83 percent of the nurses responding reported that their patients were afraid of tubal ligations.

Most doctors and nurses said that when they encountered a woman who was afraid to use a method, they would try to convince her that it would do no harm. Besides providing an understandable explanation of how the method “worked” or what was involved in its use, their principal means of convincing clients of the safety of a method was to point to women in the community who were using it successfully. By drawing upon their own clinical practice to promote the exchange of positive experiences between women, they quite consciously attempted to foster diffusion. Their strategy in promoting family planning was to continue mentioning the topic and insisting on its merit. Once a few people came to accept the idea, they could be used as examples to bring others around.

The doctors, nurses, community health workers, and traditional midwives who promoted family planning in rural Mexico were themselves closely tied together by the public health institutions that employed or engaged them. The doctors in the small rural clinics were visited regularly by their supervisors, and the community health workers and midwives were called to attend quarterly meetings for training and to exchange experiences. Those responsible for districts or regions were, in turn, called to state or national-level meetings. As a result of this socialization and in response to the guidelines and priorities transmitted down the chain of supervision, the practitioners we interviewed gave nearly uniform answers to our questions regarding the type of methods they would recommend under different circumstances, and believed that the IUD and female sterilization were suitable postpartum methods. They also agreed on the number of children women should have and on how the birth of these children should be spaced.

In retrospect, the early phase of the Mexican program successfully met many of the objectives that had been set for it. The prevalence of contraceptive use among married women of childbearing age in rural areas increased from 14 percent in 1976 to 27 percent in 1981 and 33 percent in 1987. The emphasis was on recruiting acceptors and lowering the rural fertility rate, and at least the hospital-based portion of this program appears to have made a significant contribution to these goals (Potter, Mojarro, and Nuñez 1987). Clearly, the Mexican program also fostered an interventionist style of acting on the part of the personnel who were charged with putting it into practice. Mexican authorities responsible for health and population policy would later find this manner of promoting family planning unacceptable and ineffective, but during the first decade of the program the style became entrenched.

The problematic reliance on postpartum contraception in contemporary rural Mexico

The opening of the Mexican political system and developments in the international arena such as the international conferences in Cairo and Beijing changed the context in which the Mexican national family planning program functions. The number of institutions and organizations that take an active interest in family planning, population, and the status of women has increased markedly. Many of these institutions and organizations are both responding to and fomenting demands for greater autonomy and a wider and improved array of services related to maternal health care and contraception. Some, such as the Catholic Church, the Partido de Acción Nacional, and a number of the organizations representing women’s interests, are openly critical of the government’s actions in this area. As a consequence, both the visibility and the political repercussions of population policy issues are now much greater than they were a decade ago.

The second major change in context is the decline in fertility and the increase in contraceptive practice that have taken place. The total fertility rate for rural Mexico in 1995 is estimated to have fallen below four, and contraceptive prevalence among married women was about 53 percent.¹⁶ Shown below, for married rural women, is the proportion of current users relying on various methods of contraception in 1995 as well as in 1981, when prevalence was about half the 1995 level. The table shows a concentration of use in 1995 among just two methods, female sterilization and the IUD. The proportion of use accounted for by these two methods more than doubled over the 14-year period, while the share of hormonal methods fell sharply.

	Sterilization	IUD	Pills	Injectables	Barrier methods	Others	Total (any method)
1981	20.5	8.8	35.1	11.4	2.1	22.1	100.0
1995	39.6	23.5	10.9	5.5	4.6	15.9	100.0

SOURCES: Encuesta Rural de Planificación Familiar, 1981; Encuesta Nacional de Planificación Familiar, 1995

In light of the increase in prevalence and the decline in fertility, the challenge facing the government program in rural areas is no longer solely to introduce the concept of, and overcome resistance to, fertility limitation. Rather the current goals are to reach those segments of the rural population that have low rates of contraceptive prevalence and to promote changes in the timing of fertility by delaying the first birth and increasing the spacing between subsequent births.¹⁷ With respect to the latter goals, however, the heavy emphasis on postpartum IUD insertions and tubal ligations pre-

sents cause for concern. IUDs are rarely used prior to the first birth, and the demographic impact of the high rates of surgical sterilization is limited since the procedure is mostly performed on higher-parity women who would not have many additional children. Indeed, the 1995 survey indicates that among rural women who were sterilized since 1990, 52 percent had five or more children and 27 percent were over age 35.

There is also concern among Mexican authorities regarding access to both sterilization and the IUD since most of these procedures are performed immediately following delivery in public hospitals. The use of these methods is limited among women who deliver in private maternity clinics or who deliver at home with a traditional midwife—the latter are usually the poorest women and those who live in remote villages. The table below shows the distribution of mothers in 1990–95, in percent, by contraceptive use according to place of delivery. In particular, it highlights the proportions of mothers who accepted either an IUD or sterilization following the birth of their last child, distinguishing between postpartum and later procedures. This table refers only to the rural respondents from the nine states that were assigned high priority by the national family planning program and that were sampled most heavily in the detailed survey of family planning (ENAPLAF) undertaken by CONAPO in 1995.¹⁸

Contraceptive use (percent) among mothers by place of last delivery

	IMSS hospital N=668	Other public hospital N=534	Private hospital N=492	At home/ traditional midwife N=1147	All places N=2841
Postpartum IUD	28.7	10.3	3.8	0.1	9.4
Postpartum sterilization	20.3	22.3	13.3	1.8	11.6
Later IUD or sterilization	9.8	9.8	10.1	8.5	9.3
Currently using another modern method	10.6	15.9	23.6	9.4	12.9

The last row in the table shows the percentage of women who had a child since 1990 who are currently using a modern method of contraception other than the IUD or sterilization. Postpartum procedures are far more frequent in public than in private hospitals, but private patients make greater use of other modern methods. The large number of women who deliver at home, with a traditional midwife, have no access to postpartum IUDs or sterilization, make only moderate use of these methods later in the birth interval, and are relatively unlikely to be using any other modern contraceptive methods.

Besides its limited demographic impact, another problem with the government program relates to the way acceptors of IUDs and female steriliza-

tion were recruited in public hospitals. In the rural areas of the nine states, 52 percent of current users of the IUD had the device inserted immediately following their last delivery while they were still in the hospital. This proportion was 67 percent for IUD users who obtained the method from IMSS hospitals and 36 percent for users who obtained the IUD from another public institution. Between them, these two sources account for 93 percent of all current IUD users in these rural areas. Some questions included in the 1995 survey asked about the procedures that were followed when women had their IUDs inserted. The responses indicate that the interventionist style fostered in the early phase of the Mexican program has remained prevalent more than a decade later. The decision to use the IUD was often made very close to the time of insertion, without following an appropriately elaborate procedure guaranteeing informed consent.¹⁹

Evidence from the survey regarding postpartum sterilization also warrants concern. Of all rural women who were sterilized since 1990 in the nine states, 84 percent were operated on in a public-sector institution: 53 percent in IMSS hospitals and 31 percent in other public institutions. Of these public-sector sterilizations, 70 percent were performed immediately following delivery in IMSS hospitals and 74 percent in other public hospitals. The decision to operate was taken while the woman was in the hospital in 42 percent of the IMSS postpartum sterilizations and 32 percent of the other public cases.

These survey results are indicative of heavy-handed tactics by medical personnel, and certainly suggest procedures that diverge from the guidelines for the government family program that were adopted in 1994 following the Cairo conference. In that year, in line with international recommendations, administration of family planning services was relocated to a Reproductive Health Directorate in the Ministry of Health, and a uniform set of Normative Guidelines was established to cover the implementation of family planning services in all public-sector institutions. The emphasis in the Guidelines as well as in the rhetoric of the government program was on guaranteeing freedom of choice and improving the quality of the care provided, rather than on meeting specific targets for the number of acceptors and contraceptive prevalence.

To investigate the seeming divergence between rhetoric and practice and to assess the quality of family planning services provided to the population of the nine priority states, in late 1996 CONAPO undertook a survey of the clinics, hospitals, and practitioners providing family planning services in the communities included in the ENAPLAF sample. Analysis of these data is in progress, but several conclusions can be drawn from the initial tabulations. Prominent among them is that the Normative Guidelines are not widely known or disseminated. Among the practitioners who responded to the survey, only 40 percent of medical doctors in public institutions reported having seen a copy of this document in the institution where they

worked, and less than a third of these doctors claimed that they consulted it regularly. On the other hand, all doctors questioned were well aware of the targets that existed for family planning acceptors. Virtually all of them said that their institution had numerical family planning targets, and more than half of the doctors had targets set for their own personal performance.

In many respects, the story told by the doctors in 1996 was similar to the one we heard in 1984. The doctors recognized the need for family planning in rural areas, and they believed that rural women would be better off having a limited number of children. In 1996, as before, the doctors believed that women were afraid of the IUD and surgical sterilization because of rumors and inaccurate information, but that these were the most effective methods and the ones they recommended most frequently. However, with the larger presence and coverage of the public health institutions, and many more acceptors of the two methods they promoted most intensively, the government program had come to predominate over private medical sources of modern contraception or other indigenous or market-based approaches to seeking contraceptive advice or supplies.

This point may be illustrated with an exceptional experience that proves the rule. In 1998, my colleagues and I went to a remote and impoverished town where the respondents in 1995 had included an unusually high proportion of users of the rhythm method. Rhythm was still the predominant method. Its use in the village had been initiated by a local mother who had become a community leader and recommended the method to others. Community members, in turn, had resisted the efforts of the nearest IMSS clinic to persuade mothers to adopt other, more effective methods. This “independent” village contraceptive history, which closely resembles those reported by Entwistle et al. (1996) for the Nang Rong villages in Thailand, was anomalous in the Mexican context where the government institutions almost always overrode local initiatives.

The 1995 survey of women and the 1996 survey of medical practitioners both point to the persistence of a particular way of promoting and practicing contraception that had originated 15 to 20 years ago. This pattern was the outgrowth of directives issued in the early stage of Mexico’s national family planning program. These in turn became institutionalized in the IMSS and the Ministry of Health and as recently as 1998 appeared to be resistant to the directives and guidelines issued in response to the pronounced changes that have taken place in the demographic and political context. No one in or out of the Mexican government would argue that the situation is set in stone, but meaningful reform clearly constitutes a difficult challenge. Not only is there a need to raise women’s awareness of the options that should be open to them, but a substantial investment is required to motivate medical practitioners and program administrators to develop alternative ways of providing family planning services.

Brazil

Adopting modern contraception in the presence of supply restrictions: 1964–80

The early stage of the process of adopting modern contraceptive methods in Brazil is less well documented than it is in Mexico. Nevertheless, one may identify circumstances that led to predominant dependence on the pill and female sterilization and that promoted a clearly inferior technology for performing the latter. The initial period of the Brazilian fertility transition may be identified as extending from the mid-1960s until 1980. A sample survey of urban women showed the fertility levels and contraceptive prevalence existing in 1964 in Rio de Janeiro, where control of marital fertility first appeared in Brazil. The total fertility rate was about 3.7, but there was little use of modern contraception. Fewer than 3 percent of married respondents were using the pill, 6 percent were sterilized, 10 percent used a barrier method, while 20 percent employed traditional methods such as the douche, rhythm, and withdrawal (CELADE and CFSC 1972). Fertility in the rest of the country was much higher, and use of contraception was much less prevalent. The total fertility rate for Brazil as a whole in the early 1960s was about six (Bercovich, Martins, and Oliveira 1994).

By 1975–80, the national total fertility rate had fallen to about 4.3, and fertility was declining in virtually all of the heavily populated regions of the country including the impoverished Northeast, where fertility had been very high (Committee on Population and Demography 1983). Contraceptive practice centered on the pill and female sterilization. The survey information for this period was collected in contraceptive prevalence surveys conducted in the highly industrialized southeastern state of São Paulo and in the northeastern states of Piauí, Bahia, Paraíba, Pernambuco, and Rio Grande do Norte.²⁰ Use of contraception among women in union aged 15–44 varied from 64 percent in São Paulo to 31 percent in Piauí. The percentage of these women using particular methods of contraception in these two states is shown below:

	Pills	Female sterilization	Condom	Rhythm	Withdrawal	Other	Any method
São Paulo	27.9	15.6	6.5	5.2	7.3	1.4	63.9
Piauí	10.1	15.4	0.1	2.6	2.5	0.2	30.9

SOURCE: Population Information Program (1981).

The surveys showed negligible use of IUDs or injectable contraception in either state. The ratio of sterilization to pills is much higher in Piauí than

in São Paulo, while the use of traditional methods is much lower in Piauí. Before turning to the evidence on the proportion of sterilizations conducted during cesarean sections in this period, a brief description of the institutional context in which this process of contraceptive adoption was taking place is pertinent.²¹

The 1964–80 period in Brazilian history began with a coup that led to 25 years of military government. Among the coup's more immediate effects were the suppression of many forms of public debate and expression and the initiation of massive efforts to promote industrialization and national integration. The Brazilian state made substantial commitments to expanding consumer credit, telecommunications, social security, and health care, and very substantial increases in the reach of all of these services were achieved in the post-1964 period (Faria 1989).

In the context of extreme income inequality and expanding public investments, there was a major transformation in Brazilian medicine and public health policy toward specialized, hospital-based curative care in place of the prevention and control of the "diseases of underdevelopment."²² The 1964–80 period witnessed a sharp rise in hospitalizations, especially for surgical interventions in private hospitals affiliated with the social security system. Following the reform and unification of the social security system in 1967, hospital admissions grew by more than 400 percent in ten years (Rodrigues Filho 1991). Between 1971 and 1980, the number of hospital admissions paid for by the social security system in urban areas increased from 2.9 million to 9.6 million, while the percentage of the entire population admitted to a hospital during one year increased from 3.2 percent in 1971 to 8.8 percent in 1979. By the end of the period, 76 percent of all hospital care was paid for by the social security system, and 80 percent of medical facilities with beds belonged to the private sector (World Bank 1994). This rapidly expanding, publicly funded, yet highly privatized medical system had to meet the demand for contraception and birth limitation that emerged during this period.

Despite the attention given to the evolving position of the Brazilian government on population issues (Fonseca Sobrinho 1993) and to the activities of organizations such as BEMFAM, the International Planned Parenthood affiliate (Martine 1996), most of the response to the demand for contraception in Brazil took place in the private medical sector. Pills manufactured in Brazil were sold over the counter in pharmacies beginning in the early 1960s. Annual production rose steeply from 1.7 million cycles in 1964 to 13.5 million cycles in 1970 and to 61.2 million cycles in 1980. Besides regular commercial distribution through pharmacies, a significant number of cycles were distributed by BEMFAM, but in 1976 these amounted to only about 9 percent of all the cycles produced in Brazil (Merrick and Berquo 1983).²³

One of the main reasons underlying the demand for surgical sterilization in Brazil was that many women found the pill to be an unsatisfactory method of birth control for long-term use.²⁴ The provision of sterilization, however, was complicated by regulations that made its practice virtually illegal and prevented physicians and hospitals from seeking reimbursement for procedures under the government's medical insurance program that funded about 80 percent of the surgical procedures being performed in Brazil. For physicians as well as hospitals, the remunerative way out of this regulatory dilemma involved the use of cesarean section deliveries. During this period, the reimbursement for a cesarean delivery was greater than for a vaginal delivery. This fact, combined with the argument that a cesarean section exposed a woman to high health risks in case of further pregnancies, contributed to creating a rationale for performing sterilizations during cesarean sections. The doctors and hospitals profited since the cost of the tubal ligation was subsumed under the cost of the cesarean delivery by the hospital, and the attending physician might also receive a side payment.²⁵ For women, the opportunity to obtain a sterilization whose costs were covered by health insurance presumably made a cesarean delivery an attractive alternative, even among those whose previous delivery had been vaginal. Moreover, among the growing number of women who were giving birth to a first or subsequent child by cesarean section, the possibility of a progressively weakening uterus constituted an additional motivation for obtaining a sterilization (Faúndes and Cecatti 1993).

In view of the formal restrictions on sterilizations and the limited number of contraceptive options available, this system made sense to both women and obstetricians. Undoubtedly, it also led to a substantial increase in the prevalence of unnecessary cesarean section deliveries, with consequent increases in maternal morbidity. Prevalence surveys conducted in 1980 in the northeastern states of Bahia, Paraíba, Pernambuco, and Rio Grande do Norte record that of all women who had been sterilized, about 60 percent were sterilized during a cesarean delivery (Janowitz et al. 1985). Data for later periods suggest that the proportion of sterilizations performed during cesarean deliveries was considerably higher than this level in other regions of the country.²⁶

The contraceptive adoption process in the early years of the Brazilian fertility decline contrasts sharply with that in Mexico. Most services were provided by private physicians, hospitals, and pharmacies rather than by government doctors, hospitals, and clinics. Moreover, government regulations in Brazil tended to restrict rather than promote the use of contraception. Yet, during this period, a formally illegal method of birth control gained widespread acceptance by women and physicians, all of whom were clearly responsive to the prevailing set of incentives and who together developed a seemingly perverse but innovative contraceptive culture. This process in-

volved the rejection of alternative technologies, notably the IUD, which was promoted so energetically in Mexico but which never gained a foothold in the Brazilian market in spite of a number of experimental research projects that pioneered its use.²⁷

The narrow mix of methods and the high rate of cesarean sections in contemporary Brazil

Between 1980 and the mid-1990s, Brazil experienced the gradual advent of democratic elections for municipal, state, and federal government posts and the end of a long period of military rule. Along with democratization came a large increase in the number and vitality of the organizations involved in public discussions regarding family planning, population, and women's health and empowerment. Out of the ensuing debate, the Program of Integrated Assistance to Women's Health (PAISM) was conceived in 1983 and instituted in 1986 with the objective of providing comprehensive health care for women of reproductive age, including the provision of a wide array of contraceptive services by publicly financed health centers. While PAISM remained more a set of aspirations than a functioning system during its first decade (Costa 1992 and Corrêa 1993), it served to crystalize debate as democratization proceeded. Finally, the 1994 International Conference on Population and Development served as a catalyst to define and propagate Brazil's position on issues related to family planning and reproductive health.²⁸

While the Brazilian government guarantees women the right to an adequate supply of contraceptive services to be provided by publicly financed health services, in contrast to the Mexican policy it does not promote fertility decline, nor does it set targets with respect to population growth or the adoption of contraception. Implementation of PAISM also coincided with a reform in the government's procedures for financing health care that involved a considerable delegation of authority to state and municipal governments and limited the ability of the federal Ministry of Health to implement national policies of this sort. Two further policy developments related to the use of cesarean section deliveries and surgical sterilization deserve mention. First, starting in the late 1970s in response to the rapid increase in the rate of cesarean deliveries, the schedule for reimbursing deliveries was adjusted so as to reduce and eventually eliminate the premium paid for cesarean as compared to vaginal deliveries. Second, the Brazilian Congress passed legislation in August 1997 intended to legalize and regulate the use of sterilization in public hospitals. I return to this law and the current policy issues confronting the Brazilian government after reviewing the recent evolution of contraceptive practice.

Two nationally representative sample surveys collecting data on contraceptive practice in Brazil were carried out in 1986. In that year, BEMFAM

conducted a Brazilian round of the Demographic and Health Survey (DHS), and the Brazilian Institute of Geography and Statistics added a module on contraceptive practice to the annual National Sample Survey of Households. In 1996, there was a second DHS, again implemented by BEMFAM. While these surveys revealed a large increase in the practice of contraception, with prevalence among married women reaching 66 percent in 1986 and 77 percent ten years later, the 1996 survey also showed an apparent further narrowing of the mix of methods practiced in Brazil. The percentage of currently married women aged 15–44 currently using particular methods is shown below for the 1986 and 1996 surveys:

Year	Orals	Female sterilization	Condom	Rhythm	Withdrawal	Other	Any method
1986	25.2	26.9	1.5	4.2	4.4	3.6	66.0
1996	20.7	40.1	4.4	3.0	3.1	5.4	76.7

SOURCES: National Survey of Maternal and Child Health and Family Planning, 1986 (DHS); National Survey on Demography and Health, 1996 (DHS).

The proportion of all contraceptive practice accounted for by female sterilization among married women rose from 41 percent to 52 percent during the ten years. Use of oral contraceptives declined over the decade, but in 1996 it remained the only other widely used modern method of contraception.

The ever-increasing reliance on surgical sterilization evident in these data seems to run counter to PAISM’s stated goal of making a broad array of methods available to the population, and counter to the continuation of restrictions on the use and availability of surgical sterilization. On the other hand, considering the lack of experience with alternatives to the pill, as well as the apparent desire of mothers of two or more children to terminate their childbearing, it is logical that the use of female sterilization that had first manifested itself in Brazil in the 1970s would have increased in subsequent years. What is less understandable is why the unusual way of performing these procedures that emerged in the earlier period would also have persisted to the present time. Not only had there been changes in the meantime in the schedules for reimbursing hospitals for different types of delivery, but hospitals relying on the government health insurance system were coming under increasing pressure to control their costs by, among other things, limiting the number of unnecessary surgical interventions.

Data from the 1996 DHS referring to the sterilizations performed in the five years preceding the survey show that for the country as a whole, 60 percent of sterilizations were performed during a cesarean section. This fraction was by no means uniform throughout Brazil. While the fraction of sterilizations conducted during a cesarean was only 40 percent in the North-

east, it was 71 percent in the rest of the country. Leaving aside the question of how and why the practice of sterilization is so different in the Northeast, the finding that conforms to the general argument being advanced in this article is the persistence, in most parts of the country, of a technology for carrying out sterilizations that reflects incentives that prevailed decades earlier.

The practice and consolidation of surgical delivery and surgical sterilization in Brazil were, of course, mutually reinforcing phenomena. The high fraction of sterilizations performed during cesarean sections derives from the high fraction of all births delivered surgically. Not only does a cesarean present an opportunity to perform a sterilization, but the fact of having had multiple cesareans is a justification and motivation for sterilization. The following table shows the proportion of births delivered by cesarean section during 1991–96. There is a pronounced differential according to the type of hospital where the birth took place, and in the Northeast as compared to the rest of the country. The most telling statistic is that some 72 percent of all births at private hospitals that do not accept government health insurance are cesareans. Cesareans, on the other hand, constitute less than a third of all births in public hospitals, and 45 percent of all births at private hospitals, the so-called *conveniados*, that accept government health insurance. In general, there is little variation in the cesarean rate by birth order such that, in a given type of hospital, the overall rate is similar to that for first births. Finally, there is a large difference in the prevalence of cesareans between the Northeast region and the rest of Brazil, with cesareans being less frequent in the Northeast.

Birth order	Type of hospital			Region		
	Private (N=605)	Public (N=3064)	Conveniado (N=763)	Northeast (N=2755)	Rest of Brazil (N=2226)	Brazil (N=4981)
1st	70.6	33.1	46.2	24.2	46.9	40.1
2nd	74.0	36.1	50.0	26.3	51.9	44.2
3rd	76.4	33.8	52.8	26.1	49.4	41.3
4th and higher	53.5	21.6	22.5	9.3	27.4	18.7
All births	71.5	31.6	44.5	20.6	45.6	36.9

SOURCE: National Survey on Demography and Health, 1996 (DHS).

The original pattern in which sterilization was closely tied to cesarean sections is still dominant in most of Brazil. Apart from the Northeast, 71 percent of all sterilizations are performed during cesarean sections, and 46 percent of all births are cesareans. It is difficult to know how much of the increase in the prevalence of cesareans over the last 25 or 30 years was motivated by a desire to obtain a sterilization, and how much of the increase in

the use of sterilization was motivated by a history of cesarean sections. Evidence points to the importance of both lines of causation. Moreover, much of the increase in both surgical delivery and surgical contraception occurred long after the original financial incentives favoring cesarean sections had been removed and a national policy had been instituted to promote the use of alternative methods of contraception.

Consideration of the ways in which Brazilian women and their doctors came to depend on this technology is complicated by the interdependence of choice involving type of delivery and type and timing of contraception. Nevertheless, positive reinforcement seems to be present at a number of levels. For instance, with reference to the emergence of “cultures” of sterilization and of cesarean section deliveries, women who have had either a sterilization or a cesarean are especially likely to have other relatives, such as a mother or a sister, who have also undergone the procedure (Berquo 1993). Without doubt, the prevalence and frequency of cesarean section deliveries render these procedures less exceptional than they might appear in other settings, and women are likely to know few people who are practicing a method other than sterilization for fertility limitation. But, as in the Mexican case, the most compelling examples of positive reinforcement pertain to the choices made by doctors.

The medical community avers that Brazilian doctors are more skilled than doctors in the United States at performing cesarean section deliveries. Brazilian doctors pioneered the “bikini cut,” and they note disapprovingly the larger and higher scars left by many North American obstetricians. While such local pride may seem misguided, it is evident that considerable learning has taken place and that most Brazilian obstetricians have ample practice in performing cesarean section deliveries. Furthermore, because cesarean deliveries in private hospitals are common, the doctors who perform most of their deliveries by cesarean section are well protected against possible charges of malpractice and can count on collegial support. The social interactions and professional reference groups for obstetricians also extend beyond the hospital. They often have close links to their former classmates or professors in medical school, and most of them are active members of medical associations at the state, regional, and national levels. Medical schools and associations, in turn, have played a decisive role in the consolidation of a permissive environment for the use of cesareans (Faúndes and Cecatti 1993).²⁹

The reduced reliance on cesarean sections as the means of performing sterilization in the Northeast region requires further explanation. The emergence of this divergent pattern seems to reflect the smaller fraction of the population enjoying middle-class or high incomes in the Northeast and the much smaller proportion of deliveries that take place in private hospitals. In the face of substantial unmet demand for sterilization within the popula-

tion unable to afford private care or to obtain a cesarean delivery in a public hospital, local doctors and politicians have developed alternative ways to cover the costs of sterilization performed independently from a cesarean section (Potter and Caetano 1998). These arrangements are often based on a promise of electoral support whereby the woman expecting to be sterilized agrees to vote for the political party or individual providing or paying for the procedure. As such, the arrangements seem to constitute another instance in which the demand for fertility control has led to a perverse pattern of medical practice.

Policy responses in Mexico and Brazil

The situations described in these two countries have elements of path dependence leading to the persistence of outmoded contraceptive regimes. In both instances, many of the factors that prompted the initial policies and the responses they engendered have been removed, yet the patterns have persisted or have become even more pronounced. At present, there is consensus regarding the undesirability or the problematic features of each situation, and steps are now being taken in each country to correct matters. It is unclear, however, how “locked-in” these countries are to their present regimes, hence how much effort will be needed and how long it will take to bring about change.

In Mexico, the problem is to change the way that the public health institutions promote family planning. The two corrective initiatives already underway involve the implementation of strict informed-consent procedures with regard to IUD insertions and sterilizations, and efforts to increase the familiarity of practitioners with the official norms regarding the provision of contraceptive services. Longer-term efforts to upgrade the knowledge, skills, and qualifications of the doctors and nurses who staff family planning clinics and who see patients during prenatal care, delivery, and postpartum care are also envisaged, as are efforts to educate rural women about their reproductive rights.³⁰

These efforts involve large institutions, many thousands of professionals practicing in thousands of localities, and a health bureaucracy that is now largely decentralized to the state level. Change in the nature and quality of the services the health institutions provide is likely to be difficult. Some of the more objectionable practices related to IUD insertions and sterilizations have now been controlled by way of strongly worded administrative directives, but the way programs relate to their clients may well prove more resistant to change. These institutions have been providing family planning services for nearly 25 years, and their modes of operation have considerable inertia.

In Brazil, legislation was passed in August 1997 intended to legalize and regulate the use of sterilization. Its specific goals were to reduce the

number of sterilizations that are undertaken prematurely, to increase the use of methods other than the pill and sterilization, and to reduce the number of cesarean section deliveries. The law authorizes the public health financing system to reimburse hospitals and clinics for performing sterilizations, but specifically restricts the use of postpartum sterilization to those cases where there is a compelling medical justification. Moreover, it requires institutions that provide sterilizations to offer counseling not only on the nature and consequences of the procedure but also on alternative ways of preventing pregnancy. In implementing the new law, Ministry of Health officials have been careful to respect the stipulations regarding the conditions under which sterilizations may be performed, and only hospitals or clinics that have been authorized to seek reimbursement for the procedure may do so. But this means that, to date, there has been only a modest increase in the availability of sterilization in the public health care system.

Policymakers recognize the role that the previous limitations on financing sterilizations through the public health system played in motivating women to seek a cesarean-based sterilization in the private sector, or to exchange their vote for a sterilization in the Northeast. But immediately satisfying the frustrated demand for sterilization would have led to a large number of postpartum procedures and an even greater imbalance in the method mix. The extent to which policymakers are attempting to control and influence the behavior of medical providers and their potential clients underscores the degree to which they perceive both parties to be committed to the very patterns they hope to change. At the same time, their attempt to implement the new law only gradually means that in the short run little will be done to eliminate the distortions inherent in the current system.

Conclusion

The patterns of contraceptive delivery and practice that emerged in rural Mexico and in Brazil were strongly influenced by circumstances that were present in the early phases of the respective fertility transitions, but that have long since disappeared. In the present circumstances, these patterns are highly problematic. At the same time, they are well entrenched and have an inertia that makes it unlikely they will be quickly or easily reversed by the policies that are now being considered or implemented to correct the situation. This dynamic is consistent with and, I suggest, is driven by the wayward logic of path dependence.

The concepts of increasing returns and path dependence are helpful in thinking about the fertility transition and the pattern of change in contraceptive practice. They provide an alternative perspective on some of the questions now prominent in the debates over population policy and reproductive health. Path dependence provides a way of understanding how in-

dividual societies around the globe might have adopted widely differing mixes of contraceptive methods and have become committed to a variety of contraceptive cultures. It is not an explanation for this diversity, since it refers responsibility back to seemingly insignificant or accidental historical circumstances and the erratic dynamics of positive feedbacks; but it should stop us from looking for answers solely in terms of deep-seated cultural preferences or the present-day incentive structure.

The concept of path dependence is closely related to the anthropological critique of diffusion (Kreager 1993). By addressing the issue of optimality, this complementary formulation also seems to strengthen the original critique. Not only is the outcome of the process of technology adoption open-ended, but there is no guarantee that the process will lead to the best outcome. While the anthropological critique questions the linear characterization of the adoption process offered by the proponents of diffusion, the logic of path dependence highlights the possibility that the process may go astray. This should temper confidence that social networks and social interaction will serve as engines of change for the better. While they undoubtedly contribute to the speed of fertility transitions, there is no guarantee that in every respect they will lead to a satisfactory outcome.

Another point of contact with current debates has to do with the emphasis on rights, options, and quality of care embodied in the Program of Action hammered out at the International Conference on Population and Development. The arguments advanced in this article share much common ground with the feminist critique of the status quo vis-à-vis contraceptive practice and delivery systems. There is ample reason for concern about the quality of care and the range of contraceptive options available to women. The feminist critique also addresses the problematic aspects of the fertility transitions that have occurred over the last four decades and of the existing state of contraceptive regimes, and emphasizes the problems that have to be dealt with rather than the accomplishment of attaining lower rates of fertility. Feminist critiques are also articulate about the specific ways both providers and women are committed to the status quo, and the difficulties they face in attempting to establish alternative systems and adopt alternative behaviors (Diaz and Rogow 1995).

Finally, the notion that remote historical events may, over time and through the logic of increasing returns, result in contraceptive practices and delivery systems that are far from optimal has important if somewhat contradictory implications for public policy. On the one hand, the notion suggests that the transition should be monitored and regulated since it can take an undesirable path that may become entrenched in the absence of prompt and potent corrective actions. The case of Brazil seems to support such an interpretation: remedial measures were "too little, too late." On the other hand, while the presence of increasing returns implies that unregulated

market outcomes will not always be efficient, the impact of early efforts to hasten and direct the transition may also be amplified and perpetuated in an undesired direction by the type of dynamics described here. The persistence in Mexico of a heavy-handed, hospital-based family planning program serving the rural population provides a telling example of an approach that outlived the problems it was designed to solve.

Notes

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1 Some of the most influential publications have been Bongaarts and Watkins (1996), Watkins (1987 and 1990), Montgomery and Casterline (1996), Montgomery and Chung (1999), and Rosero-Bixby and Casterline (1994).

2 Earlier publications reaching a similar conclusion are Coale (1973), Knodel and van de Walle (1979), Watkins (1987), and Cleland and Wilson (1987).

3 For example, Bulut et al. (1997) seek, albeit unsuccessfully, an explanation of the high use of withdrawal in Turkey in terms of the reproductive morbidity experienced in the population. Goldberg and Serbanescu (1995) have considered how the economic and political history of Romania and the Czech Republic account for the low use of modern methods in those countries. But perhaps the most intriguing is Coleman's (1981) study of the factors underlying the high use of condoms in Japan. He ends up suggesting that

"a large proportion of Japanese married couples who are using condoms are not particularly pleased with the method" (p. 36), and that "Japanese couples' extensive reliance on condoms results largely from the unavailability of other methods, in a cultural context of embarrassment and passivity toward contraception" (p. 29).

4 Quantitative evidence on the importance of health concerns has been captured, albeit summarily, by Demographic and Health Survey questionnaires. See Bongaarts and Bruce (1995) and Lesthaeghe (1998).

5 Rutenberg and Watkins (1997) provide a recent account of the importance given to health concerns and side effects in evaluative conversations about contraceptive methods in Nyanza Province, Kenya.

6 Leal (1994) provides an excellent description and analysis of the ways that people's understanding of the reproductive system can impinge on use of pills.

7 A second but indeed prior function of doctors is to motivate the use of contraception or sterilization. There are many ways that medical personnel may attempt to motivate use, but they have a particular advantage in drawing attention to the deleterious health consequences of continued childbearing for the mother. They may also point to the positive health consequences of a lengthy interval between pregnancies for both mother and child. They may make recommendations that extend beyond their medical competence, and point to the limits of a mother's or a family's capacity to care for and educate a large number of children.

8 One of the clearest statements regarding the potential importance of such guidance was offered by Howard Taylor (1966), an

early advocate of postpartum family planning programs. Taylor held that the medical practitioner who attended a mother's delivery was in a special position to counsel her with respect to family planning. Having been "accorded the role of guide and protector to assure a safe delivery," this practitioner was likely to give advice of "special significance" during the critical postpartum period (p. 436). Moreover, it came at a moment when the mother was likely to have ample motivation to prevent or at least postpone another pregnancy. While Taylor's pronouncements now sound outdated, patronizing, and far removed from the spirit and recommendations of the International Conference on Population and Development, they may be quite representative of the ideology that was imbedded in many of the doctors who were providing family planning services over the past 30 years. Moreover, Taylor's emphasis on the role of trust and assurance seems like a necessary antidote to fear of the health consequences of contraception.

9 For an overview of the literature on effectiveness that highlights the methodological inconsistencies and contradictory findings, see Trussell and Kost (1987).

10 An industrial example is jet aircraft designs such as the Boeing 727 that "undergo constant modification and they improve significantly in structural soundness, wing design, payload capacity and engine efficiency as they accumulate actual airline adoption and use" (Arthur 1989: 116; Rosenberg 1982). Arthur and others have cited numerous technologies such as gasoline-powered motor vehicles and light-water nuclear reactors that, for particular chance reasons, got a head start and came to dominate their market or industry even though the alternative technology probably had greater promise.

11 The following statement by Arthur and Lane (1994), articulating the situation of anyone who must choose between a variety of new technologies, captures the essence of the phenomenon, and has a clear relevance to the problems faced by prospective adopters of new contraceptive technologies:

For the potential purchaser, a new technically based product can be a source of considerable uncertainty. Specifications, advertising brochures, and consumer reports may

be available, and the cost of purchase precisely known. Yet the purchaser may still be unsure about how the product will perform for him: how smoothly it can be integrated into his existing operations; how much maintenance or "down time" the product will require; whether the product in fact is suited to the particular uses he has in mind. . . . In cases like these, usually the potential purchaser tries to reduce this uncertainty by asking previous purchasers about how *they* have fared with the products *they* bought and subsequently used. (p. 70; emphasis in original)

12 While the likelihood of rumors will, of course, increase as a new method becomes more widely adopted, it is not clear that this is a continuous source of decreasing returns. My suspicion is that rumors of serious health consequences constitute an inevitable and possibly lethal threat that surfaces early in the life course of a new contraceptive technology. Either the method survives the threat and continues to grow in acceptance, eventually outrunning the danger, or it succumbs and virtually disappears.

13 The definition of rural is that used in the Mexican census, namely places with fewer than 2,500 inhabitants.

14 COPLAMAR was the acronym for the General Coordination of the National Plan for Depressed Zones and Marginal Groups. In May of 1979 IMSS agreed to provide primary health care to a wide range of disadvantaged rural areas on COPLAMAR's behalf.

15 There was also an acknowledgment of the deleterious influence of actual as well as anticipated side effects of hormonal methods and the IUD. Three-quarters of the doctors believed that such symptoms as excessive bleeding commonly reduce continuation rates for these methods.

16 These estimates are based on unpublished tabulations from the Encuesta Nacional de Planificación Familiar (ENAPLAF) undertaken by the National Population Council in late 1995. More details concerning the design and content of this survey are found below.

17 These goals are clearly set forth in the National Population Program 1995–2000 (CONAPO 1995).

18 These were the states of Chiapas, Guanajuato, Guerrero, Hidalgo, México,

Michoacan, Oaxaca, Puebla, and Veracruz. They contain about half the population of Mexico and account for most of the poorest areas of the country.

19 When the IUD was inserted for reasons of a "medical indication," the mother was informed about the placement of the device only following the procedure.

20 The National Investigation on Human Reproduction carried out in nine purposively selected locations in the states of São Paulo, Espírito Santo, Rio Grande do Sul, Pernambuco, Piauí, and Pará also collected information on contraceptive practice in this period (Merrick and Berquo 1983).

21 There has been an extensive debate in the Brazilian literature concerning the determinants of fertility decline in this period. The central issues concern the various aspects of the Brazilian pattern of development that may have accounted for the emergence of the demand for fertility control, as well as the role played by organizations that were seeking to promote family planning and control Brazilian fertility. The latter are more germane than the former to my present purpose, which is simply to provide a brief historical reconstruction of the environment in which contraceptive decisions were made between 1964 and 1980.

22 Preventive medicine's share of the health budget fell from 64 percent in 1965 to barely 15 percent in 1982. Preventive medicine in this context refers to expenditures on sanitation, immunization campaigns, disease control, and inspection.

23 BEMFAM was, however, a more important source of the pill in the five north-eastern states in which it had cooperative agreements with the state health secretariats (Merrick and Berquo 1983).

24 There is little direct evidence concerning the character and nature of pill use during this period, but on the basis of evidence for the mid-1980s it seems reasonable to assume that medical supervision was often lacking and that complaints about side effects were frequent (Corrêa and Ávila 1989). Moreover, pills were just one of a large number of medications that were widely adopted during a time when the pharmaceutical industry was expanding rapidly, and the pre-

scription and administration of medications were highly problematic for the bulk of the population (Scheper-Hughes 1993).

25 For more complete discussion of the relationship between sterilization and cesarean section delivery in Brazil, see Berquo (1993 and 1995). Direct evidence regarding side payments, albeit for a later period, is given in Vieira and Ford (1996).

26 This is clearly revealed in the maternity history in the 1986 Demographic and Health Survey, which recorded for all births information on whether or not the delivery was by cesarean section.

27 There are two different explanations for the lack of acceptance of the IUD in Brazil. One concerns the considerable discussion that occurred between various groups as to whether use of the IUD constituted a form of induced abortion. This controversial theme arose in congressional inquiries as well as in the scientific and popular press. The other reason is simply the cumulative effect of individual incidents involving serious side effects or accidents resulting from IUD use. The latter explanation seems to most observers to have been the more important of the two (Sonia Corrêa, personal communication, 1997).

28 The Brazilian delegation to the Cairo conference included a broad representation of nongovernmental organizations and played an important role in forging the consensus that emerged in the final conference document. Moreover, following the inauguration of President Cardoso in 1995, a National Commission on Population and Development was set up to coordinate the implementation of the main recommendations of the Program of Action adopted in Cairo (Berquo 1997).

29 Comparatively permissive or generous criteria for the use of cesareans are embedded in several of the most widely used obstetric textbooks published in Brazil, for example Rezende and Montenegro (1992).

30 In January 1998, a memorandum of agreement was signed by officials representing CONAPO and the various public health agencies involved in family planning, setting forth a plan of action for improving the quality of services and ensuring full respect for reproductive rights.

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Longer Life and Population Growth

JOSHUA R. GOLDSTEIN

WILHELM SCHLAG

RECENT SUCCESSES in prolonging the life spans of laboratory animals have raised the possibility of large increases in human longevity (Carey et al. 1998; Lin et al. 1997; Biddle et al. 1997). The prospect of longer life is often greeted by fears of overpopulation (Kevles 1999; Kolata 1999; Gavrilov and Gavrilova 1991; Bova 1998). Kevles's concerns, which appeared on the opinion page of the *New York Times*, are typical. He wrote that "forestalling death would inevitably worsen many of the social crises that we already see looming. It would increase population, further burdening the planet—and might well create a generation gap of titanic proportions." In this article, we use a simple mathematical model to show that longer life need not—and, if current trends continue, will not—lead to population growth.

We distinguish between two types of post-reproductive life extension. Life-cycle telescoping occurs when death is postponed without affecting the timing of childbearing. The alternative is life-cycle stretching, in which longer life is accompanied by delays in the timing of reproduction. Our model shows that population growth will result from life-cycle telescoping, but not from stretching. Stretching appears to be the more likely scenario, judging from animal experiments, evolutionary and behavioral theory, and recent human experience. We conclude thus that current forecasts of an end to world population growth before the end of the twenty-first century (Lutz, Sanderson, and Scherbov 1997) may not be upset even by quite dramatic increases in human longevity. Similarly, differential access to life-extension technology (Silver 1997) may not alter the population composition in favor of those who live longer. Life-cycle stretching may itself be an evolutionarily adaptive mechanism.

Population growth consequences of different scenarios for increased longevity

To study the effects of increased longevity on population size, we consider stationary populations in which mortality declines occur in post-reproduc-

tive ages. Near zero population growth rates are typical of most developed countries and are forecast for the world population by the end of the twenty-first century (e.g., Lutz, Sanderson, and Scherbov 1997). In stationary populations, an identity relates population size K to years of life expectancy at birth e and the annual number of births B :

$$K = Be. \quad (1)$$

Any change in life expectancy that leaves the number of births unchanged, such as life-cycle telescoping, will produce a proportional change in total population size.

Consider now the case where a population undergoes a transition in which the timing of reproduction is allowed to vary with the timing of death. Let the change in demographic regimes occur from one cohort to the next, such that everyone born before a given moment in time has the original demographic regime, and everyone born after this time has the longer-life regime. Replacement fertility holds for all cohorts. Denote the expectation of life e' and the mean age of reproduction μ' under the new regime. We find that

$$\lim_{t \rightarrow \infty} K'(t) = K \cdot \frac{\mu}{\mu'} \cdot \frac{e'}{e}, \quad (2)$$

where $K'(t)$ is the size of the population t years after the change in regime. This result provides the conditions under which life expectancy can be increasing without causing population growth: namely, when the ratio of life expectancy to the mean age of reproduction is kept constant across demographic regimes (i.e., $\frac{e'}{\mu'} = \frac{e}{\mu}$).

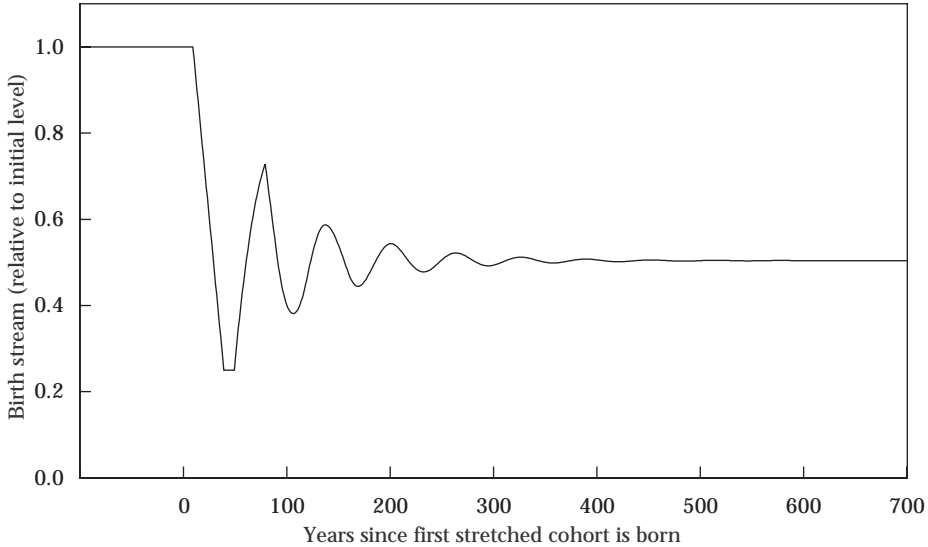
This is the scenario we call life-cycle stretching. Telescoping is a special case of (2) where $\mu' = \mu$. More generally, population will increase whenever longevity increases faster than the mean age

of reproduction ($\frac{e'}{e} > \frac{\mu'}{\mu}$), while population declines will be produced if the

opposite occurs ($\frac{e'}{e} < \frac{\mu'}{\mu}$).

The dynamics of stretching the life cycle can be illustrated by simulation. Figure 1 shows the birth stream that results from a simple form of stretching in which the mean age of reproduction was doubled by shifting the onset and end of childbearing to older ages. After an initial period of oscillation, the birth stream settles down to a new equilibrium equal to one-half of the previous equilibrium. The existence of an equilibrium is a well-known consequence of demography's strong ergodic theorem (Sharpe and Lotka 1911). What is remarkable is that the level of this equilibrium de-

FIGURE 1 Simulated birth stream following a stretching transformation of the life cycle



NOTE: The original net maternity function is defined uniformly at 0.025 for ages 10 through 49. The stretched maternity function has the same value, but the age range has been shifted to ages 40 through 79. The simulation shows that the stream of births declines during the first few years following the change in demographic regimes as the births of the “stretched” cohorts are postponed. This decline is reversed as the new cohorts occupy the full range of ages of their reproductive span. Oscillations follow as the original dip in births is echoed.

pend only on the shift in mean age of reproduction.¹ It is also possible to derive this result as a consequence of the renewal theorem (Feller 1971). Li and Tuljapurkar (1999) use related methods to study population momentum.

Evidence for life-cycle stretching

While it is not possible to specify the form that future extensions of life will take, there are a number of reasons to believe that increases in longevity will be accompanied by delays in childbearing. The biological link between reproductive timing and mortality has been demonstrated repeatedly. The same animal experiments that have succeeded in extending longevity in Mediterranean fruit flies (Carey et al. 1998), drosophila (Finch 1990: 304–310), mice (Biddle et al. 1997), and nematode worms (Lin et al. 1997) also resulted in postponing the timing of reproduction. In humans, historical studies of the British peerage (Westendorp and Kirkwood 1998) and con-

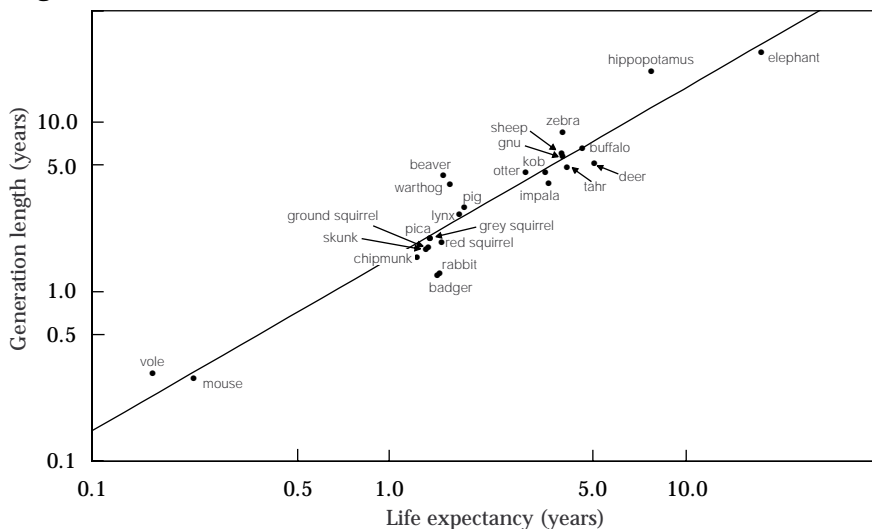
¹A self-contained proof of equation (2) using elementary methods is available from the authors <<http://opr.princeton.edu/~josh/stretchproof.pdf>>.

temporary epidemiological studies (Perls and Silver 1999) have found a positive association between longevity and late childbearing.

Contemporary variation across species provides a proxy measure of evolutionary history, although ideally one would want to study change within species. The correlation between life expectancy and age at sexual maturity is very strong both across mammalian species (Harvey and Zammuto 1985) and across primates in particular (Harvey and Clutton-Brock 1985), a relationship often attributed largely to differences in body weight. Figure 2 shows the relationship between life expectancy and mean age at reproduction (generation length) in 25 mammalian species for which data are available. The correlation coefficient is large ($r = 0.95$) and the slope of the logarithmic regression line through these data is 1.01 (s.e. = 0.07). The regression line thus indicates that a doubling of life expectancy is accompanied by a 101 percent increase in the mean age of reproduction.

There are several explanations for the connection between reproductive timing and mortality (Charlesworth 1994). The costs of early reproduction may be high both in terms of subsequent survival and in terms of the survival of offspring. For density-dependent populations the linkage between longevity and age of reproduction may be evolutionarily adaptive because it allows increases in longevity without placing larger demands on the local environment. Life-cycle stretching may also be adaptive in the con-

FIGURE 2 Relationship between life expectancy at birth and mean age at reproduction (generation length) for 25 mammalian species (logarithmic scale)



NOTE: Logarithmic regression line has a slope of 1.01 (s.e. = 0.07); $r = 0.95$ ($r = 0.94$ in original scale).
SOURCE: Millar and Zammuto 1983.

text of environmental variation (Tuljapurkar 1997). There may also be an evolutionary argument for the ideal number of generations that are simultaneously alive. Grandparents may be able to contribute to the fitness of their offspring by assisting their grandchildren. On the other hand, if too many generations are alive at the same time, the fitness of the youngest generation may be diminished through competition for resources. Evolution may have introduced a mechanistic biological link between the timing of birth and death, a link that may mean that the same technological advances that postpone death will also, however inadvertently, postpone reproduction.

Although the future life-cycle demography of humans may be influenced in part by biological constraints, choices will also play a role in determining when long-lived humans, using their own free will, will decide to bear children. Behavioral theories such as economic theories of human capital investment (Becker 1983) support the proposition that delayed childbearing is a rational response to longer life spans. Kaplan and Lam (1999) have shown theoretically that increased productivity at older ages creates incentives for postponing childbearing. Life-course stretching may thus result as much from the optimizing choices of individuals facing increased longevity as from more-deterministic biological processes.

Empirical support for the link between longer life and postponement of childbearing can be found in the low-mortality populations of North America, Europe, and Asia, where reproductive ages have been rising in recent decades. As shown in Table 1, the mean age at childbearing has been increasing at approximately the same pace as life expectancy over the last two decades in the United States, Japan, and Sweden. Ages at first birth have been increasing slightly faster than mean ages at childbearing because of a decline in higher-order births to older women (Bongaarts and Feeney 1998). Later onset of reproduction appears to be driven by changes in behavior rather than changes in biology, since the age at menarche has been getting earlier during most of the twentieth century (Eveleth and Tanner 1990).

TABLE 1 Annual rates of change (in percent) in life expectancy and women’s reproductive timing in selected low-mortality populations, 1975 to 1995

Country	Life expectancy at birth (females)	Mean age at first birth	Mean age at childbearing
United States	0.1	0.4	0.2
Japan	0.4	0.3	0.3
Sweden	0.2	0.5	0.4

NOTES: United States maternal ages at birth are medians and available from 1975 through 1993. Swedish female life expectancy in 1975 estimated from 1970 to 1979 average. Swedish maternal mean age at childbearing data available from 1978 to 1995.

SOURCES: National Center for Health Statistics 1999: 108; Japan Ministry of Health and Welfare 1998: Table 4.19; Statistics Sweden 1996: Tables 3.23, 3.24, and 4.17.

Life-cycle stretching appears to be a feasible scenario if we place it in the context of currently forecast improvements in human longevity. Lee and Carter (1992) forecast a joint-sex life expectancy of 86.05 years by 2065, an increase of 13.5 percent from 1990. The same proportional increase in the timing of reproduction would imply a mean age at childbearing of 30.0 years instead of the current value of 26.4 years. Such levels are clearly possible without biological innovations; in Japan, the current mean age at childbearing is already 29.2 years (Japan Ministry of Health and Welfare 1998). Whether reproductive timing is as elastic as longevity for very large changes, like a doubling of life expectancy, is not yet known. While animal experiments suggest that this may be the case, it may turn out to be easier to postpone death than menopause. Nonetheless, it is clear that reproductive timing in human populations has not yet begun to approach biological limits.

Conclusion

Fears that extension of the human life span will lead to population growth in replacement-level populations may be misplaced. As long as later ages at death are accompanied by proportional delays in the timing of childbirth, a shrinking birth stream will exactly offset increases in longevity. Current forecasts, which omit the possibility of dramatic increases in longevity, suggest that world population growth will cease toward the end of the twenty-first century. Our results suggest that these forecasts can still hold, even if longevity is greatly increased.

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The Long-Term Effect of the Timing of Fertility Decline on Population Size

BRIAN C. O'NEILL

SERGEI SCHERBOV

WOLFGANG LUTZ

LONG-RANGE POPULATION projections derive from underlying assumptions about the future paths of fertility, mortality, and migration. Fertility scenarios are usually constructed by choosing a level at which fertility is assumed eventually to become constant and a path from the current to the eventual fertility rate. Stable population theory (Keyfitz 1968) shows that populations experiencing constant fertility, under the assumption of constant mortality and migration, tend toward a fixed age structure and growth rate that are independent of the history of vital rates. However, the long-term population size is determined by both the eventual fertility level and the transition path. Two projections with identical eventual fertility rates but different transition paths will produce population sizes that differ in the long term by a constant proportion.

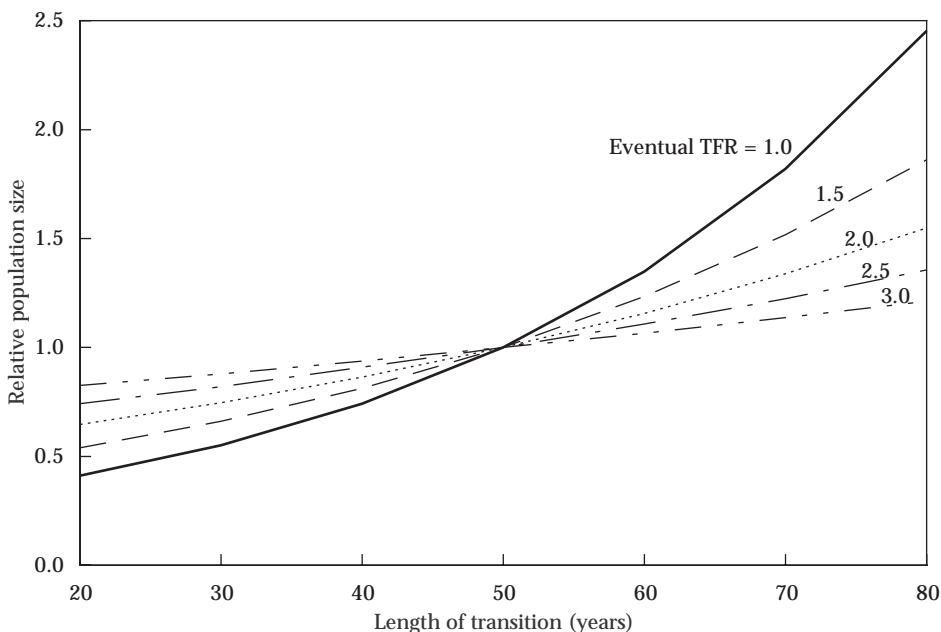
For example, long-range population projections that assume universal convergence to a replacement-level fertility rate show that doubling or halving the length of the transition from current to eventual fertility produces a range in population size in 2150 of about ± 20 percent (Bos et al. 1994). In contrast, projections in which eventual fertility rates vary by half a birth per woman around a central estimate produce global populations that differ by ± 50 to 70 percent in 2100 and by more thereafter (United Nations 1998). Taken together, these results have been interpreted as implying that the timing of the fertility transition has a relatively unimportant effect on long-term population size. Nevertheless, no long-range projections have systematically investigated the importance of the path of fertility de-

cline as distinct from the effect of the eventual fertility level, and theoretical analysis (Keyfitz 1971) has been limited to the case of eventual replacement-level fertility.

In this note, we first demonstrate the effect of varying the assumed length of the fertility transition—an indicator of the rate of change in fertility—for different eventual levels of the total fertility rate (TFR) by carrying out an extensive set of projections for the single region of North Africa. Figure 1 shows the results of 35 projections for the region in which, starting from the age distribution of 1995, the eventual TFR was varied from 1.0 to 3.0 births per woman, while the length of the transition from the current total fertility rate of 4.24 to the eventual TFR was varied from 20 to 80 years. Each curve shows the results of projections in which fertility converges to a different eventual fertility level. The length of the fertility transition (assumed to be linear) is given along the x-axis, and results are normalized to the population size assuming a 50-year transition. Migration is assumed to be zero, and mortality follows a central scenario (Lutz 1996). The projections cover a period of 155 years from 1995 to 2150.

The scenario assuming the lowest eventual fertility level shows the greatest sensitivity to the speed of the decline. If eventual TFR is assumed

FIGURE 1 Population of North Africa projected from 1995 to 2150 assuming various levels of the total fertility rate (TFR) at which fertility eventually stabilizes and differing lengths of transition from the current to the eventual fertility rate. For each set of projections assuming a given eventual fertility rate, population size is shown as a ratio to the population size assuming a 50-year fertility transition



to be 1.0, then as the length of transition varies by ± 30 years around a central value of 50 years, population size varies in the long term by +145 to -60 percent. In contrast, if eventual TFR is 3.0, long-term population size varies by +21 to -17 percent around its value in the 50-year transition scenario. These differences are achieved at different times depending on the length of the transition. In general, much of the difference is apparent within two generations of the time at which fertility becomes constant. We report results for 2150, by which time the relative sizes of populations projected with different transition lengths but common eventual fertility rates have become nearly constant in all cases. Beyond 2150, relative population sizes change little. However, absolute population size, changing at a constant rate, will become either extremely large or extremely small if the eventual fertility rate remains constant above or below replacement level; we make no assumptions as to the likelihood of these outcomes. For reference, Table 1 shows the absolute size of the projected population of North Africa in 2150 for a selection of the scenarios considered here.

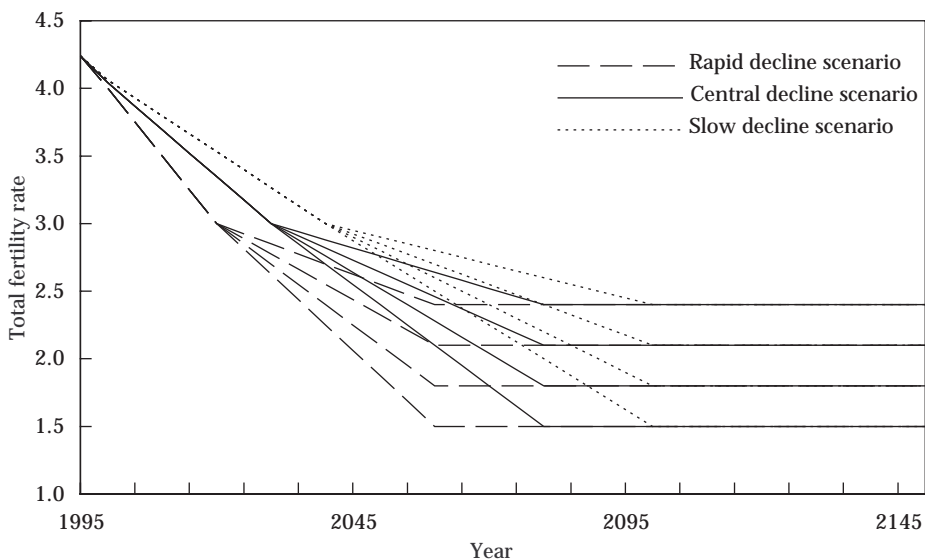
The results of the analysis are explained by the fact that the difference between the initial and the eventual fertility rate over the course of the transition is the key factor in determining the impact of the path on population size. The lower the eventual fertility, the greater the rate of change in fertility over the transition, and the greater the impact of altering that rate on population size. By analogy to geography, this relationship is equivalent to the observation that the more distant a geographic destination, the more important travel speed becomes.

To investigate the effect within the context of an existing set of long-term population projections, we constructed a set of 12 scenarios by modifying the central scenario from the projections of the International Institute for Applied Systems Analysis (IIASA; see Lutz 1996), as shown in Figure 2 for the example of North Africa. In the four central scenarios, represented by solid lines in the figure, TFRs in regions currently above replacement level follow the IIASA central scenario to 2030-35, then reach an eventual

TABLE 1 Projected population of North Africa in 2150, in millions, under various assumptions concerning the length of fertility transition from the current level of the TFR of 4.24 to various levels at which fertility eventually stabilizes

Eventual total fertility rate	Length of transition		
	20 years	50 years	80 years
1.0	24	59	145
1.5	96	178	332
2.0	279	432	669
2.5	679	916	1240
3.0	1460	1770	2140

FIGURE 2 Scheme of the alternative fertility scenarios for developing regions, 1995–2150, illustrated with the example of North Africa, where the initial level of TFR is 4.24



NOTE: See discussion in text.

level of 2.4, 2.1, 1.8, or 1.5 in 2080–85, the time interval used to specify eventual constant fertility in the IIASA projections. We tested the sensitivity of each scenario to the timing of the decline by defining two alternative scenarios involving a rapid and a slow decline to each of the four assumed eventual fertility levels. Dashed lines represent the rapid fertility decline scenarios in which the TFR achieved in 2030–35 and 2080–85 in the central scenario is achieved 10 and 20 years earlier, respectively. Dotted lines represent the slow fertility decline scenarios in which these TFR values are achieved 10 and 20 years later, respectively. For all scenarios, mortality and migration assumptions are identical with the paths specified in the central scenario.

Table 2 shows that if the high-fertility regions stabilize near replacement level, an acceleration or deceleration of the fertility decline would cause an eventual change in the combined population size of all regions of –16 percent to +21 percent, similar to the effect found in previous studies (Bos et al. 1994). If the eventual fertility rate is assumed to be 0.3 births per woman higher, the impact on population size weakens to –11 percent to +13 percent. In contrast, if eventual fertility stabilizes below replacement

TABLE 2 Percent difference in projected long-term population size in developing regions assuming rapid (R) and slow (S) fertility declines relative to population size in a central scenario as dependent on the assumed level of the eventual stable total fertility rate^a and on the speed with which that rate is attained

Region	TFR = 2.4 ^a		TFR = 2.1		TFR = 1.8		TFR = 1.5	
	R	S	R	S	R	S	R	S
North Africa	-17	+20	-23	+29	-29	+40	-36	+55
Sub-Saharan Africa	-23	+29	-28	+39	-34	+51	-40	+66
Latin America	-3	+3	-10	+10	-17	+20	-26	+34
Central Asia	-13	+15	-20	+25	-26	+36	-34	+51
Middle East	-19	+24	-25	+33	-31	+44	-37	+59
South Asia	-8	+9	-13	+15	-21	+25	-28	+39
Pacific Asia	-2	+2	-8	+9	-16	+18	-24	+31
Total	-11	+13	-16	+21	-23	+31	-31	+45

^aThe eventual total fertility rate in Latin America, South Asia, and Pacific Asia is assumed to be identical with its 2030–35 value of 2.35.

level at 1.8, the impact on population size strengthens to -23 percent to +31 percent, and strengthens further to -31 percent to +45 percent if eventual TFR is 1.5. Thus, a lowering of eventual fertility by 0.6 births per woman relative to replacement level roughly doubles the effect of altering the length of the transition by 20 years. The magnitude of such relative differences varies region to region, as detailed in Table 2. In Latin America and Pacific Asia, for example, the impact of a change in the timing of fertility decline roughly triples at lower eventual fertility levels. Table 3 provides absolute

TABLE 3 Projected population size of developing regions in 2150, in millions, as dependent on the level at which fertility eventually stabilizes according to the central scenario

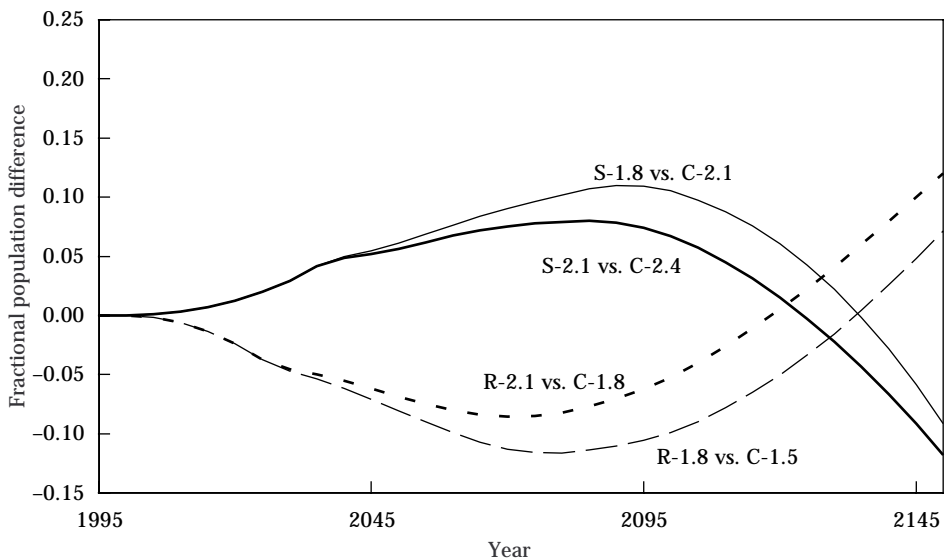
Region	Eventual total fertility rate ^a			
	2.4	2.1	1.8	1.5
North Africa	865	637	459	321
Sub-Saharan Africa	2079	1519	1084	750
Latin America	1409	1073	758	522
Central Asia	303	222	159	111
Middle East	1088	812	593	422
South Asia	3051	2326	1642	1126
Pacific Asia	1146	875	619	425
Total	9941	7465	5313	3677

^aThe eventual total fertility rate in Latin America, South Asia, and Pacific Asia is assumed to be identical with its 2030–35 value of 2.35.

sizes of populations in 2150 according to the central scenario for each eventual fertility level.

These results demonstrate that a given change in the speed of the fertility transition has a larger impact on population size the lower the assumed eventual fertility rate. It is also true that a given change in eventual fertility itself has a larger impact the lower the eventual fertility rate in a reference case. For example, changing eventual fertility by 0.3 births per woman from a reference case in which eventual fertility is low will have a larger impact than the same change from a case in which eventual fertility is high. We therefore investigated the relative sensitivity of projected population size to these two factors. Figure 3 illustrates the relative impact of the speed and extent of the fertility transition on the projected population size of the developing regions. It demonstrates both that a change in transition speed has a greater impact at lower eventual fertility levels and that its impact increases relative to the effect of a change in the eventual fertility rate. The thick solid line in the figure represents the difference between the increase in population (relative to the “central 2.1” scenario) brought about by slowing the fertility transition by 20 years and the increase caused by raising the eventual fertility level from 2.1 to 2.4 while holding the transition length

FIGURE 3 Illustration of the relative impact of the speed and extent of the fertility transition on the projected population size of the developing regions by comparing scenarios differing in the eventual level of the total fertility rate and the speed with which that level is attained



NOTE: R, C, and S represent the rapid, central, and slow fertility decline scenarios; 2.4, 2.1, 1.8, and 1.5 indicate the eventual fertility level achieved in each case.

constant. This difference is positive between 1995 and about 2125, indicating that the change in the speed of the transition dominates the increase in eventual fertility in terms of its effect on population size. After 2125, the change in eventual fertility is the dominant influence. The thick dashed line compares the effect of speeding up the fertility transition by 20 years to the effect of lowering the eventual fertility rate from 2.1 to 1.8. It shows that between 1995 and about 2120, speeding up the fertility decline reduces population size by more than reducing eventual fertility. After 2120, lowering the eventual fertility rate is the dominant influence.

The two thin lines in Figure 3 show a parallel set of results that demonstrate how these relationships change when an eventual fertility rate of 1.8 instead of 2.1 is taken as a reference point. Changes in the speed of fertility decline are dominant for a longer period of time, relative to changes in eventual fertility, than is the case when the reference eventual fertility rate is at replacement level.

Our analysis of the impact of changes in the timing of the fertility transition could easily be extended to include regions in which fertility is currently at or below replacement level. However, concern in low-fertility societies centers less on population size than on issues related to aging (de Jong-Gierveld, van Solinge, and Wormser 1995; van Praag and van Dalen 1994); and while the rate of aging will be affected by the path and by the eventual level of fertility, the long-term age structure is independent of the path over the next several decades. This implies that a more rapid pace of fertility decline is not achieved at the expense of a higher eventual proportion elderly.

These findings place new emphasis on the task of constructing scenarios for fertility decline. As demographers begin to take into account the possibility of eventual subreplacement-level fertility in long-term population projections (Bongaarts 1998; Lutz 1996), they need to be cognizant of the significant role the path of fertility decline will play in determining the size of the ultimate stable population. Our results also have implications for policies seeking to take into account the consequences of population growth for economic change and the environment (Vitousek et al. 1997; O'Neill, MacKellar, and Lutz, in press). Finally, while considerable aging will take place under all scenarios of future population growth, the speed of fertility decline over the coming decades will make a significant difference to the long-term levels of population size that will accompany older age structures.

Note

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Urban Growth in Developing Countries: A Review of Projections and Predictions

MARTIN BROCKERHOFF

BECAUSE THE YEAR 2000 figures prominently in urban population projections, it is timely to assess whether the United Nations' earliest projections of urban population growth in developing countries, made in the 1970s, have been reasonably accurate, and if not, why. Despite being accompanied by advice to interpret urban population projections with caution and not as forecasts (United Nations 1980), these early projections of rapid growth fueled common perceptions of an impending "urban population explosion" in poor countries (Bairoch 1988; Schiffer 1989), while providing many governments with a pretext for concentrating economic resources and focusing population control efforts, such as restrictions on in-migration, in big cities (Badshah 1996; United Nations 1981).

The recent availability of data from the 1990-round censuses makes it equally opportune to examine whether influential predictive models of urban and city growth in developing countries, published around 1980, have remained robust over time. The most prominent of these models were pessimistic in assessing the prospects for modifying rapid urban growth through direct interventions in cities and against urban in-migration. Economists concluded that pricing policies biased in favor of cities, as well as national development strategies and global economic conditions that spurred manufacturing rather than agricultural productivity, made rapid urban growth until the year 2000 likely (Kelley and Williamson 1984b: Table 6.6). Meanwhile, demographers linked city growth rates closely with national population growth rates, implying that municipal authorities and planners were virtually powerless in controlling the future sizes of their cities (United Nations 1980: 43). These empirical studies supported Lipton's (1976) thesis of "urban bias," which contends that economic development policies of governments in low-income countries favor cities to such an extent as to un-

dermine efforts to slow urban growth, including measures to discourage rural-to-urban migration.

Contradicting these scenarios of rapid growth, the United Nations and urban scholars have tentatively concluded that rates of urban and city growth in the developing world have been slower in recent decades than was once anticipated (Becker and Morrison 1999; Satterthwaite 1996; United Nations 1998). A glaring and often-cited example is Mexico City, whose estimated current population of about 18 million does not approximate the more than 30 million inhabitants projected for 2000 as recently as 1980 (United Nations 1980).¹ Such discrepancy reflects in part the limitations of the data to which UN urban estimation and projection procedures are applied. Yet, descriptive accounts are lacking to indicate whether the experience of Mexico City is unique or whether it is illustrative of widespread, highly erroneous urban population projections at the regional, national, and city levels in developing countries. Moreover, it is not known whether slower-than-expected urban growth has been consistent with economic trends that influence migration between urban and rural areas, or with demographic factors, such as declining national population growth. An examination of the patterns and causes of unexpectedly slow urban growth in recent years is needed to improve the basis for urban population projections in the future, and thereby assist development planning. Such an exercise is also important for assessing the plausibility of current projections according to which virtually all world population growth in the near future will occur in urban areas of the developing world (United Nations 1998).

This article has two objectives: (1) to scrutinize the slower than formerly anticipated urban growth noted by the United Nations for the developing world as a whole in recent years at lower levels of population aggregation—regions, countries, and cities—so as to ascertain whether this phenomenon is common throughout the South or, rather, is particular to certain areas and sensitive to population size; and (2) to reevaluate the strength of predictive models of city and urban growth developed around 1980 by demographers and economists, as typified respectively by Preston (1979) and Kelley and Williamson (1984a), in light of urban population data now available from the 1980- and 1990-round censuses, as well as data accumulated since 1980 that may reflect changes in potent explanatory factors (for instance, economic conditions). Reexamination of these models may indicate the forces responsible for a slowdown of urban growth in recent years, if this phenomenon has indeed occurred.

An assessment of urban population projections to the year 2000

The accuracy of population projections to 2000 and later dates can be assessed most conclusively through *ex post facto* comparisons of observed

populations in the twenty-first century to currently available published statistics. For evaluation at present, one must accept the most recent UN urban projections to 2000, revised in 1996, as reasonably correct given their recent data base and short projection period. Because the methodology employed by the United Nations to estimate and project national urban and rural populations was reformulated in the late 1970s (United Nations 1980: 9–11) and has not changed since then (United Nations 1998: 31–36), the most recent figures serve as a benchmark for determining to what extent subsequent developments and the use of newly available data affected the accuracy of projections made in 1980.² Comparison of these sets of projections is also appropriate to detect an unanticipated slowdown of urban growth, because the latest projections make full use of all available data from the 1980- and 1990-round censuses, whereas the earlier set of projections did not.

Table 1 presents the size of the urban population in developing regions and subregions in the year 2000, as projected in 1980 and 1996 by the United Nations. The figures in the table are derived from an identical group of 134 countries classified as less developed in 1980 (therefore excluding those countries in the former Soviet Union that are now classified as less developed) whose definitions of urban did not change between the two years.³

The most recent United Nations projections foresee a less developed country (LDC) urban population of somewhat under 1.9 billion in the year 2000, more than 10 percent (or 222 million) lower than the somewhat over 2.1 billion expected in 1980 (13 percent lower if China is excluded). In contrast, the size of the projected total population has been revised downward by only 2 percent, and the size of the rural population has been revised upward by 4 percent. These percentage changes suggest that the United Nations has been much more successful in projecting accurately the total LDC population than the urban population. However, roughly half (110 million) of the downward revision of the projected urban population is attributable to the projected total population growth in the developing world that was slower than anticipated in 1980.⁴ Slower total population growth, in turn, has largely resulted from faster-than-expected fertility declines in LDCs.⁵

The 1996 projections of the size of the 2000 urban populations are lower than those projected in 1980 in all major developing regions and in 10 of the 12 subregions listed in Table 1. Most striking is the shift in these figures for Latin America and the Caribbean: some 17 percent fewer urbanites according to the 1996 projection (which corresponds to a sharply revised average annual urban growth rate between 1980 and 2000, from 3.31 percent to 2.54 percent). The urban population of Asia in 2000 as projected in 1996 is 105 million less than was projected in 1980, while recent urban growth in Africa—frequently claimed as occurring at high levels unprecedented in history—has been apparently occurring at an appreciably slower pace than was anticipated in 1980 (at roughly 4.3 percent per year, on average, rather than 4.8 percent).

TABLE 1 Projected urban, rural, and total populations of developing regions to the year 2000 (in millions)

	As projected in		Percent change
	1980	1996	
Urban areas of LDCs			
All developing regions^a	2,115.5	1,893.4	-10.5
Excluding China	1,672.3	1,455.1	-13.0
Africa	345.8	309.7	-10.4
Eastern	70.5	64.2	-8.9
Middle	45.2	33.5	-25.9
Northern	111.9	89.1	-20.3
Southern	32.6	26.2	-19.6
Western	85.5	96.6	12.9
Asia	1,299.0	1,194.2	-8.1
Eastern ^b	508.3	502.0	-1.3
South-central	517.6	431.5	-15.1
Southeastern	207.7	192.7	-7.2
Western	65.4	68.0	4.0
Latin America and the Caribbean	466.2	387.6	-16.9
Caribbean	28.8	23.9	-17.0
Central America	124.6	91.2	-26.8
South America	312.9	272.5	-12.9
Oceania ^c	4.6	2.0	-57.1
Rural areas of LDCs	2,751.3	2,863.9	4.1
Total	4,866.8	4,757.2	-2.2

^a Projections in both years are based on the 134 countries that (1) were classified as less developed in 1980 and for which data were available in 1980 and 1996, and (2) whose definitions of urban did not change between the two years.

^b Excluding Japan.

^c Excluding Australia and New Zealand.

SOURCES: United Nations 1980, 1998.

Table 2 shows that the consistent pattern among regions—of much slower urban growth than was expected earlier—masks a high degree of diversity in the accuracy of projections among countries within subregions, even between adjacent countries (for instance, Mozambique and Malawi).⁶ The countries in Table 2 show the extremes of differences within subregions. In Middle Africa, for example, the Congo's urban population was projected in 1996 to number almost 2 million in 2000, about 40 percent higher than was projected in 1980. In contrast, in the neighboring Democratic Republic of the Congo (formerly Zaire), the 1996 projected urban population is 12 million, or almost one-half fewer than was projected in 1980. Since rates of natural increase are very similar in neighboring coun-

TABLE 2 Extremes of intraregional differences in UN urban population projections to the year 2000 (in thousands)

Region	Country ^a	As projected in		Percent change ^b
		1980	1996	
Africa				
Eastern	Mozambique	3,199	7,869	146.0
	Malawi	6,489	1,686	-74.0
Middle	Rep. of Congo	1,347	1,865	38.5
	Dem. Rep. of Congo (Zaire)	27,839	15,670	-45.4
Northern	Libya	3,405	5,597	64.4
	Sudan	16,551	10,772	-34.9
Southern	Lesotho	217	641	195.4
	South Africa	30,109	23,291	-22.4
Western	Senegal	3,002	4,463	48.7
	Ghana	10,843	7,644	-29.5
Largest countries	Nigeria (Western)	45,041	55,561	25.8
	Egypt (Northern)	37,048	31,297	-16.5
Asia				
Eastern	Hong Kong	5,210	6,097	17.0
	Dem. Rep. of Korea	20,006	15,021	-24.9
South-central	Nepal	2,275	2,893	27.2
	Sri Lanka	8,860	4,434	-48.8
Southeastern	Singapore	2,453	3,587	46.2
	Vietnam	27,574	15,891	-42.4
Western	Oman	248	2,282	820.2
	Lebanon	5,269	2,951	-44.3
Largest countries	China (Eastern)	443,213	438,263	-1.1
	India (South-central)	360,688	286,323	-20.6
Latin America and the Caribbean				
Caribbean	Haiti	2,765	2,727	-1.4
	Dominican Republic	7,834	5,537	-29.3
Central America	Costa Rica	2,067	1,970	-4.7
	El Salvador	4,628	2,947	-36.3
South America	Argentina	28,875	33,089	14.6
	Colombia	41,779	29,154	-30.2
Largest countries	Brazil (South)	163,027	137,527	-15.6
	Mexico (Central)	102,293	73,553	-28.1

^a Excluding countries with an estimated total population less than 2 million in 1995 (United Nations 1998).

^b Median change for 134 developing countries: -7.5 percent.

SOURCES: United Nations 1980, 1998.

tries throughout Africa, such large discrepancies—great upward revisions in one country and massive downward revisions in another—suggest that early projections of urban growth in African countries were based on too

few reliable data sources to be taken seriously, or that these projections were subsequently nullified by unforeseen patterns of migration.

In Southeastern Asia, Singapore and Vietnam exhibit a pattern similar to that of the two countries of Middle Africa just cited, with Vietnam expected to have in 2000 just over half the urban population that was projected in 1980. In Latin America, the 1980 projections of the urban population for 2000 have been revised downward in 1996 for all countries except Argentina, Bolivia, and Paraguay. In El Salvador the 1996 projection was lower by 36 percent. Upward revisions of anticipated urban populations in countries such as Lesotho and Oman are not surprising, given the small initial size of the urban populations. Revisions of the magnitude made, for example, for Vietnam and South Africa, however, are significant also in terms of the absolute numbers of persons involved.

Comparison of Tables 1 and 2 reveals that the much-revised urban projections of subregions correspond closely to revised projections for the largest countries in those subregions. This is clearly the case with Egypt, China, India, Brazil, Mexico, and their respective subregions. The exceptional upward revision in 1996 as compared to 1980 of Western Africa's urban population projected to 2000, by 13 percent, is largely a result of a 26 percent upward revision for urban Nigeria, where about 60 percent of Western Africa's urbanites reside. The seemingly accelerated urban growth of Nigeria in the 1980s and 1990s is remarkable given that the projected total population of the country in 2000—which was much influenced by the surprising results of the 1991 census—was revised downward by 18 percent between 1980 and 1996, from 135 to 111 million; as a result of the two revisions, Nigeria's expected level of urbanization in 2000 has been changed from 33 to 44 percent.⁷ The consistency of the two projections for China, despite change in the national definition of urban during 1980–96, has been explained by Banister (1997: 79–80).⁸ The revised projection for urban India—of 75 million fewer urban residents projected in 1996 than was projected in 1980—is by far the largest absolute change of any country, and represents a decrease in the 1980–2000 average annual urban growth rate from 4.24 percent to 2.95 percent.⁹

Table 3 compares projections to the year 2000 made in 1980 and 1996 for the largest cities of the 15 most populous countries in each of the three major developing regions. The same definition of each city—as an agglomeration, the city proper, or by the application of some other criterion—is used for both years. Most of the early projections of LDC city growth appear to have been far too high, indicating the weakness of data on which city population statistics, in particular, are calculated. In each region, the 2000 population projected in 1980 has been lowered in the 1996 projections in 9 or 10 of the 15 cities. The 13-million downward revision of the projection for Mexico City is hardly exceptional: projections for Shanghai, Jakarta, Baghdad, and São Paulo have each been lowered by more than 6

TABLE 3 Projected population in 2000 of the largest city in the 15 largest countries in each developing region (in thousands)

Region/country	Largest city	As projected in		Percent change ^a
		1980	1996	
Africa				
Nigeria	Lagos	4,518	13,488	198.5
Egypt	Cairo	13,058	10,772	-17.5
Ethiopia	Addis Ababa	5,600	3,112	-44.4
Dem. Rep. of Congo	Kinshasa	8,411	5,068	-39.7
South Africa	Cape Town	2,850	3,092	8.5
Tanzania	Dar es Salaam	4,645	2,051	-55.8
Algeria	Algiers	2,643	4,447	68.3
Kenya	Nairobi	4,869	2,320	-52.4
Sudan	Khartoum	5,079	2,748	-45.9
Morocco	Casablanca	4,624	3,535	-23.5
Uganda	Kampala	3,015	1,207	-60.0
Ghana	Accra	3,842	2,010	-47.7
Mozambique	Maputo	2,619	3,017	15.2
Madagascar	Antananarivo	1,880	1,128	-40.0
Ivory Coast	Abidjan	1,800	3,359	86.6
Asia				
China	Shanghai	22,677	14,173	-37.5
India	Bombay	17,056	18,042	5.8
Indonesia	Jakarta	16,591	9,815	-40.8
Pakistan	Karachi	11,774	11,774	0
Bangladesh	Dhaka	9,725	10,979	12.9
Vietnam	Ho Chi Minh City	4,502	3,678	-18.3
Iran	Teheran	11,329	7,380	-34.9
Philippines	Metro Manila	12,313	10,818	-12.1
Thailand	Bangkok	11,936	7,221	-39.5
Myanmar	Yangon	4,747	4,458	-6.1
Rep. of Korea	Seoul	14,246	12,215	-14.3
Afghanistan	Kabul	1,270	2,716	113.9
Dem. Rep. of Korea	Pyongyang	2,240	2,726	21.7
Iraq	Baghdad	11,125	4,796	-56.9
Malaysia	Kuala Lumpur	2,552	1,378	-46.0
Latin America and the Caribbean				
Brazil	São Paulo	25,796	17,711	-31.3
Mexico	Mexico City	31,025	18,131	-41.6
Colombia	Bogotá	6,834	6,834	0
Argentina	Buenos Aires	12,104	12,431	2.7
Peru	Lima	8,930	7,443	-16.7
Venezuela	Caracas	5,209	3,153	-39.5
Chile	Santiago	5,760	5,261	-8.7
Ecuador	Guayaquil	2,370	2,127	-10.3
Guatemala	Guatemala City	2,084	2,697	29.4
Cuba	Havana	3,213	2,302	-28.4
Dominican Republic	Santo Domingo	4,176	3,601	-13.8
Bolivia	La Paz	1,963	1,458	-25.7
Haiti	Port-au-Prince	1,558	1,791	15.0
Honduras	Tegucigalpa	1,150	1,241	7.9
El Salvador	San Salvador	895	1,415	58.1

^a Median change for LDC cities with at least 750,000 residents in 1995 = -15.1 percent.

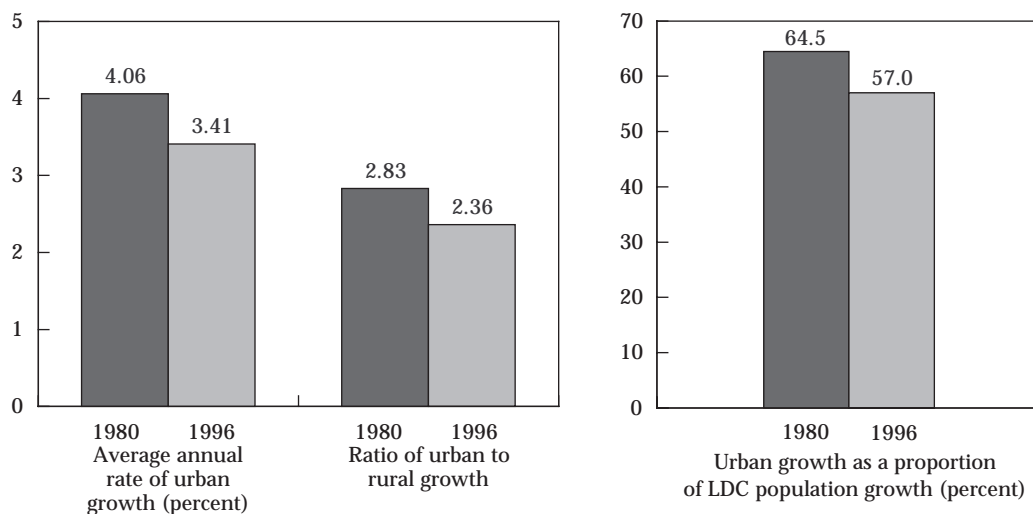
NOTE: Within each region the order of listing is according to population size of country in 1996.

SOURCE: United Nations 1980, 1998.

million. The relative over-projection of Mexico City's 2000 population in 1980 as compared to 1996 by 42 percent is exceeded by the shift for several smaller cities in Africa as well as by Kuala Lumpur. A remarkable change, as compared to the general pattern of cities, is the threefold increase in the projected 2000 population of Lagos, which accounts for 85 percent of the upward revision of Nigeria's urban population. In 1980 it was projected that 389 cities would reach sizes of at least 750,000 by 1995; according to the most recent estimates 239 did, 150 did not (United Nations 1980, 1998). Projections in 1980 to the year 2000 were far less accurate for cities than for the urban population at large. For example, whereas the urban population of developing regions has been revised downward by 10.5 percent (and by a median average of -7.5 percent among all developing countries), the projected population of the 239 cities with at least 750,000 residents in these countries in 1995 has been lowered, on average, by 15.1 percent.¹⁰

Figure 1 summarizes salient aspects of the apparent slowdown of urban growth in the developing world during 1980-2000 (excluding China). Undoubtedly, most total population growth has been urban (a combined result of urban natural increase and net rural-to-urban migration), and the component of urban growth within total growth will certainly increase in the future (United Nations 1998). Nonetheless, the average annual rate of urban growth during the last two decades of the twentieth century, which was projected in 1980 to exceed 4 percent, is anticipated to be 3.4 percent according to the 1996 projections. The changed outlook implies a 1980-2000 urban population increase of 98 percent rather than 127 percent. The pace of urbanization in 1996 appears more modest than was the case in

FIGURE 1 Measures of urban population growth between 1980 and 2000 in developing countries, as projected in 1980 and 1996 (excluding China)



1980: between 1980 and 2000 the urban population is projected to be growing 2.4 times, rather than 2.8 times, more quickly than the rural population. And whereas in the 1980 projections 65 percent of the 1980–2000 population growth in developing countries was expected to occur in urban areas, this figure in the 1996 projections has been revised downward to 57 percent. This last comparison raises doubt about the reliability of current UN projections according to which over 90 percent of LDC population growth during 2000–25 will occur in urban areas (United Nations 1998), if one assumes that the factors that contributed to slower urban growth in the 1980s and 1990s will persist in the future and have not been fully accounted for in the most recent set of projections.

Sources of city growth since the 1970s

While the UN's earliest projections of year 2000 urban and city populations in the developing world, made in the late 1970s, were generally far too high as compared to projections made in 1996 (which presumably are more accurate given the recency of the information on current population size and the much shorter projection period), there has also been considerable variation among countries and cities in the size and direction of change from the earlier to the later projections. The substantial revision of projections may be to some extent an artifact of assumptions that underlie the UN's methodology. This hypothesis could be explored by applying alternative assumptions to the data used by the UN in 1980 to make urban population projections to 2000 and then assessing whether results more closely approximate the populations projected in 1996 than did the projections published in 1980. At present, such an analysis can only be undertaken by the United Nations Population Division; the specific data used for projections in 1980 are not presented in any publication and cannot be identified with certainty from UN *Demographic Yearbooks*. An alternative approach is to examine potential sources of the recent slowdown and variation in urban and city growth based on existing theory of the underlying determinants of such growth, taking advantage of abundant population and development data collected for developing countries in recent years.

Preston (1979) and the UN Population Division (1980) analyzed the effects of several variables on intercensal growth rates of 1,211 cities in more and less developed countries (excluding China) between the 1960- and 1970-round censuses; no analysis of this scale has been conducted for developing countries alone or since that time. The most striking finding was an almost perfect association between national population growth rates and city growth rates: a 1 percent increase in the former resulted in a 1.002 percent increase in the latter. For example, if a country with an annual population growth rate of 3 percent experienced average city growth rates of 4 percent, then a country that experienced 4 percent growth had cities growing,

on average, by 5.002 percent per annum. From this finding, one could conclude that the same forces fuel population growth in cities as in the countries in which they are located and thus, by implication, that high natural increase in rural areas does not propel cityward migration, nor are programs that modify natural increase (for instance, family planning and child survival programs) differentially effective in cities and in the countryside. Other notable results of the investigation just cited were that levels of economic development and performance positively affect city growth rates, whereas rates are significantly lower in more urbanized countries, and higher in Latin American countries, than elsewhere.

Table 4 replicates the analysis of Preston and the United Nations for 1,154 cities of developing countries only, based on city population data compiled from UN *Demographic Yearbooks* covering a span of 26 years (1971–97). This sample represents all cities in the developing world whose population sizes are reported for two time points—before and after 1980, and at least eight years apart—and whose population size was at least 100,000 at the earlier date.¹¹ On average the period covered is 1977–90, although for some cities estimates extend to 1996. Independent variables are derived from United Nations and World Bank publications for the same years as estimates of city size. While alternative measures of the variables may be preferable (for instance, adjusting conventional gross national product and gross domestic product according to purchasing power), this would preclude strict comparison to results of the Preston/UN study. The findings of this earlier study are shown in the final column of the table.

Analyses of the earlier and more recent periods show little consistency of results. One constant determinant in size and direction of effect is the annual growth rate of national GDP per capita: a 1 percent increase raises city growth rates by roughly 0.2 percent (or 2 per thousand persons). This is not surprising, as fast-growing LDC economies (for instance, in East Asia) presumably stimulate demand for labor in urban industry, manufacturing, and services, a situation conducive to net urban in-migration. Because cities are the historical engines of national economic growth, reverse causality could also be hypothesized from this relationship (that is, city population growth may be driving national economic growth). As Preston observes, however, it is unlikely that the average city is large enough for its population growth to contribute substantially to measured national economic growth during a short period of years.

On balance, results indicate that factors that drove city growth in the 1960s and 1970s have had markedly different effects on LDC city growth rates in recent years. Initial levels of GNP per capita are generally irrelevant to rates of city growth in subsequent years ($\beta=0.042$, $p=.728$). The importance of national economic conditions therefore appears ambiguous—economic progress as measured by GDP growth per capita spurs city growth,

TABLE 4 Effects of demographic, economic, and political variables on city growth rates, 1960s–1990s (annual percentage growth rates)

Variable	Unit of measurement	Effect of one unit increase in variable on city growth rate ^a	
		LDCs only (1970s–1990s)	MDCs and LDCs combined (1960s–1970s; Preston 1979)
Demographic			
National population growth rate	Annual percentage growth	0.788*	1.002*
Natural log, initial city size	Persons	–0.314*	–0.211*
Initial proportion urban	Urban percentage	–0.062*	–0.029*
Economic			
Initial level of national GNP per capita	Thousands of US dollars (LDCs only: initial year of observation; Preston: 1964)	0.042	0.332*
Growth rate of national GDP per capita	Annual percentage growth (unadjusted to purchasing power)	0.189*	0.239*
Political			
Capital city	1 if capital city; 0 otherwise	0.933*	0.589
Largest city	1 if largest city in country; 0 otherwise	1.152*	0.292
Regional			
Latin America	1 if in Latin America; 0 if Asia (excluding China and India)	–0.294	0.614*
Africa	1 if in Africa; 0 if Asia (excluding China and India)	0.372	–0.025
China	1 if in China; 0 if other Asia (excluding India)	0.817*	—
India	1 if in India; 0 if other Asia (excluding China)	–0.544*	—
Constant		3.548	4.119
R ²		0.352	0.312
(N)		1,154	1,212
Initial year of observation (mean)		1977	1962
Average duration of observation (years)		12.7	10.0

NOTE: Based on cities with at least 100,000 residents in the initial year of observation.

* $p < .05$

^aPartial regression coefficients.

SOURCES: Preston 1979; United Nations 1998; United Nations *Demographic Yearbook* (selected volumes 1971–97); World Bank *World Tables* (1985, 1995); World Bank *World Development Indicators 1998*; World Bank *World Development Report* (selected volumes 1977–97).

but it does so independent of a country's level of economic development. City growth rates are dampened in highly urbanized countries—in part owing to smaller proportions of potential in-migrants from rural areas—but the

negative effects of urbanization levels on city growth are twice the magnitude reported for the 1960s, at about $-.06$ for every one percentage point increase in the initial proportion urban. Given our global sample of developing countries, inclusion of both primate and smaller cities, and statistical control of regional effects, this result suggests that counter-urbanization may be widespread across city sizes, and within the developing world, not restricted to cities of Latin America.¹²

Largest cities and capital cities of LDCs grew approximately 1.15 and 0.93 percent more quickly per annum than other cities, figures much higher (and more reliable statistically) than those reported by Preston. Therefore, presuming an average annual growth rate of 4.10 percent for other cities with at least 100,000 residents in the initial year of observation, cities that were both the national capital and the largest city in their countries grew, on average, by 6.18 percent per annum. Several factors account for these discrepancies with earlier findings. First, most of the cities analyzed for the 1960s are located in more developed countries, whereas our sample is exclusively from less developed countries where “urban bias,” or the concentration of migration-inducing resources, has been much more pronounced in favor of major urban centers. Second, the largest and capital cities of most countries in sub-Saharan Africa, and of many countries in other regions, have populations of less than one million (United Nations 1998: Tables 11, 12), population bases that are sufficiently small to translate population increments in absolute terms into high city growth rates. Third, high estimates for major urban centers run counter to the observed slowdown of mega-city growth rates since the 1970s, but these slow-growing giant cities—cities of 8 million or more residents—represent less than one percent of cities in the developing world with more than 100,000 inhabitants (hence included in our sample). Finally, support for these findings comes from other studies that indicate that cities of 1,000,000–5,000,000 residents grew more quickly than cities of 500,000–1,000,000 residents in developing regions during 1975–90 (Brockerhoff and Brennan 1998: 81).

With respect to regional location, cities grew more rapidly in Latin America than elsewhere in the 1960s—other factors being equal—but in recent years cities in Asia (excluding China and India from this reference category) grew more rapidly. The evidence of a sharp reduction in city growth in Latin America (relative to city growth in Asia), after controlling for national economic conditions that largely determine migration flows between cities and the countryside, points to Latin America’s remarkable fertility decline—from an average total fertility rate of 6 in the early 1960s to 3 in the early 1990s (United Nations 1999)—as a likely major component of reduced city growth in the region. As compared to other Asian cities, the much more rapid growth of China’s cities (greater by 0.8 percent per annum) and more sluggish growth of Indian cities (less by 0.54 percent per

annum) is noteworthy insofar as China and India had virtually equivalent levels of urbanization and GNP per capita around 1980.¹³ As one might expect, these regional estimates for cities are consistent with the direction of revised UN projections for regional urban populations shown in Tables 1 and 2.

A striking result in Table 4, as compared to findings for the 1960s–1970s, is that a one percent increase in national population growth rates of LDCs increases city population growth rates by less than 0.8 percent, despite the fact that urban growth has been more rapid than total population growth since 1975. Indeed, 351 of the 1,154 cities in our sample experienced slower growth than their country's population during the period of observation. This finding suggests that small urban centers not included in this analysis, those with fewer than 100,000 residents, may be the fastest-growing settlements in the developing world, as has been noted elsewhere (UNCHS 1996). This result also supports the notion that, on the whole, there has not been net in-migration to LDC cities from smaller urban areas and rural areas; the net flow may be in the other direction, if weak city economies have discouraged out-migration from small areas and encouraged return migration to towns and villages. Such reverse flows from cities have been documented since the late 1980s, for instance in Ivory Coast and Guinea (Bocquier and Traoré 1998). Alternatively, technological progress and improved economic performance in agriculture, as compared to urban economic sectors, may have induced many potential migrants to remain in rural areas, a pattern consistent with some theories of rural demographic change (for instance, Boserup 1965) but at odds with others (for instance, Davis 1963). Yet another explanation is that cities may have experienced a widening difference in rates of natural increase as compared to rates in smaller areas (for instance, resulting from more rapid fertility decline in big cities), to an extent that more than offsets high net migration into cities. These hypotheses warrant investigation to reveal the demographic and economic underpinnings and policy instruments in rural areas that affect the pace of city growth.

Sources of national urban growth since 1980

In addition to examining sources of city population growth since the 1970s, causes of national urban population growth since 1980 also merit investigation, with reference to predictions of national-level urban growth made around 1980. Kelley and Williamson (1984a and 1984b) examined whether the rate of urban growth in developing countries during 1973–79 would have differed in the absence of the major increase in oil prices and related economic conditions that prevailed in those years. Their analysis was exceptional in considering economywide influences on urban growth in an “open” setting, in which migration between rural and urban areas is af-

ected by exogenous forces that confront an entire country. The study found that the average annual urban growth rate of a “representative” developing country (4.65 percent) would have been much higher—more closely approximating the rate during 1960–73—if urban-based manufacturing had not declined relative to rural-based agriculture in terms of trade and productivity.¹⁴ In contrast, the slow growth of agricultural land stock and high growth of the population of labor force age—factors that presumably “push” surplus rural population toward urban areas—as well as foreign capital inflow and the higher price of fuels and raw materials did not affect the pace of urban growth. Kelley and Williamson concluded that imbalance between manufacturing and agriculture matters most to urban growth, in part by instigating (or inhibiting) migration to urban centers of employment and economic advantage. Continuation of unfavorable trends in manufacturing relative to agriculture therefore would indicate slower rates of urban growth in the 1980s and 1990s than would be expected otherwise.

Table 5 presents the key findings of Kelley and Williamson and comparable results from an analysis of data from 95 developing countries representing the period 1980–96. Variables examined for recent years are those identified as potent causes of urban growth during 1973–79 (and, implicitly, before and after those years) as well as factors deemed insignificant at that time but nonetheless apposite to consideration of the influence of population pressures on urban growth since 1980. The importance of four nationwide factors that could have reduced urban growth in part by depressing migration from the countryside is also examined: (1) the percentage of population aged 65 or older in 1980; (2) the growth rate of the proportion of the population age 65 or older during 1980–96; (3) a policy in 1980 to alter the spatial distribution of population—as defined by the simultaneous existence of a negative perception by government of the population distribution, intention to decelerate or reverse migration flows, and intention to modify the rural/urban configuration of settlements (United Nations 1981); and (4) country size in terms of area, which when large might indicate a greater distance between rural and urban places. An alternative to counterfactuals—values that Kelley and Williamson derived from historical data and expert opinion and that presumably approximate conditions prior to the rise of oil prices—is used to determine the impact of national trends and conditions on urban growth. Additionally, analysis of data for 1980–96 shows the mean values of variables among these 95 countries as recorded by the United Nations and the World Bank, presents the median annual urban growth rates for countries that experienced values above and below the means, and estimates the linear effects of variables on the urban growth rate.¹⁵

A substantial technological slowdown has occurred in the developing world since 1980 (encompassing the so-called lost decade of the 1980s),

TABLE 5 Effects of economywide variables on the national urban growth rate (UGR) in LDCs, 1973-79 and 1980-96

Variable	Kelley and Williamson, 1973-79		Observed, 1980-96			Effect of variable on average annual UGR	
	Assumption	Counterfactual	UGR from counterfactual		≤ Mean		
			> Mean	≤ Mean			
Unbalanced factor productivity (agriculture growth / manufacturing growth), % per annum	0.8	0.5	5.86	0.89	3.65	4.83	-0.296*
Relative price of manufactures, % growth per annum	-1.6	0	6.49	-0.97	5.30	2.89	-0.735*
Foreign capital inflow per annum, as % of GDP	3.0	0	4.67	1.26	4.11	4.01	0.137
Agricultural land stock, % growth per annum	0.5	1.0	4.61	0.83	4.02	4.13	0.083
Labor force, % growth per annum	2.68	2.54	4.60	2.50	4.46	3.92	0.261
Percent of population aged 65 or older in 1980	—	—	—	4.20	3.24	4.83	-0.279*
Proportion of population aged 65 or older, % growth per annum	—	—	—	0.74	3.31	4.85	-0.412*
Policy in 1980 to curb urban growth (1 = yes, 0 = no)	—	—	—	0.40	Yes: 3.53 No: 4.88	No: 4.88	-0.713*
Size of country (sq. miles, in thousands)	—	—	—	226,411	4.01	4.13	-0.002
N = (40)	(Actual avg. UGR = 4.65)				(Actual avg. UGR = 4.05)		Constant = 1.292 R ² = .577 N = (95)

* P ≤ .05

NOTES: The urban growth rate resulting from each counterfactual assumes other counterfactuals held constant. The value of 5.86 for unbalanced factor productivity is also based on a decline from 0.5 to 0.25 percent growth per annum in urban-based capital-intensive services (e.g., electricity) relative to manufacturing. See appendixes in Kelley and Williamson 1984b for calculation of variables for 1973-79. See text for definition of policy to curb urban growth. The urban and elderly populations in 1996 used to calculate growth rates are derived from linear interpolation of values for years 1995 and 2000 (using the medium-variant projection of persons aged 65 and older in 2000).
SOURCES: Kelley and Williamson 1984b: Tables 5.4, 5.5; Kelley and Williamson 1984a: Table 5; World Bank World Development Indicators 1998 (book and CD-ROM). World Bank World Tables (Selected volumes 1985-95). United Nations 1981, 1998, 1999. US Bureau of the Census 1991.

and the price “squeeze” on the agricultural sector has been reduced. These trends are reflected by the much higher productivity increase in rural agriculture as compared to urban manufacturing (at 0.89 percent per annum, even exceeding OPEC-period levels) and by the price decline of manufactures relative to agricultural goods (at -0.97 percent per annum). Countries that experienced lower than average relative growth in manufacturing had a median annual urban growth rate of 3.65—or 0.4 percentage points lower than all countries on average, and about 1.2 percentage points lower than countries with comparatively strong manufacturing growth. Among countries where the price of manufactures fell by more than 0.97 percent yearly as compared to agricultural prices, the median annual urban growth rate was 2.89—or 1.2 percentage points lower than the aggregate average and just over half the rate of countries where price trends have been more favorable to manufactures. The effect of these sector productivity trends during 1980–96, quite disadvantageous to manufacturing, was to reduce the average annual urban growth rate by 0.3 percentage points. Likewise, declining relative prices for manufactures reduced the rate by 0.74 percentage points. In sum, results indicate that, as in the 1970s, the sluggish performance of manufacturing (as compared to agriculture) remains largely responsible for the observed slower pace of urban growth in developing countries, and may have decelerated urban growth from what otherwise would have been higher rates in the 1980s and 1990s by curbing net rural-to-urban migration.

Sustained periods of reduced international capital inflows experienced by many countries since the 1980s might be expected to have dampened urban growth—given that most capital inflows (hence income-earning opportunities) typically come to cities—but strong evidence remains that, for LDCs on the whole, the level of foreign capital inflow over time has had no significant effect on the pace of urban growth. Likewise, agricultural land expansion and the rate of growth of the population of labor force age (the main contributor to urban fertility and net rural-to-urban migration) have had negligible effects on urban growth. In all, despite the use of more-limited data for a much earlier period, Kelley and Williamson were remarkably on target in identifying those overarching forces that do, and do not, determine rates of urban growth in developing countries.

Of the additional variables considered here, size of country turns out to be unimportant, but population aging appears to be crucial. Aging populations would logically be associated with slower national population growth, but their relationship to the pace of urban growth is undocumented. Many developing countries, notably in Latin America and the Caribbean, had high proportions of elderly persons among their populations in 1980 or earlier (US Bureau of the Census 1992: Table 5). Those countries with percentages of persons aged 65 or older exceeding 4.2 experienced urban growth rates 0.8 percentage points lower than average. Moreover, a yearly increase of

one percent in the proportion of population aged 65 or older (for instance, from 5 percent to 5.05 percent)—a value slightly higher than the 0.74 percent mean increase per annum observed in our sample—reduces the urban growth rate by 0.41 percentage points (for instance from 4.05 percent to 3.64 percent). The difference in median urban annual growth rates between countries that experienced higher and lower rates of growth in their proportion of elderly persons than the mean exceeds 1.5 percentage points (3.31 percent as compared to 4.85 percent per annum).

High levels and rapidly growing proportions of elderly persons could reduce urban growth through several mechanisms. These include, most directly, lower and declining urban fertility and decreased propensity among the aging rural population to resettle in urban areas (if rural-to-urban migration is prompted mainly by job, school, or marriage prospects). On the other hand, the concentration and growth of the elderly population in developing countries may be largely an urban phenomenon—given that curative health care services are overwhelmingly based in cities in many countries, while higher fertility persists in the countryside. Unfortunately, no comprehensive data on the age structures of urban and rural populations exist to examine these arguments. Without engaging in undue speculation, suffice it to say that the more-rapid growth expected in the future of the proportion of population aged 65 or older in developing countries—at 2.1 percent per annum between 2000 and 2025, to represent over 8 percent of the total population by the end of the period (according to the UN medium-variant projections)—implies a potentially strong dampening effect on rates of urban growth. Whether changing age structures reduce urban growth purely through urban fertility decline or are associated with it through other linkages is a question for future research.

Spatial aspects of population policy appear more significant to curbing urban growth than is conventionally assumed on the basis of the failed “migration policies” of many governments in the 1960s and 1970s (Simmons 1981). Measures implemented to modify the distribution of population, including migration policies, substantially reduced the average annual rate of urban growth in LDCs during 1980–96, by about 0.7 percentage points, and likely would have had a greater dampening impact on urbanization in the developing world if applied in more countries. Admittedly, the policy indicators are crude, as they reflect governments’ perceptions of the comparative desirability of alternative spatial patterns, not their actual interventions, and they are reported to the United Nations by potentially biased or not well-informed offices of government. Nonetheless, many countries that viewed their population distributions as unacceptable and acted to change them—for instance, Mexico, Egypt, and India—experienced lower urban growth rates during 1980–96 than did their global subregions, and much lower growth than neighboring countries—Guatemala, Sudan, Bangladesh—

that had less negative stances on urban growth. This result points to a need to identify which migration-related policies most influence urban growth—for instance, rural development schemes versus the imposition of eligibility requirements for movement from the countryside. In the absence of such research, and given the strong effect of migration policy on urban growth independent of economic and demographic conditions, one cannot dismiss spatial distribution policies as uniformly ineffective instruments to manage the urban transition.

Conclusion

While short-range population projections sometimes prove imprecise, the large downward revision of the projected size of the urban population of most developing countries in the year 2000—based on a considerable amount of accumulated evidence—suggests that a slowdown of urban growth has occurred since the 1970s. A much-modified picture of the “urban population explosion” in recent years reflects the effects of relatively weak expansion of urban industries and price shifts unfavorable to manufactured goods, population aging, policies to alter migration and spatial distribution patterns in some countries, and no doubt other forces not examined in this analysis. National population growth rates that produce less than commensurate city growth rates, net of other factors, suggest that reduced net rural-to-urban migration has been a principal demographic component of slower-than-expected urban growth. However, the continued absence of timely, adequate data on rural-to-urban migration in most developing countries, as well as on natural increase in urban and rural areas separately, precludes attribution of the slowdown of urban growth in most countries to any single demographic process (or to statistical changes due to such causes as redrawing of city boundaries or reclassification of urban places). Further clarification of the demographic underpinnings of urban growth—rather than of its underlying economic and social causes examined here—awaits analysis of data from the 2000-round censuses.

It remains to be seen whether economic downturns and other recent trends have just temporarily slowed the process of the urban population transition in the developing world—as implied by current projections that anticipate rapid urban growth and very large population increments in cities in the next few decades—or whether conditions of the 1980s and 1990s have a more lasting effect on the future growth and size of the urban population. Comparison of the biennial urban estimates and projections issued by the United Nations with earlier data, as done here with reference to the 1996 revision, on a routine basis would shed light on this issue provided that the UN methodology is not altered in future estimates and projections.

The discrepancy between early and the most recent urban population projections is no doubt attributable, in part, to the continued inadequacy of

the underlying data on which these projections are based; urban population statistics should be interpreted with caution. As illustrated above, however, the increased availability of basic population, economic, and geographic data for most developing countries in the last 20 years now enables detailed analysis of the causes of urban growth. With few exceptions (for instance, Becker, Hamer, and Morrison 1994; McGee and Robinson 1995), this topic has been neglected for some time, despite its obvious demographic significance. This article has revisited notable examples of research on sources of urban and city growth in the 1960s and 1970s and has derived results that inform our understanding of the causes of growth since that time (either through confirmation or refutation of earlier findings). An apparent priority for future research is to determine whether policy interventions of governments can hasten the pace of urban growth, if more rapid growth is deemed desirable on economic or other grounds. Alternatively, research might determine whether the pace of urban growth in developing countries can be controlled by governments if, for instance, doing so is suggested by global economic conditions or by demographic conditions identified in this study. Fortunately, sufficient data are becoming available in some countries to address these and other questions pertinent to the growth of cities and urban populations.

Notes

1 Mexico City's population increased from 5.4 million in 1960 to 13 million in 1980 (Garza 1999: 153). By simply extrapolating this rate of growth, the UN projected a population size of 31.3 million by the year 2000.

2 The method for projecting city size, however, has been changed (see United Nations 1998: 33–36). National urban and rural projections made in 1980 and 1996 may both be flawed as a result of the UN's methodology. Much potential inaccuracy may be associated with the central measure used in calculations, a single urban–rural growth differential derived from 228 countries in both developing and developed regions and applied hypothetically to each individual country (including those 22 countries with no definition of an urban area, and 8 countries where all population officially resides in areas designated as urban or rural). For urban population projections of individual countries, the use of data from other countries inevitably introduces potential error (even if the hypothetical differential, properly weighted,

applies to countries at any level of urbanization). At national and higher levels of population aggregation, the UN's urban projections may also prove inaccurate if any of numerous assumptions are violated: for instance, if the urban–rural growth differential assumes a negative value, as it has in Oceania since the late 1970s; if the exclusion of countries with small populations from the procedure produces a less, not more, valid hypothetical differential; if the linear incremental weights applied to the differential over successive five-year intervals are inappropriate; and so forth. However, since the method has remained constant between 1980 and 1996, all discrepancy in projections between the two dates that results from the method would originate from changes in the country-level data that enter into the procedure (including their source, amount, timeliness, and validity in measuring demographic events).

3 Almost no developing country changed its official definition of urban between 1980 and 1996. The few countries that did change their definition—for instance, Afghanistan,

Benin, and Iran—did so in a manner that did not change the locales classified as urban. The UN urban projection method allows for the graduation of rural areas to urban areas (and vice versa) based on population size criteria, and therefore does not invalidate the trends shown in Table 1.

4 The extent to which over-projection of the urban population in 1980 is attributable to over-projection of the total population varies by region. For instance, the projected urban population of Africa in 2000 has been revised downward by about 36 million since 1980, whereas the projected total population of Africa in 2000 has been revised upward by about 6 million. In this case, none of the downward revision of the projected urban population can be attributed to slower total population growth in Africa than was expected in 1980. In contrast, the projected urban population of Latin America and the Caribbean has been revised downward by about 79 million, while the projected total population of the region has been revised downward by 105 million. Therefore, in Latin America and the Caribbean one could attribute all of the over-projection of the urban (and rural) population to slower-than-expected growth of the total population. The point to emphasize is that errors in projecting urban populations are affected by errors in projecting total populations.

5 As recently as 1988, for instance, the UN's medium variant projection of the total fertility rate (TFR) in less developed regions in 1990–95 was 3.69 (United Nations 1989). The UN now estimates that the TFR during this period was 3.27 (United Nations 1999). Admittedly, the current estimate includes some relatively low-fertility developing countries that were formerly part of the Soviet Union whereas the earlier projection did not, but these countries in sum account for a very small proportion of the developing world's population.

6 Countries with populations of less than 2 million in 1995 are not examined, because small absolute changes in their projected urban population sizes may have resulted in such large percentage changes that comparison with larger countries is misleading.

7 Faster-than-expected urbanization and urban growth in Nigeria since 1980 are especially intriguing insofar as the structural

adjustment policies imposed in that country by international financial institutions in the 1980s (though not strictly adhered to by the governments) would be expected to have reduced migration to cities and perhaps to have lowered urban fertility (Olu Abiodun 1997). A plausible explanation for the revision of the size of Nigeria's (and Lagos's) urban population is that estimates and projections have been based on poor-quality census data, particularly preceding the 1991 census.

8 In the 1980s, China established hundreds of new cities and thousands of new towns with extraordinarily large land areas. This reclassification of rural places as urban greatly magnified the size of China's urban population (for instance, it raised the proportion classified as urban from 21 percent in 1982 to 57 percent in 1990). To correct for this change in definition, the State Statistical Bureau created a second, more realistic definition of urban applied to the 1990 census, which defines the urban population as including urbanized residents of neighborhood committees.

9 Mohan (1996) speculates from 1991 census data that would-be migrants to cities were discouraged from moving by the lack of jobs and a worsening quality of urban life in the 1980s.

10 These represent all cities in developing regions with a population of at least 750,000 in 1995 (United Nations 1998) whose projected populations to 2000 can be traced to those included in United Nations (1980).

11 For China, data are taken from the 1982 and 1990 national population censuses.

12 In this case, counter-urbanization would be defined as the movement of people away from cities, regardless of city size criteria, toward smaller areas, including suburbs or peri-urban areas not officially recognized as part of the city proper. Descriptive accounts of this process in the 1980s for large as well as small cities are given by Gilbert (1996) and UNCHS (1996). History suggests that in regions where urbanization levels are relatively low, such as South Asia and sub-Saharan Africa, counter-urbanization would be fleeting; it may reflect the more adverse impact on cities than on other areas of economic downturns in the 1970s–1990s.

13 Detailed explanations of recent city growth patterns in China and India, respectively, are found in Scharping (1997) and Mohan (1996).

14 Data for a representative developing country were based on unweighted averages of 40 countries. These developing countries included only “price-takers” in international trade—therefore excluding net oil-exporting countries of OPEC—and countries with favorable economic situations between 1960 and 1973. The present analysis of 95 developing countries during 1980–96 includes any of these formerly omitted states for which suitable and complete data are available, since the capacity of these countries in dictating global fuel prices has greatly diminished since 1980, and because economic forces unfavorable to rapid urban growth prevailed in most developing countries in the 1980s and early 1990s (with the exception

of some Asian countries that experienced rapid economic growth during that period).

The characterization of manufacturing as “urban” and agriculture as “rural” is somewhat inaccurate, especially in countries where “mega-urbanization” or metropolitan sprawl has dispersed industries to adjacent rural areas (McGee and Robinson 1995), or where export-oriented manufacturing has been established in rural hinterlands (for instance, in “New Economic Zones” of countries in Southeast Asia and the Caribbean). Even in this minority of developing countries, however, the manufacturing and agricultural sectors are overwhelmingly concentrated in urban and rural areas, respectively.

15 For some small countries, data taken from the World Bank *World Development Indicators 1998* are available only in CD-ROM format, not in publication.

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Alfred Marshall on the Growth of Population

Classical views of population, as expounded in the works of Smith, Malthus, and Mill, retained their influence through the nineteenth century and into the twentieth—until sidelined, many would argue, by the marginalist revolution in economics. Oddly, Alfred Marshall (1842–1924), the major figure in that revolution, was, when it came to population, himself firmly in the classical tradition. He diverged from it in two main respects. Writing in the late nineteenth century he had of course to take account of Darwinian theory, with the potential implications it suggested for differential fertility. And, deriving from his interests in industrial organization and efficiency and in biological analogies in economics, he gave greater attention than his forebears to the possibility that returns to labor could routinely be increasing as well as diminishing.

Marshall, the preeminent economist of his time, was for most of his career professor of political economy at the University of Cambridge. His major work, Principles of Economics, was first published in 1890, and then in a series of revised editions over the rest of his life. The final—8th—edition appeared in 1920. (A “ninth” variorum edition was issued in 1961.) The Principles has been described, by G. J. Stigler, as the second greatest work in the history of economics. The contributions to theory and method warranting such praise, however, are chiefly in the later parts of the volume. Up to and including Book IV (The Agents of Production: Land, Labour, Capital and Organization), the reader is given the impression, according to Keynes, of “perusing a clear, apt and humane exposition of fairly obvious matters.” Certainly in comparison to the rest, these early sections were left fairly intact in their 1890 form over subsequent editions. But Keynes also remarks, in his lengthy obituary of Marshall, how deceptive that surface smoothness could be—and notes that Marshall “had a characteristic habit in all his writings of reserving for footnotes what was most novel or important in what he had to say.”

The excerpts below are taken from Book IV, Chapters IV (§§1–2, 4–5) and XIII (§3), of the 1890 edition of the Principles. In the first, Marshall presents a

brief, selective history of population doctrines up to Malthus, and then the doctrine "in its modern form"; in the second, from the concluding chapter of Book IV, he explores the applicability of the law of increasing returns—stated, earlier in the chapter, as: "An increase of labour and capital leads generally to improved organization, which increases the efficiency of the work of labour and capital."

The supply of labour. The growth of numbers.

§1. In the animal and vegetable world the growth of numbers is governed simply by the tendency of individuals to propagate their species on the one hand, and on the other hand by the struggle for life which thins out vast numbers of the young before they arrive at maturity. In the human race alone the conflict of these two opposing forces is complicated by other influences. On the one hand regard for the future induces many individuals to control their natural impulses; sometimes with the purpose of worthily discharging their duties as parents; sometimes, as for instance during the decay of the Roman Empire, with the vilest and meanest motives. And on the other hand society exercises pressure on the individual by religious, moral and legal sanctions, some times with the object of quickening, and sometimes with that of retarding, the growth of population.

The study of the growth of population is often spoken of as though it were a modern one. But in a more or less vague form it has occupied the attention of thoughtful men in all ages of the world. To its influence often unavowed, sometimes not even clearly recognized, we can trace a great part of the rules, customs and ceremonies that have been enjoined in the Eastern and Western world by law-givers, by moralists, and those nameless thinkers, whose far-seeing wisdom has left its impress on national habits. Among vigorous races, and in times of great military conflict, they aimed at increasing the supply of males capable of bearing arms; and in the higher stages of progress they have inculcated a great respect for the sanctity of human life; but in the lower stages, they have encouraged and even compelled the ruthless slaughter of the infirm and the aged, and sometimes of a certain proportion of the female children.

With the safety valve of the power of planting colonies, and in the presence of constant war, the legislators of ancient Greece and Rome did not hesitate to give special privileges to the fathers of many children. But thoughtful men were even then aware that action in the contrary sense might be necessary if the responsibilities of parentage should ever cease to be burdensome;¹ and in Western Europe during the Middle Ages there may be observed as Roscher says² a regular ebb and flow of the opinion that the State should encourage the growth of numbers. It flowed generally when plague or war had thinned out the people, or when the fear of

war made the recruiting officers anxious; but it seems to have ebbed in England after the Reformation, when the abolition of the celibacy of the religious orders and the more settled state of the country had given a great impetus to population, while the effective demand for labour had been diminished by the increase of sheep runs, and by the collapse of that part of the industrial system which had been organized by the monastic establishments. Later on the growth of population was checked by the licentious habits that grew up with the later Stuarts, and by that rise in the standard of comfort which took effect in the general adoption of wheat as the staple food of Englishmen during the first half of the eighteenth century. At that time there were even fears, which later inquiries showed to be unfounded, that the population was actually diminishing. Petty had forestalled some of Carey's and Wakefield's arguments as to the advantages of a dense population. Child had argued that "whatever tends to the depopulating of a country tends to the impoverishment of it;" and that "most nations in the civilized parts of the world, are more or less rich or poor proportionably to the paucity or plenty of their people, and not to the sterility or fruitfulness of their land³." And by the time that the world-struggle with France had attained its height, when the demands for more and more troops were ever growing, and when manufacturers were wanting more men for their new machinery; the bias of the ruling classes was strongly flowing in favour of an increase of population. So far did this movement of opinion reach that in 1769 Pitt declared that a man who had enriched his country with a number of children had a claim on its assistance to educate them. An act, passed amid the military anxieties of 1806, which granted exemption from taxes to the fathers of more than two children born in wedlock, was repealed as soon as Napoleon had been safely lodged in St Helena⁴.

§2. But during all this time there had been a growing feeling among those who thought most seriously on social problems, that an inordinate increase of numbers, whether it strengthened the State or not, must necessarily cause great misery: and that the rulers of the State had no right to

¹Thus Aristotle (*Politics*, II. 6) objects to Plato's scheme for equalizing property and abolishing poverty on the ground that it would be unworkable unless the State exercised a firm control over the growth of numbers. And as Professor Jowett points out, Plato himself was aware of this; (see *Laws*, v. 740: also Aristotle, *Politics*, VII. 16). The population of Greece is said to have declined from the seventh century B.C., and that of Rome from the third. (See Zumpt, *Bevölkerung im Alterthum* quoted by Rümelin in Schönberg's *Handbuch*. Comp. also Hume's essay on *The populousness of ancient nations*.)

²*Political Economy*, § 254.

³*Discourse on Trade*, Chap. X.

⁴See Twiss, *Progress of Political Economy*, Lect. VII. Note also that a comparison of the rapid increase in the population of Germany with that of France was a chief motive of the order of the French Chamber in 1885 that education and board should be provided at the public expense for every seventh child in all necessitous families. Napoleon the First had offered to take under his own charge one member of any family which contained seven male children: and Louis XIV., his predecessor in the slaughter of men, had exempted from public taxes all those who married before the age of 20 or had more than ten legitimate children. (See Garnier's article on *Population* in the *Dictionnaire de l'Economie Politique*.)

subordinate individual happiness to the aggrandizement of the State. In France in particular a reaction was caused, as we have seen, by the cynical selfishness with which the Court and its adherents sacrificed the well-being of the people for the sake of their own luxury and military glory. If the humane sympathies of the Physiocrats had been able to overcome the frivolity and harshness of the privileged classes of France, the eighteenth century would probably not have ended in tumult and bloodshed, the march of freedom in England would not have been arrested, and the dial of progress would have been more forward than it is by the space of at least a generation. As it was, but little attention was paid to Quesnay's guarded but forcible protest:— "one should aim less at augmenting the population than at increasing the national income, for the condition of greater comfort which is derived from a good income, is preferable to that in which a population exceeds its income and is ever in urgent need of the means of subsistence."

Sir James Steuart was much under the influence of the Physiocrats, and was indeed in some respects imbued with Continental rather than English notions of government: and his artificial schemes for regulating population⁵ seem very far off from us now. With regard to the tendency of population to increase up to the margin of subsistence he accepted the Physiocratic doctrine that, to use Turgot's words, the employer "since he always has his choice of a great number of working men, will choose that one who will work most cheaply. Thus then the workers are compelled by mutual competition to lower their price; and with regard to every kind of labour the result is bound to be reached—and it is reached as a matter of fact—that the wages of the worker are limited to that which is necessary to procure his subsistence"⁶.

Adam Smith said but little on the question of population, for indeed he wrote at one of the culminating points of the prosperity of the English working classes; but what he does say is wise and well balanced and modern in tone. Accepting the Physiocratic doctrine as his basis, he corrected it by insisting that the necessaries of life are not a fixed and determined quantity, but have varied much from place to place and time to time; and may vary more⁷. But he did not work out this hint fully. And there was nothing to lead him to anticipate the second great limitation of the Physiocratic doctrine, which has been made prominent in our time by the carriage of

⁵See his *Inquiry*, Bk I. Ch. XII., "Of the great advantage of combining well digested Theory and a perfect Knowledge of Facts with the practical Part of Government in order to make a People multiply."

⁶*Sur la formation et la distribution des richesses*, § VI. Steuart's own words are (Bk. I. Ch. III.), "The generative faculty resembles a spring loaded with a weight, which always exerts itself in proportion to the diminution of resistance; when food has remained some time without augmentation or diminution, generation will carry numbers as high as possible; if then food comes to be diminished the spring is overpowered; the force of it becomes less than nothing; inhabitants will diminish at least in proportion to the overcharge. If on the other hand, food be increased, the spring which stood at 0, will begin to exert itself in proportion as the resistance diminishes; people will begin to be better fed; they will multiply, and in proportion as they increase in numbers the food will become scarce again."

wheat from the center of America to Liverpool for less than what it used to cost to carry it across England.

The eighteenth century wore on to its close and the next century began; year by year the condition of the working classes in England became more gloomy. An astonishing series of bad harvests⁸, a most exhausting war⁹, a change in the methods of industry that dislocated old ties combined with an injudicious poor law to bring the working classes into the greatest misery they have ever suffered, at all events since the beginning of trustworthy records of English social history. And to crown all, well meaning enthusiasts, chiefly under French influence, were proposing communistic schemes which would enable people to throw on society the whole responsibility for rearing their children¹⁰.

Thus while the recruiting sergeant and the employer of labour were calling for measures tending to increase the growth of population, more far-seeing men began to inquire whether the race could escape degradation if the numbers continued long to increase as they were then doing. Of these inquirers the chief was Malthus, and his *Essay on the Principle of Population*¹¹ is the starting point of all modern speculations on the subject.

. . . .

[The doctrine of population in its modern form]

§4. The growth in numbers of a people depends firstly on the “natural increase,” that is, the excess of their births over their deaths; and secondly on migration.

The number of births depends chiefly on habits relating to marriage, the early history of which is full of instruction; but we must confine ourselves here to the conditions of marriage in modern civilized countries.

The age of marriage varies with the climate. In warm climates where child-bearing begins early, it ends early, in colder climates it begins later

⁷See *Wealth of Nations*, Bk. I. Ch. VIII. and Bk. V. Ch. II.

⁸The average price of wheat in the decade 1771–1780 in which Adam Smith wrote was 34s. 7d.; in 1781–1790 it was 37s. 1d.; in 1791–1800 it was 63s. 6d.; in 1801–1810 it was 83s. 11d.; and in 1811–1820 it was 87s. 6d.

⁹Early in the present century the Imperial taxes—for the greater part war taxes—amounted to one-fifth of the whole income of the country; whereas now they are not much more than a twentieth, and even of this a great part is spent on education and other benefits which Government did not then afford.

¹⁰Especially Godwin in his *Inquiry concerning Political Justice* (1792). There is some interest in the comparison of Malthus' criticism of this *Essay* (Bk. III. Ch. II.) with Aristotle's comments on Plato's *Republic* (see especially *Politics*, II. 6).

¹¹First edition 1798, second and more careful edition in 1806. Malthus' results were not all new and were not all true: but his work has the merit of being the first thorough application of the inductive method to social sciences. The chief workers therefore in the modern historical school of economics justly regard him as one of the founders of that school and his work as a solid possession for ever.[. . .]

and ends later¹²; but in every case the longer marriages are postponed beyond the age that is natural to the country, the smaller is the birth-rate¹³. Given the climate, the average age of marriage depends chiefly on the ease with which young people can establish themselves, and support a family according to the standard of comfort that prevails among their friends and acquaintances; and therefore it is different in different stations of life.

In the middle classes a man's income seldom reaches its maximum till he is forty or fifty years old; and the expense of bringing up his children is heavy and lasts for many years. The artisan earns nearly as much at twenty-one as he ever does, unless he rises to a responsible post, but he does not earn much before he is twenty-one; his children are likely to be a considerable expense to him till about the age of fifteen; unless they are sent into a factory, where they may pay their way at a very early age; and lastly the labourer earns nearly full wages at eighteen, while his children begin to pay their own expenses very early. In consequence, the average age of marriage is highest among the middle classes; it is low among the artisans and lower still among the unskilled labourers¹⁴.

Unskilled labourers, when not so poor as to suffer actual want and not restrained by any external cause, have seldom, if ever, shown a lower power of increase than that of doubling in thirty years; that is, of multiplying a million-fold in six hundred years, a billion-fold in twelve hundred; and hence it might be inferred *a priori* that their increase has never gone on without restraint for any considerable time. This inference is confirmed by the teaching of all history. Throughout Europe during the Middle Ages, and in some parts of it even up to the present time, unmarried labourers have usually slept in the farmhouse or with their parents; while a married pair have generally required a house for themselves. When a village has as many hands as it can well employ, the number of houses is not increased; and young people have to wait as best they can.

There are many parts of Europe even now in which custom exercising the force of law prevents more than one son in each family from marrying; he is generally the eldest, but in some places the youngest: if any other son marries he must leave the village. When great material prosper-

¹²Of course the length of a generation has itself some influence on the growth of population. If it is 25 years in one place and 20 in another; and if in each place population doubles once in two generations during a thousand years, the increase will be a million-fold in the first place, but thirty million-fold in the second.

¹³Mr F. Gallon (*Inquiries into Human Faculty*, pp. 320-1) estimated that in England the probable number of children of women married at the ages of 17, 22, 27 and 32 are respectively 9.0, 7.5, 6.0 and 4.5; that is, that their relative fertilities are as 6, 5, 4, and 3. [. . .]

¹⁴The term marriage in the text must be taken in a wide sense so as to include not only legal marriages, but all those informal unions which are sufficiently permanent in character to involve for several years at least the practical responsibilities of married life. They are often contracted at an early age, and not unfrequently lead up to legal marriages after the lapse of some years. For this reason the average age at marriage in the broad sense of the term, with which alone we are here concerned, is below the average age at legal marriage. The allowance to be made on this head for the whole of the working classes is probably considerable; but it is very much greater in the case of unskilled labourers than of any other class. [. . .]

ity, and the absence of all extreme poverty are found in old fashioned corners of the Old World, the explanation generally lies in some such custom as this with all its evils and hardships¹⁵. It is true that the severity of this custom may be tempered by the power of migration; but in the Middle Ages the free movement of the people was hindered by stern regulations. The free towns indeed often encouraged immigration from the country: but the rules of the guilds were in some respects almost as cruel to people who tried to escape from their old homes as were those enforced by the feudal lords themselves¹⁶.

§5. In this respect the position of the hired agricultural labourer has changed very much. The towns are now always open to him and his children, and if he betakes himself to the New World he is likely to succeed better than any other class of emigrants. But on the other hand the gradual rise in the value of land and its growing scarcity is tending to check the increase of population in some districts in which the system of peasant properties prevails, in which there is not much enterprise for opening out new trades or for emigration, and parents feel that the social position of their children will depend on the amount of their land. They incline to limit artificially the size of their families and to treat marriage very much as a business contract, seeking always to marry their sons to heiresses. Mr Francis Galton has pointed out that though the families of English peers are generally large, the habit of marrying the eldest son to an heiress, who is presumably not of a fertile stock, and sometimes dissuading the younger sons from marriage, has led to the extinction of a great many peerages; and in the like manner among the French peasants this habit combined with their preference for small families keeps their numbers almost stationary¹⁷.

On the other hand there seem to be no conditions more favourable to the rapid growth of numbers than those of the agricultural districts of new countries. Land is to be had in abundance, railways and steamships carry away the produce of the land and bring back in exchange implements of advanced types, and many of the comforts and luxuries of life. The "farmer," as the peasant proprietor is called in America, finds therefore that a large

¹⁵A typical instance is that of the valley Jachenau in the Bavarian Alps. There the custom is rigidly enforced: and there are scarcely any small cottages in the valley. Aided by a great recent rise in the value of their woods, with regard to which they have pursued a farseeing policy, the inhabitants live prosperously in large houses, the younger brothers and sisters acting as servants in their old homes or elsewhere. They are of a different race from the work people in the neighbouring valleys, who live poor and hard lives, but seem to think, so far as I could gather their opinions that the Jachenau purchases its material prosperity at too great a cost.

¹⁶See e.g. Rogers, *Six Centuries*, pp. 106-7.

¹⁷The birthrate in France is known to vary inversely with the predominance of small properties, being lowest in those departments in which the largest proportion of the agricultural population are landowners, and highest in those in which there are fewest peasant proprietors. See Dr Berthillon's statistics quoted by M. Yves-Guyot (*Social Economy*, Bk. IV. Ch. I.). The birthrate in France was 32.3 per 1000 at the beginning of the century, and it has diminished steadily from decade to decade till now it is only 24.6. The extreme prudence of peasant proprietors under stationary conditions was noticed by Malthus. See for instance his account of Switzerland (*Essay*, Bk. II. Ch. V.).

family is not a burden, but an assistance to him. He and they live healthy out-of-door lives; there is nothing to check but everything to stimulate the growth of numbers. The natural increase is aided by immigration; and thus, in spite of the fact that some classes of the inhabitants of large cities in America are, it is said, reluctant to have many children, the population has increased sixteen-fold in the last hundred years.

. . .

[The law of increasing return]

§3. Our discussion of the character and organization of industry taken as a whole tends to show that an increase in the volume of labour causes in general, other things being equal, a more than proportionate increase in the total efficiency of labour. But we must not forget that other things may not be equal. A rapid growth of population has often been accompanied by unhealthy and enervating habits of life in overcrowded towns. And sometimes it has started badly, outrunning the material resources of the people, causing them with imperfect appliances to make excessive demands on the soil; and so to call forth the stern action of the law of diminishing return as regards raw produce, without having the power of minimizing its effects. Having thus begun with poverty, an increase in numbers may go on to its too frequent consequences in that weakness of character which unfits a people for developing a highly organized industry.

These are serious perils: but yet it remains true that the collective efficiency of a people with a given average of individual strength and energy may increase more than in proportion to their numbers. If they can for a time escape from the pressure of the law of diminishing return by importing food and other raw produce on easy terms; if their wealth increases at least as fast as their numbers; and if they avoid habits of life that would enfeeble them; then every increase in their numbers is likely to be accompanied by a more than proportionate increase in their power of obtaining material goods. For it enables them to secure the many various economies of specialized skill and specialized machinery, of localized industries and production on a large scale: it enables them to have increased facilities of communication of all kinds; while the very closeness of their neighbourhood diminishes the expense of time and effort involved in every sort of traffic between them, and gives them new opportunities of getting social enjoyments and the comforts and luxuries of culture in every form. No doubt deduction must be made for the growing difficulty of finding solitude and quiet and even fresh air: but there is in most cases some balance of good¹⁸.

Taking account of the fact that an increasing density of population generally brings with it access to new social enjoyments we may give a rather broader scope to this statement and say:—An increase of population accompanied by an equal increase in the material sources of enjoyment and aids to production is likely to lead to a more than proportionate increase in the aggregate income of enjoyment of all kinds; provided firstly, an adequate supply of raw produce can be obtained without great difficulty, and secondly there is no such overcrowding as causes physical and moral vigour to be impaired by the want of fresh air and light and of healthy and joyous recreation for the young.

The accumulated wealth of civilized countries is at present growing faster than the population: and though it may be true that the wealth per head would increase somewhat faster if the population did not increase quite so fast; yet as a matter of fact an increase of population is likely to continue to be accompanied by a more than proportionate increase of the material aids to production: and in England now, with easy access to abundant foreign supplies of raw material, an increase of population is accompanied by a more than proportionate increase of the means of satisfying human wants other than the need for light, fresh air, etc. Much of this increase is however attributable not to the increase of industrial efficiency but to the increase of wealth by which it is accompanied: and therefore it does not necessarily benefit those who have no share in that wealth. And further, England's foreign supplies of raw produce may at any time be checked by changes in the trade regulations of other countries, and may be almost cut off by a great war, while the naval and military expenditure which would be necessary to make the country fairly secure against this last risk, would appreciably diminish the benefits that she derives from the action of the law of increasing return.

¹⁸The Englishman Mill bursts into unwonted enthusiasm when speaking (*Political Economy*, Bk. IV, ch. VI, § 2) of the pleasures of wandering alone in beautiful scenery: American economists from Carey to Henry George no less characteristically use their highest eloquence in splendid descriptions of the growing richness of human life as the backwoodsman finds neighbours settling around him, as the backwoods settlement develops into a village, the village into a town, and the town into a vast city. (See for instance Carey's *Principles of Social Science* and Henry George's *Progress and Poverty*.)

BOOK REVIEWS

CHRISTOPHER WILLS

Children of Prometheus: The Accelerating Pace of Human Evolution

Reading, MA: Perseus Books, 1998. ix + 310 p. \$25.00.

The sciences of human behavior are being inexorably transformed by the introduction of genuinely neo-Darwinian evolutionary reasoning. Not to be confused—as is still too often the case—either with noxious expressions of a discredited Social Darwinism or with versions of societal developmentalism frequently mislabeled evolutionism, the current intellectual transformation is grounded in the realization that animal, including human, behavior is but another phenotypic expression of organisms whose traits are products of a complex interaction of genetic information and environmental constraints. The upshot of these developments is that social and behavioral scientists can no longer deny or ignore the fundamental principles of the evolutionary sciences in their attempts to formulate more nearly complete explanations of their subject matter. Into this setting steps Christopher Wills, professor of biology at the University of California at San Diego, whose most recent book, *Children of Prometheus*, should appeal to a diverse audience. Indeed, his argument should be especially intriguing to students of human demography and ecology because, as Wills correctly points out, “demographic trends are, after all, the very stuff of the evolutionary process” (p. 118).

The central problem that Wills explores concerns the rapid pace of hominid evolution over the past few million years. His answer to this intriguing puzzle is that, relative to other primate species, humans and their hominid ancestors have been more likely to migrate into novel physical environments that posed unprecedented challenges and, therefore, new selective pressures on their repertoire of anatomical, physiological, and behavioral traits. Moreover, our ancestors were remarkably clever creatures, owing to the development of relatively big brains. This mental agility undergirded their capacity for cultural innovation, further modifying the environments that our ancestors occupied.

Other organisms, of course, behave in ways that alter their environments. But none do this to the degree exhibited by hominids. Our ancestors' extraordinary adaptive flexibility enabled them to occupy physical environments far removed from those typical of their African origins, thereby exposing them to novel selective pressures. In addition, cultural innovations triggered additional environmental modifications that represented new constraints on our ancestors' array of anatomical, physiological, and behavioral traits. It is this very mental and cultural flexibility, according to Wills, that continues to accelerate the pace of human evolution.

All these genetic and environmental changes have tended to reinforce each other in a feedback loop. Any cultural or environmental change would have selected for individuals who happened to carry genes that made them best able to take advantage of it. As a result, some of them (or their progeny) would have been clever enough to produce still more cultural and environmental changes. This would lead to even more

selection, not only for new genetic variants that had arisen by mutation but also for new combinations of old genes that are produced by the genetic shuffling known as recombination that takes place every generation. (p. 5)

The story of hominid evolution is complex, constantly amended by new discoveries, and only incompletely grasped. Still, Wills does a masterful job of telling the tale in an engaging and thought-provoking manner.

The book is divided into three well-integrated parts. Part I, "The many faces of natural selection," traces the debate over whether human traits continue to evolve and provides a strongly affirmative response. In a series of chapters, Wills provides readers with an overview of the basic mechanisms of natural selection; sketches, by way of a fascinating comparison of Andean and Tibetan peoples, some intriguing physiological adaptations and their possible genetic foundations in human populations living at high altitudes; reviews recent evidence regarding host-parasite coevolution and its implications for understanding certain human diseases, including one of the most informative accounts of sickle-cell anemia and of AIDS that I have encountered in recent years; examines the relationship between position in the social hierarchy and levels of stress, partly by reference to a recent study of the British civil service; and assesses the evolutionary implications of declining fertility and patterns of immigration in advanced industrial societies, making frequent mention of the effect of social and psychological attitudes on birth rates. These chapters, in particular, will be of special interest to demographers and human ecologists.

Part II of the volume, "Our stormy evolutionary history," reviews the latest findings regarding hominid evolution; contrasts this evidence with what is known about the evolution of other ape species; and, throughout, emphasizes the relative rapidity of hominid and human evolution. The concluding Part III, "Selection for diversity," focuses on patterns of brain evolution and selection for mental flexibility in humans. This latter characteristic, according to Wills, will assuredly be put to the test in years to come.

Whether our physical environment becomes safer in the future or takes a turn for the worse, our intellectual environment is certainly becoming more challenging. It is in this realm that our future evolution will primarily take place, continuing and enhancing the trend that has continued uninterrupted for the last several million years. The challenges we will face—traveling to other stars, healing our damaged planet, learning how to live with our differences—will be met in part because we will be able to draw on that genetic legacy. (p. 271)

The conclusion is an apt one. No one can doubt that the most severe challenges our species will face in years to come will be those of our own making, as Wills rightly emphasizes throughout the volume. He singles out the threats stemming from the simplification of ecosystems stimulated by the spread of agriculture, from excessive global population growth, from the horrors of industrial accidents, and from the introduction of new and potentially toxic substances that pose potentially serious selective pressures on our species' traits. These and other forms of cultural transformation will certainly introduce potent selective pressures to which our species may or may not adequately adapt.

A brief review of *Children of Prometheus* can hardly do justice to Wills's richly textured argument. He effectively pulls together materials from a variety of specialized fields, including archaeology, cultural and physical anthropology, epidemiology, medicine, neurobiology, primatology, social psychology, and sociology. That he tells this complexly woven story with a graceful style and an occasional dose of keen wit only adds to the reader's enjoyment and enlightenment. It is, in short, a volume from which social scientists with varying interests will be able to learn much. Wills's argument illustrates the manner in which evolutionary theory may usefully inform analyses of, for example, migration, ethnic intermarriage, fertility behavior, and patterns of morbidity and mortality. Above all, it stresses the potent selective pressures emanating from the cultural environment that continue to shape the evolutionary pathway of our species and, in the process, reminds us that the same selective forces that forged our traits in the distant past are still actively constraining our species' destiny.

*Department of Sociology and Anthropology
Mary Washington College*

TIMOTHY CRIPPEN

HELEN FISHER

The First Sex: The Natural Talents of Women and How They Are Changing the World

New York: Random House, 1999. xx + 378 p. \$25.95.

LIONEL TIGER

The Decline of Males

New York: Golden Books, 1999. 323 p. \$23.00.

These two anthropologists have the same two goals: to present a case for evolutionary psychology and to sell books. Both incorporate demographic factors into their analyses, making their efforts of potential interest to students of population. Fisher focuses on women's increased participation in the labor force, a global trend she believes to be biologically driven. Evolutionary forces have molded women into "web thinkers," who see the broad picture, consider all options, are sensitive to others, accept ambiguity, and easily modify objectives when necessary. Women, in short, are ideal members of the twenty-first-century corporate work team. Occasionally Fisher's propensity to see biological advantage borders on the silly—such as when contending that women's greater ability to see in dim light makes them more adept viewers of slide presentations—but most of her exposition follows stereotypes: women will come to predominate in the health professions because their greater natural empathy makes them better healers and because their greater dexterity makes them better surgeons. Her one foray into demographic analysis is to provide a sociobiological slant on the aging of the baby boom generation: women will burst through the glass ceiling in their corporate careers as their female hormones decline with menopause, unmasking the power of their testosterone. Demographers will find her analysis of which societies will experience this shift vague and occasionally misleading, and readers who like their stories

well plotted will find her testosterone explanation of employment success somewhat at odds with her thesis about the new workplace's affinity for female traits. She does, however, manage to have something new to say about the baby boom.

Tiger contributes to this "production" debate, but from the other side of the podium. He bemoans the fate of the prey-stalking, physically assertive male programmed to focus single-mindedly on demanding tasks. When young, the contemporary male finds himself in schools that unnaturally expect him to sit still for hours a day, for years on end, and when he rebels he gets filled with tranquilizers and is said to suffer from "attention deficit disorder." Once discharged from school he enters a workplace with few occupations, outside of the military and sports, suited to his inclinations. But no matter how great are the male's contemporary workplace problems, Tiger argues that his decline has even more to do with estrangement from the reproductive realm. The arrival of female-controlled contraception, specifically the midcentury development of "the Pill," marked the true downfall of the male. In a world with the Pill a female can have sex when, and with whom, she wants. If she desires a child, her improved work status frees her from the need for male support. The Pill infects the male, biologically driven to assure a place for his genes in the next generation, with a terminal case of "paternity uncertainty." He reacts by walking away from his now questionable fatherhood, and societies everywhere experience sharp upsurges in divorce and single motherhood. Tiger foresees a twenty-first-century world in which the male has become so much the "second sex" that there might be no need for him.

What do these analyses offer the student of population? Both provide entertaining introductions to the thinking of evolutionary psychologists. Since they incorporate familiar demographic themes in their analyses, one might hope that demographers reading them would be induced to broaden their explanatory horizons. I fear, however, that the authors' deductive methods and unsophisticated social trend analyses (most of which are lifted from newspaper accounts) will elicit more dismissal than marvel from this readership. Tiger, for example, never offers any empirical evidence, other than a rough reference to timing, to support his theory that the arrival of the Pill caused societal increases in divorce and single motherhood—not even a cursory discussion of Pill use rates, divorce rates, and rates of single motherhood in various societies. He deduces the societal significance of female-controlled contraception from a consideration of general sociobiological premises, but attempts no empirical proof. This, however, might be a good thing because in Tiger's demographic analyses what is most memorable are his gaffes: his discussions of "zero birth rates" and his embarrassing explanation of how sex-selective abortion of female fetuses in India somehow produces "an excess of potential brides over potential grooms" that facilitates the growing problem of dowry deaths (p. 139).

There is increasing scientific evidence that evolutionary processes have produced sexes with distinct physiological and psychological traits, traits that might be especially relevant to any student of human behavior wishing to better understand patterns of work, marriage, and reproduction. These two books, however, provide a cautionary tale to those who would use trends of a comparatively brief duration to illustrate the utility of what, by its very nature, is a perspective on human behavior suited to explaining trends encompassing, at the least, many generations. No doubt it is tempting in an era when the war between the sexes makes

headline news, and the public is troubled by having half its marriages fail and by having many of its daughters bring forth babies without husbands, to offer a “deep” explanation of the factors behind these events. But as demographers are acutely aware, having themselves not foreseen the baby boom, social trends can be very fickle things. Although just published, Tiger’s talk of high unemployment among American males already sounds “odd” today. And having characterized the single young mother as a “Mother Courage” who is “at the heart of the ancient mammalian process” (p. 174), one wonders what he would make of the sharp decline in birth rates of single teens in the United States during the 1990s.

*Department of Sociology
Fairfield University*

DENNIS HODGSON

FRANCIS FUKUYAMA

The Great Disruption: Human Nature and the Reconstitution of Social Order

New York: The Free Press, 1999. xii + 354 p. \$26.00.

Big-picture social science aims to lend order to social facts, finding or refinding patterns in them and telling stories about them. The facts need to be important, the stories interesting. Francis Fukuyama is an accomplished practitioner in this domain. *The Great Disruption*, like his earlier books, is directed at a wide audience. It should be of more than passing interest to social demographers.

The plot line is simple. A great disruption in Western society has occurred; the author characterizes it. There are competing explanations for it, each of which the author finds unsatisfactory; he proposes his own. The disruption needs to be healed: history suggests that this healing may be largely a spontaneous process, but it is also likely to require deliberate efforts at social innovation; the author makes a few general suggestions about what might be done.

In the middle of this argument the author takes the opportunity to introduce some contemporary ideas in social science: kernels of theory and gobs of evidence that might be drawn on in understanding what is going on and predicting how matters might develop. These are popularizations rather than original contributions, but are well done and sustain interest in themselves. However, they are not in fact much drawn on. Indeed, the single chapter on “what comes next” is quite perfunctory. The reader, it might be said, has been shown the facts, given some tools, and now should go away and use them to fashion the remedy—or simply to be better informed in watching the repair take place unaided.

So much for the skeleton; now for the flesh. The disruption of the title refers to a set of changes in Western societies observed starting in the 1960s: “increasing levels of crime and social disorder, the decline of families and kinship as a source of social cohesion, and decreasing levels of trust” (p. 60). The demographic component of the disruption is seen in falling marriage rates, falling fertility rates and at the same time many more extramarital births, and sharply higher divorce rates. Fukuyama sees all these as manifestations of a decline in social capital.

Social capital, roughly speaking, is the resources that inhere in social relations. The concept was examined thoroughly in a recent issue of this journal by Nan

Marie Astone and colleagues (vol. 25, no. 1), where it was traced back to George Homans's 1950 monograph *The Human Group*. Fukuyama finds a much earlier use of the term—in 1916, in an article on school community centers by Lyda Judson Hanifan. But the current popularity of the concept is owed mainly to Pierre Bourdieu, James S. Coleman, and Robert D. Putnam.

Analytically, it is a rather critical question, as Astone et al. point out, whether social capital is a characteristic of an individual or a group. They hold strongly that it should be the former, and criticize Coleman for fudging the issue. For Fukuyama social capital is more the glue of society, a measure of societal health. It is "a set of informal values or norms shared among members of a group that permits cooperation among them" (p. 16). This was a theme developed in his last book, *Trust*. It is also the sense in which the term is used in the influential writings on Italy and the United States by Robert Putnam, and in the current debate over the empirical issue of whether social capital in the US has in fact been declining.

Fukuyama sees societies as being in the business of maintaining systems of norms—indeed, that is essentially what societies *are*. It is a dynamic enterprise, entailing constant adaptation and adjustment to changing circumstances. Sometimes those changes may be so abrupt or severe as to undermine or destroy the norms governing some area of behavior, perhaps many areas. But the same societal adjustment processes are engaged—now in the task of repair and restoration, what Fukuyama calls the task of *renorming*. There is a kind of institutional homeostasis at work, not with any particular structural outcome in view (it is not a teleological process) but influenced by enduring human qualities and values that are probably hard-wired into our species. As hints on how renorming might work, in the middle part of the book, titled *On the Genealogy of Morals*, the reader meets in short compass the incest taboo, iterated prisoners' dilemmas, bonobo society, self-organization, the logic of collective action, the Hayekian extended order, and various other ideas that could bear on natural and spontaneous sources of social order.

How reasonable is a faith in self-correcting mechanisms? Fukuyama's main instance of a successful renorming is the way he perceives that Victorian values brought back into line the disarray of early industrial society. A striking graph shows the incidence of crime in England peaking in the 1840s and thereafter steadily dropping. In both Britain and the United States, "masses of rude, illiterate agricultural workers and urban poor were converted into what we now understand as the working class" (p. 268)—disciplined, washed, and sober. Much of this change was a "moral renovation" brought about through inculcation of new values. It was associated with a widespread increase in religious observance, notably in sectarian Protestantism. Overt social control, through establishment of modern police forces and a kind of early zero-tolerance policy, also helped.

Fukuyama sees the currently disrupted order as already embarking on the path to reconstitution. Crime is down, family values are being reasserted, the era of ever-expanding individualism is ending. As in the Victorian case, religion is held to be playing an important role in the process. But now it is religion as ritual and tradition rather than belief: a benign, social religiosity impelled by the desire for community and the wish to instill the right values in children. (This might seem a more plausible prospect in the US than in Europe—of a measure with the cynic's one-time view of Anglicanism as the Tory party at prayer.)

Familism in itself would presumably help to sustain fertility, but Fukuyama makes no claims in this regard. A stable, reformed social order, replete with social capital, might turn out to be compatible with high rates of childlessness and single-person households and total fertility nearer a one than a two child average. His modest hope is for “cultural adaptations that will make information age societies more hospitable to children” (p. 276). Economic trends may help in this, through the shift from Taylorite working conditions to telecommuting. In addition, he suggests, the income and work status forgone by women through childrearing will seem less serious as men too increasingly lose security of employment and routinely come to experience downward as well as upward mobility over the course of their working lives.

Fukuyama concludes by contrasting the unidirectionality of history in the political and economic sphere—culminating, as *The End of History* argued, in Western-style liberal democracy—with the cyclical nature of history in the social and moral sphere, “with social order ebbing and flowing over the space of multiple generations” (p. 282). Historically, fertility could be viewed as if it were an incidental part of the first sphere; demographers have yet to come to grips with fertility as part of the second.

*Australian National University
and Population Council*

GEOFFREY MCNICOLL

TOM KIRKWOOD

Time of Our Lives: The Science of Human Aging

New York: Oxford University Press, 1999. x + 277 p. \$27.50.

Tom Kirkwood has written an interesting and readily accessible book on the “new” biology of aging. He presents a wealth of recent scientific material that is changing our view of biological senescence. Much of the scientific research Kirkwood cites is organized in reference to an article he published in *Nature* in 1977 on a specific theory of aging: the so-called disposable soma theory for which he received the guiding intuition—as he indicates several times in the book—while sitting in a bathtub at home.

The disposable soma theory eschews the notions that there are strictly programmed life spans, that “death genes” have evolved to prevent overcrowding, or even that biological senescence, as a unified process, is necessarily a direct outcome of evolution. Kirkwood suggests that cell replication, especially DNA error checking, is an energy-intensive process, for which reason a species’ optimal survival strategy is to favor genetic traits that enhance reproduction and maximize survival through the primary reproductive ages. This implies that there are intrinsic limits to the energy available for biological error checking and other basic cellular functions at later ages and that, indeed, biological traits found to be optimal during reproductive life may not be optimal at advanced ages. Hence, the somatic cells (in contrast to germ cells) are “disposable” in the same scheme of species-specific survival.

Around this core model and theme Kirkwood reviews a number of classic research studies on aging such as the long-lived cell lines cultured by Alexis Carrel, the Hayflick and Martin experimental results on cell replication limits, and more recent work on such specialized topics as Werner's syndrome, helicases, apoptosis, heat-shock proteins, and telomerase. By using a readily understandable conceptual model as a basis (i.e., the disposable soma model), Kirkwood skillfully challenges some specific scientific results, such as earlier assertions about the complete independence of the genetic mutations underlying cancer from those underlying senescence.

Despite the evident value of the book as a comprehensive scientific review of many recent results, a few shortcomings may limit the book's value for certain scientifically trained readers. One problem is the absence of a standard bibliography. Instead, a brief bibliographic essay discusses broad areas of relevant literature and identifies their primary authors. As a consequence, a number of assertions about particular scientific results or lines of investigation made in the text cannot be directly verified. Although most of Kirkwood's assertions appear correct, often the ideas of scientific investigators evolve over time, through several publications, so that this lack of reference to results in specific scientific publications will be a serious handicap to readers interested in the development of certain theoretical arguments.

A second major departure in the book is the inclusion of a science fiction-type epilogue that presents an image of the socio-biological future as generated by long-term extensions of current biomedical research and technology directed to biological aging processes. How much value this adds to the book will depend upon the individual reader and his interests. My version of the future of aging and longevity might be very different from that presented in the epilogue. One individual's view of the likely long-term development of the science of aging and its social implications must be highly speculative.

A more substantive reservation concerns instances in which I feel the topic of research on aging was not as completely developed as it might have been. For example, there is limited discussion of the ability to manipulate the internal biochemical environment of the organism to modify phenotype expression, an area of study now often referred to as pharmacogenomics. This approach is clearly the basis of modern molecular medicine and pharmacology, which, aided by the advent of micro-computers and processors, the evolution of bio-informatics, and special-purpose silicon chips that sense physiological levels of critical compounds and release drugs to the organism in nano-quantities, promise to modify age-related processes in a quite different fashion, and with greater control, than is currently possible. One aspect of this process is the control of phenotype and gene interactions, especially of "latent" (i.e., unexpressed) genes, by sets of complex proteins generically called growth factors. This also suggests that more dimensions of aging and of aging-related changes could be environmentally, or exogenously, manipulated than once thought. We might, for example, allow neurons in specific areas of the brain to be replicated—a principle Kirkwood seems not to explicitly recognize (see, e.g., p. 130). Such replication has been suggested, at least in theory, to occur naturally in mammals and in humans, and there is evidence that physical and cognitive activity stimulates the development of neurological complexity in various animal species.

Thus, as with any rapidly developing scientific field, new areas of research are constantly emerging and it is not possible for all of them to be included in any single book. Many parts of the present book will undoubtedly have to be rewritten within a few years. For example, the critical Hayflick limit model has been largely surpassed by a 1998 study that showed no correlation between age and the remaining number of cell replications in healthy human subjects. Five new drugs, intended to counteract the recently discovered enzymes forming the plaques found in the brains of patients with Alzheimer's disease, will enter human trials shortly. There is now even talk of curing Alzheimer's disease within several years through drug therapy. There were at least a dozen studies reporting several forms of neurogenesis and stem cell activity in the human brain in 1999. The production of such scientific results is growing exponentially. This phenomenon is made possible by advances in micro-electronics and computing. Such is the nature of life and aging—and, in turn, of basic research on those topics.

*Center for Demographic Studies
Duke University*

KENNETH G. MANTON

MARGO J. ANDERSON AND STEPHEN E. FIENBERG

Who Counts? The Politics of Census-Taking in Contemporary America

New York: Russell Sage, 1999. x + 319 p. \$34.95.

While census-taking may seem to be a cut-and-dried administrative procedure—merely counting the people—in many countries national population censuses have become flashpoints of controversy. This is because censuses reveal the relative weights of numbers of different segments of the population. Which region has the greatest population? Which cities have grown; which have shrunk? And, usually most contentious of all, what are the numbers of the various religio-ethnic groups? Insofar as these numbers are eventually translated into fundamental desiderata such as economic resources and political power, it is no surprise that the census sits at a point of potential conflict. *Who Counts?* tells the story of an ongoing and apparently intractable census dispute in the United States.

The authors, Margo Anderson, a social historian, and Stephen Fienberg, a mathematical statistician, represent a uniquely qualified team. Anderson, author of the valuable *The American Census: A Social History* (1988), has spent years studying the sociopolitical process of creating population statistics in the United States. Fienberg, former president of the American Statistical Association, has been deeply involved with special scientific committees that have advised the U.S. Census Bureau on statistical methodology for the 1990 and 2000 censuses. Together they have written a book that takes advantage of both of their areas of expertise: it presents the historical background and the unfolding “current history” of what has been happening in the US government regarding the census, and it clearly explains the statistical techniques along with the arguments that have arisen about them. The well-edited text moves smoothly between the governmental and the statistical developments, producing a very readable volume.

The principal issue in the US census is this: regardless of the diligent efforts of the Census Bureau, time after time, the decennial enumeration is incomplete. The undercount is consistently biased such that African-Americans are more likely to be missed than whites. It has also been shown that other minorities, such as American Indians and Latinos, are more likely to be missed as well. These biases have ramifications for the system of allocating seats in the House of Representatives (Congress), which are based upon population size. If the 1990 census had been adjusted to correct for the undercount, two states would have lost Congressional seats, which would have been allocated to other states. Within individual states, the undercount may also affect the way in which seats are allocated in the state legislature. Because big cities tend to have populations with disproportionate numbers of members of minority groups, the undercount negatively affects them more than it does suburbs and rural areas. Indeed, suburban areas are sometimes "overcounted."

For more than 30 years the issue has been how to address this problem. The political story begins with judicial rulings in the 1960s that increased the value of small-area statistics, particularly in the process of allocating legislative seats, but also in distributing tax dollars to local areas. Once politicians became aware of the impact of these rulings, they became more attentive to census numbers than they had been in the past. Over time the political controversies intensified and, by the mid-1990s, the two political parties were sharply and bitterly divided about how to conduct the 2000 census.

The scientific story begins with a series of demographic discoveries that demonstrated that the 1940 census had systematically missed black males. Each census thereafter was accompanied by evaluation studies. Starting in 1950, the demographic analysis was accompanied by studies employing a second method, based upon large-scale surveys. These studies became increasingly sophisticated, incorporating different forms of dual-systems analysis. Demographic analysis made it possible to measure census undercounts in a historical series, even retrospectively into the late nineteenth century. The survey-based evaluations gave a second set of estimates of undercounts in censuses from 1950 onward. Apparently both series of results showed that census coverage improved consistently: typically the gross undercount in each census was less than that of the previous census. Despite this accomplishment, the census-takers were unable to eliminate or even diminish the black-white differential.

Anderson and Fienberg devote a chapter to the measurement of "race" and "ethnicity," a topic that has been neglected in discussions of this problem. They point out the unscientific nature of the concept of race and demonstrate the weakness of the census's questions on ethnicity. In this context, it is no wonder that it is so difficult to solve the problem of counting racial and ethnic groups.

The authors emphasize that it is misleading to focus upon the census's net undercount, which represents the difference between the number of persons missed and an actual overcount, consisting of persons who were counted more than once. For various reasons, the 1990 census included individuals who were counted more than once. It also included "erroneous enumerations." Although the published net undercount was 1.8 percent, the authors suggest that "it might be reasonable to expect that the percentage of people correctly counted was closer to 90 percent for the 1990 count (corresponding to a gross error of about 10 percent)." Anderson and Fienberg assert that rather than evaluating a census on the basis of its net undercount, the correct criterion should be its overall error rate.

By 1990, statisticians at the U.S. Census Bureau had developed methods to make statistical corrections at all geographical levels, including for small areas, but were prevented from using them. Thus, despite the errors in the census of that year, the Census Bureau published uncorrected numbers. The principal decision-maker who rejected the correction procedure was the Secretary of Commerce, a Republican, whose department includes the Census Bureau. Although the director of the Census Bureau along with most knowledgeable statisticians supported correction, the Secretary's decision was eventually upheld by the Supreme Court.

Anderson and Fienberg contend that a court of law is an inappropriate forum in which to make a decision about the best way to take a census. This is because the court must make a decision based upon the legal formulation of the issue. In the case of the 1990 census, the Supreme Court's 1996 decision was based upon the question of whether the Secretary of Commerce had violated the Administrative Procedures Act, not whether he had executed the census in the most accurate manner. The authors point out a number of ironies in the differences between the ways in which census issues are defined by social scientists and the way in which they are defined in the legal process.

Much of *Who Counts?* is devoted to the story of the 2000 census, its planning, the statistical developments that support its methodology, and the political machinations that affected its final form. From the point of view of the population sciences, this is a sad tale. While census officials, along with supportive colleagues outside the government, were working to develop an efficient and accurate methodology, political groups had mobilized to thwart their plans. Census officials experienced defeats in Congress and in the courts and were forced to withhold certain procedures and to enter into cumbersome political compromises.

While this book was published prior to the execution of the 2000 census, it is timely. Indeed, on its final pages, it even alludes to a January 1999 Supreme Court decision. *Who Counts?* is well-organized, full of interesting material, and clearly written. It is accessible to students as well as professionals. It should be of interest to anyone interested in censuses, population statistics, and issues at the nexus of statistics and politics. I suspect that the authors would be pleased if American journalists, lawyers, and members of Congress, many of whom have misconstrued the recent issues (sometimes deliberately), would read this book.

Department of Sociology
University of Illinois, Urbana-Champaign

HARVEY M. CHOLDIN

ALAIN DESROSIÈRES

The Politics of Large Numbers: A History of Statistical Reasoning. Translation by Camille Naish of *La politique des grands nombres: histoire de la raison statistique.* Cambridge, MA: Harvard University Press, 1998. 368 p. \$45.00.

There have been a number of notable histories of statistics. The one by Harald Westergaard (*Contributions to the History of Statistics*), published in 1932 after his re-

tirement from academia, is an interesting survey with full attention to population data. A later book by Stephen Stigler (*A History of Statistics*, published in 1986) covers much the same material as the work under review, with equations or graphs on almost every page. Alain Desrosières, who has written what he calls a history of “statistical reasoning,” generally assumes that the reader has the requisite background in mathematics and focuses rather on the relation of the analytical structure to its social and political context.

The word “statistics” was introduced into English in the late eighteenth century to denote a survey of a political entity. As with the German *Statistik* from which it derived, in its original sense the “survey” did not have to be given in numbers. It was only later that “statistics” took on the same meaning as the earlier “political arithmetic,” numerical data about a state’s population and other measurable characteristics. That both terms are etymologically related to the affairs of state, to politics, is evident; a “statist,” now rare in any sense, can mean either a statesman or statistician. But in most works on statistics this enduring association with official bureaucracy is not given its due. That Desrosières emphasizes it constitutes a distinctive and valuable feature of his book.

The range of his history covers the principal Western countries, but, as a French scholar, he concentrates on France, and this is a happy circumstance. No other country exemplified so well the characteristics of the mercantilist era, and the career of a man such as Marshal Vauban (1633–1707) combined analysis with administration. And it was during the revolutionary and Napoleonic period that France’s *adunation* (or consolidation into one unit) took place. The metric system replaced various traditional measures; dialects were cut back and, through schools and the army, standard French was generalized; the new *départements* were given names that pointedly avoided any association with the former provinces. In every respect Paris became the nucleus of France, and the major role of statistics was to help administrators at the center.

Typical of the book’s style is the discussion of nineteenth-century debates over averages. Not only does it elaborate on the contributions of Gauss, Laplace, and Quetelet but the whole controversy is presented as a continuation of the fourteenth-century confrontation between realists and nominalists. “The process of addition caused local singularities to disappear and caused a new object of a more general order to appear.” Quetelet’s “average man” was a way to raise the sum of multiple units to a higher level, such as *the price index* or *the unemployment rate*, which soon was converted into inflation/deflation or, as a concept, the unemployment that was being measured. Similarly, when in his work on suicide Durkheim spelled out how the “moral constitution of groups” differs radically from that of individuals, he set a pattern followed by the next century’s sociologists. But what if the average *département’s* characteristics were used to describe Paris, for instance, which everyone knew was idiosyncratic? Then the “realist” point of view would be false, and those on the other side of the long debate held that in such an instance using the average would be illegitimate. When the account of how modern statistical thought developed is tied to a recollection of medieval philosophizing, the result is a novel and attractive presentation.

A chapter on correlation begins with a review of Karl Pearson’s *The Grammar of Science* (together with its 1912 French translation by Lucien March, director of

the national statistical bureau). It was Pearson's central doctrine that "we have to replace the old idea of causation" with a correlation, ranging from 0 to 1, between any two occurrences. Between the work's first edition (1892) and the third (1911), its tools were applied by Francis Galton, who gave the dogmas of eugenics a quasi-scientific underpinning. Desrosières gives us a detailed account of the controversy over eugenics and the role that evolving statistical techniques played in it. Quetelet had used the normal curve to map human heights, and Galton, adapting it to social aptitudes, divided the population into five categories of increasing genetic worth: criminals, paupers, etc.; the poor and low-paid; the "respectable" working class; skilled workers, foremen, clerks, small tradesmen, etc.; and independent professionals, large employers, etc. Pearson wrote a highly favorable biography of Galton and thus enhanced the latter's already high reputation.

How did the social-political structures of France, Britain, Germany, and the United States affect the establishment and development of the national statistical bureaus of these four countries? The question is intriguing, and Desrosières's response is too complex to attempt an adequate summary here. In brief, national statistics were characterized in France, in conflict with local interests, by a "discreet legitimacy." Britain benefited from a unique contribution of academic science to the political process. The style of Prussian administration was spread to the rest of Germany. In the United States the constitutional legitimacy of the census was gradually extended to an accounting of such "social problems" as immigration and unemployment and so to the nation's natural resources. The International Statistical Institute, founded in 1885, helped to consolidate the different kinds of achievement and, also, to legitimize sampling as a new method of gathering more data.

One major problem in the development of all the countries' national statistics was what Desrosières calls "the encoding stage" in their production, essentially the rationale of aggregation. Were categories actual things, as the Durkheimian tradition held, or were they statistical constructs, or—even more confusing—an indeterminate blend of the two? Choosing the method of aggregating data results in a distinctive "knowledge" and thus, based on those "facts," a specific policy. For example, the shift in attention from "poverty" to "unemployment" resulted in "the birth of a new variable." In summary, the book presents a graph showing lines of derivation from eighteenth-century sources (mathematics, classical political economics, German statistics, English political arithmetic, astronomy, and probability theory) to the probabilistic method in twentieth-century econometrics.

This is more a work of sociology and political economy than a technical account of how statistical operations developed. The reification of numbers characteristic of the Durkheimian tradition, and thus of much of today's sociology, is depicted especially well. So far as I know, it is in this respect a pathbreaking book.

The one striking lack is that Desrosières omits any discussion of how national bureaus use their products to present a desired profile of the country depicted. *The Politics of Numbers* (1987), edited by William Alonso and Paul Starr, contains a number of interesting discussions of American statistics, together with a general introduction by Starr that parallels the book under review. A still richer crop of ambiguity/falsity could be garnered from Europe, not to say less developed countries. In his book on *Europe's Population in the Interwar Years* (1946), Dudley Kirk noted some of the extraordinary devices used to enlarge particular sectors of nations'

populations. In the old Austrian censuses, thus, Yiddish speakers were classified as part of the German majority, which thereby increased in size and implicit power. In Germany's censuses the two dialects of Kaschub and Masurian were counted as different from Polish, but no less distinctive dialects of German were incorporated into High German. Between the 1910 census of Austria-Hungary and the 1921 census of the successor state of Czechoslovakia, the recorded number of German speakers fell by 13.7 percent, the recorded number of Hungarian speakers in Slovakia by 43.6 percent. The interest of the state in the formation of statistics does not always encourage accuracy.

Carmel, California

WILLIAM PETERSEN

HENK A. DE GANS

Population Forecasting 1895–1945: The Transition to Modernity

Dordrecht/Boston/London: Kluwer Academic Publishers, 1999. xvii + 290 p. \$130.00.

Early efforts at population forecasting, in the late seventeenth century, were based not on calculations but rather on prophecies or descriptions of possible future demographic scenarios. Not until the end of the nineteenth century did demographers forecast future population developments on the basis of mathematical calculations. As prerequisites for this they needed both data on past demographic patterns and methods for calculating future population trends.

For data to be collected, systematized, and evaluated on a regular basis required statistical offices. Within a few decades of the establishment of such offices, demographers and statisticians were engaged in a scientific discussion of adequate methods for population forecasting. The earliest methods, based on geometric extrapolation, were challenged and new methods and principles were tested and introduced into the practice of statistics. This process, which extended from the end of the nineteenth century to the middle of the twentieth century, is the temporal focus of de Gans's study. De Gans also focuses his book geographically, concentrating on the evolution of population forecasting in the Netherlands.

It is now widely accepted that 1895–1945 was roughly the period in which population forecasting occupied center stage in demography and statistics, although debates about demographic forecasting methods continue up to the present.¹ But de Gans's argument that the innovative and essential ideas in this debate came from the Netherlands (pp. 2–3 and 111–112) is novel.

In his introduction, de Gans outlines the methodological approaches to the geometrical extrapolation of trends that were employed in population forecasting up to the end of the nineteenth century. In 1895, the English economist and statistician Edwin Cannan (1861–1935) introduced the "component method" of popu-

¹See Nico Keilman, *Uncertainty in National Population Forecasting: Issues, Backgrounds, Analyses, Recommendations* (Amsterdam: Swets & Zeitlinger, 1990); Dennis A. Ahlburg and Wolfgang Lutz, "Introduction: The need to rethink approaches to population forecasts," in *Frontiers of Population Forecasting*, ed. Wolfgang Lutz, James W. Vaupel, and Dennis A. Ahlburg, *Population and Development Review*, Supplement to Volume 24 (1998): 1–14.

lation projection,² ushering in a modernization of population forecasting methods. According to de Gans, however, more than 20 years passed before other scientists recognized the innovative nature of the new approach and applied it.

De Gans claims that Dutch town planners, insurance experts, and other specialists were the first to reexamine the methodological foundations of population forecasting in the 1920s, at a time when the “scientific statistical and actuarial establishment” was unwilling to accept the new methods. According to de Gans, the great gulf between the representatives of mainstream statistics and the supporters of the new methods developed as a result of the mathematization of demography. Those who favored “modern” methods were convinced that probability analysis would allow for more precise forecasts of future demographic trends, whereas more conservative economists and statisticians believed that probability calculus was not a valid component of official statistics. De Gans attributes the rejection of the new methods by influential representatives of official statistical institutes to their limited knowledge of mathematics. In their opinion, any observations extending beyond evaluating official statistics were of a speculative nature and incompatible with the traditional objectives of government agencies.

The debate between the traditionalists and the followers of modern approaches was triggered by a doctoral dissertation by the statistician Gerhard Adolf Heinrich Wiebols (1895–1960). Wiebols calculated future population trends in the Netherlands on the basis of both the age structure of the initial population and the age-specific mortality and fertility rates of preceding years. This approach was an extension of the methods introduced by Cannan. In the early 1920s, long before R. R. Kuczynski (1876–1947) published calculations of the net reproduction rate, Wiebols based his own calculations on this method. Without disputing Kuczynski’s accomplishments in this area, de Gans demonstrates the diversity of research approaches to the NRR and emphasizes Wiebols’s contribution in propagating the new method.

For the most part de Gans corroborates his argument with references to and quotations from primary sources. However, he is not fully consistent in applying these principles of scientific-historical investigation. He fails to follow them when his exposition of the graphical representations of the evolution of fertility rates since the second half of the nineteenth century relies not on Kuczynski’s data but rather on Chesnais’s compilations thereof, published in 1992 (pp. 86–87).³ Of greater importance, it seems to me, is the question of how Kuczynski himself interpreted his scientific work, especially his contributions to population forecasting. According to de Gans, Kuczynski followed the zeitgeist of those years without argument; like his contemporaries, he was concerned about the prospect of zero growth or population decrease as a result of prevailing demographic trends. However, de Gans presents no quotations to support these assertions.

²Instead of using the normally employed method of mathematical extrapolation, Cannan developed a new approach that was basically aimed at calculating the number of survivors in the 15–45 age range. See Edwin Cannan, “The probability of a cessation of the growth of population in England and Wales during the next century,” *The Economic Journal* 5(20): 505–515. (This article was reprinted in the December 1978 issue of *Population and Development Review*.)

³Jean-Claude Chesnais, *The Demographic Transition: Stages, Patterns, and Economic Implications: A Longitudinal Study of Sixty-Seven Countries Covering the Period 1720–1984* (Oxford: Clarendon Press, 1992). (This book is a translation of the French original that appeared in 1986.)

An original motivation for de Gans's investigation was the question of why scant notice has been taken of the innovative methods developed by Dutch demographers and statisticians, either nationally or internationally. The methodology of demographic forecasting was discussed at the World Population Conference held in Geneva (1927) and at a meeting of the International Statistical Institute in Tokyo (1930). At these conferences, however, the official representatives of Dutch statistics and demography failed to inform participants about the new methods developed by Wiebols and others. This, according to de Gans, is why the international community of scientists had little knowledge of these innovations.

It remains unresolved whether the skepticism the traditionalists maintained vis-à-vis the Dutch representatives of "modern" methods was part of official policy and of the associated administrative and planning institutions. The question gains interest when one takes note of the discrepancy between the expectations of public policymakers concerning population forecasting, on the one hand, and outcomes of the new approaches to demographic forecasting, on the other. In contrast to their counterparts in other European countries, Dutch demographers in the 1920s were not concerned about a decline of the birth rate but rather about a population "explosion." The population of the Netherlands seemed to be growing too quickly in relation to the rate of economic development. This population growth was atypical in Western Europe for the 1920s and 1930s and, apparently, it was cause for concern as the Dutch economy showed signs of stagnation. One might surmise that the discrepancies between demographic and economic trends were expressed all too clearly by those using modern statistical methods. Could it be that population forecasts threatened the political and economic establishment and were therefore not accepted by the representatives of official statistics?

This and other questions call for continued research into the history of demography—a subject to which de Gans has made an impressive contribution.

*Max Planck Institute for Demographic Research
Rostock, Germany*

JOCHEN FLEISCHHACKER

MASSIMO LIVI-BACCI AND GUSTAVO DE SANTIS (EDS.)

Population and Poverty in the Developing World

Oxford: Clarendon Press, 1999. x + 305 p. \$70.00.

This volume contains selected papers from a seminar on "population and poverty" held in Florence in 1995 under the auspices of the IUSSP, UNICEF, and the University of Florence. The seminar brought together a multidisciplinary group, mainly of demographers, economists, and social scientists. It represented a laudable attempt by the organizers to bring poverty-related issues to the demographic research agenda, issues that had long been the domain of economists who commonly defined poverty "in terms of income or consumption deprivation relative to a monetary threshold (the so-called poverty line)" (p. 11).

The delay in publication has meant that other works, such as the UNDP *Human Development Report 1997*, have since contributed to the clarification of some of the conceptual issues surrounding the definition of poverty as well as approaches

to poverty alleviation. Under the circumstances, one is bemused to read in the blurb on the dust jacket a statement that the book begins with “an exact definition of poverty.” In fact, several authors of chapters in the book begin with a description of “poverty concepts” as understood in their particular study. Michael Lipton’s chapter, “Population and poverty: How do they interact?” illustrates the multifaceted nature of the relationships between population variables and poverty-related variables. The introductory overview by the editors recognizes the complexity of the problem, stating: “At the risk of oversimplification, three main lines of thought may perhaps be identified” (p. 2).

Exclusive reference to the developing world in the title of the book (or to developing countries, as the title is rendered on the spine of the book) is a misnomer. The chapter by Giovanni Andrea Cornia and Renato Panicià, “The transition’s population crisis: Nuptiality, fertility, and mortality changes in severely distressed economies,” deals exclusively with East European countries. In spite of the economic shocks and subsequent changes in demographic parameters that these countries have undergone after the dissolution of the Soviet Union, this chapter can hardly be said to deal with the developing world. Anastasia Gage’s chapter on “The social implications of adolescent fertility” uses data from sub-Saharan Africa and the United States but fails to make a case for poverty as a social consequence of adolescent fertility in Africa. In fact, she cites earlier research by Bledsoe and Cohen, who conclude that “for very young married women living in rural areas, where society may define early childbearing as normal and even desirable, the social and economic risks of *not* bearing children probably outweigh the physical risks of bearing children” (quoted on p. 142).

Two chapters do provide a broad sweep of problems of poverty in the developing world: David Satterthwaite on “Rapid urbanization and the urban environment” and René Wéry and Christine Oppong on “Household labour allocation and mobility in times of crisis.” Environmental hazards, particularly those related to health that low-income groups face in urban areas of the developing world, are well documented in Satterthwaite’s chapter. The enormity of the problem can be gauged by his statement that “[a]t least 600 million urban dwellers in Africa, Asia, and Latin America are estimated to live in ‘life and health-threatening’ homes” owing to environmental hazards (p. 215). The chapter questions two common assumptions, namely that “large and often rapidly growing cities in the South have the most serious environmental problems; and that poverty necessarily contributes to environmental degradation” (p. 189). Wéry and Oppong’s chapter traces the changes in labor allocation arising from globalization and increased poverty in many parts of the world. Citing a 1992 World Bank study, they state that in sub-Saharan Africa the number of persons below the Bank’s poverty line increased by 30 million during the five-year period 1985–90 (p. 162). The chapter studies such coping mechanisms available within the family as child labor and the increased feminization of the labor force. Rural-to-urban migration has created masses of urban unemployed poor, and international migration offering remittances to the family is often considered the only option. Wéry and Oppong note: “A general conclusion of the analysis of urban poverty, at least in Africa and in Latin America, is that poverty is much more linked to the composition of households in terms of economically active and non-active members . . . than to the demographic structure (size and age composition)” (p. 171).

The household as a unit of study is the focus of several chapters from both economists' and demographers' standpoints. Cynthia Lloyd, in her chapter "Household structure and poverty: What are the connections?" points out that in economic literature the terms "household economics" and "family economics" are used interchangeably. Demographers use the current UN definition of "household," which implies the sharing of residence and food and other resources, whereas the term "family" is restricted to a group of individuals "related by blood, marriage, or adoption" (pp. 86–87). The chapter indicates how variants of the relationship between household and family as well as intrahousehold resource allocation could have different implications for the poverty of individuals. Focusing on individuals within households would require modifications in methods used to fill in household questionnaires.

Patricia David's chapter, "High fertility and short spacing: The poverty consequences of family-building patterns," points out the need to use "in-depth surveys" to elicit information that usual cross-sectional methods are unable to capture. "Studies of small homogeneous groups living in poor conditions may help to clarify the mediating processes that families use to cope with limited resources, and the factors that enable them to cope" (p. 119). She reaches a conclusion different from Lloyd's on data-collection methods: "Focusing on families, rather than on individual members may provide us with further information on factors that affect all household members" (p. 119).

Sudhir Anand and Jonathan Morduch's chapter, "Poverty and the 'population problem,'" examines the conflicting economic and demographic interpretations of the oft-cited positive correlation between poverty and household size. They state that the "evidence from Bangladesh underscores the importance of considering the poverty of *individuals* and not just poverty at the level of households, families or regions" (p. 10). They stress the need for the study of negative externalities—the notion that "the actions of a household can have adverse consequences for other households" (p. 18)—particularly as related to "gender inequality." They also note that while "high fertility can be an important way that households cope with poverty, . . . it is mothers and their daughters who often end up paying the highest price" (p. 24).

My own work on poverty and widowhood in Kinshasa confirms the need for in-depth interviews as an important instrument in understanding poverty: thus there is a marked difference, in terms of coping after the death of their spouses, between widows from patrilineal ethnic groups and widows from matrilineal groups. Widows from the former tend to be immediately left to their own resources, while the latter can count on some family support and safety nets. Further, the macro view that having many children is a burden is not perceived at the micro level, since widows regard their offspring as their major security, at least in the long term.

Two chapters study the consequences of poverty as related to nutrition. Anna Ferro-Luzzi and Francesco Branca deal with the biological effects of nutritional insecurity, while Siddiqur Osmani correctly warns of the long-term negative consequences of famine, which the study of purely demographic variables might miss. The volume also contains a chapter by Alaka Basu on poverty and AIDS.

Several of the chapters in this volume are “review papers”: there are only 25 tables in all, of which fully 14 are in the chapter by Cornia and Paniccià. However, the reference list, taking up nearly one-seventh of the book, will be useful to those interested in a multidisciplinary approach to the subject of demography and poverty. The absence of an in-depth chapter illustrating the strengths and difficulties involved in interpreting convergent “soft” data—often the only data available in sub-Saharan Africa to identify and measure poverty—is a shortcoming. Data measuring indicators such as income/expenditure, calories consumed per head in relation to some standard requirement, and proportion of income/expenditure spent on food may be separately weak, but if they identify roughly the same poverty group, use of the estimates obtained would be justified. Discussions of policy issues related to poverty alleviation, outside those concerned with fertility, are also mainly absent.

International Population Concerns
Brussels

STAN D’SOUZA

WILLIAM A. JACKSON

The Political Economy of Population Ageing

Cheltenham, UK and Northampton, MA: Edward Elgar, 1998. viii + 248 p. \$80.00.

Written by a British economist, this book extends beyond the conventional territory of works on the economics of aging. This field, Jackson tells us, “demands political economy rather than economics, that is to say, it spills over into politics and other social sciences.” Jackson regards the framework provided by neoclassical economics as inadequate for dealing with the aging of individuals or populations and is skeptical about the practical significance of general equilibrium modeling and other attempts to depict the macroeconomic effects of aging. His thesis, not original but still welcome, is that “Alarmism about population ageing is at least partly ideological in character.” He points out, as have a number of others, that it is inconsistent to tolerate unemployment as a necessary feature of a market economy while focusing on the threat of old-age economic dependency.

The book includes chapters on such standard economic themes as productivity and employment and pensions and retirement (although surprisingly little attention is paid to wealth, incomes, or expenditure patterns). Additionally, Jackson reviews sociological theories of aging and briefly discusses current debates about morbidity change in the chapter on health and social services. This chapter follows the standard approach of assuming rising health care costs as a result of population aging (see Normand 1998 for an alternative view), but also includes consideration of other influences on these costs. The section on social services is tied fairly closely to British experience, although some comparative material is included. Informal economic activity is given a chapter of its own, including rather complicated suggestions for estimating the benefits and costs of the contributions of caregivers.

Perhaps inevitably, covering such wide territory means that some sections are superficial, including, unfortunately, the introductory demographic review.

Jackson's grasp of population dynamics seems shaky in places, and in his discussion of the causes of demographic change he follows a traditional line in assuming that economic change leads to mortality decline, which is then followed by fertility decline. While the book is not intended to be global in coverage, some appreciation of the changes in vital rates and age structure now underway in much of the less developed world would have been welcome. As it is, Jackson merely asserts that "most Third World countries have yet to experience significant population ageing. . . . Future prospects rest on whether, as Third World countries undergo economic development, their fertility declines in the same way that it has declined in the developed countries."

The book includes extensive references and a reasonable index, though very little in the way of tabular material. It is unlikely to replace the classic texts on the economics of aging (Schulz 1976; Clark and Spengler 1980) but would make a useful addition to the reading lists of social science students whose courses include consideration of the effects of population aging.

*Centre for Population Studies
London School of Hygiene and Tropical Medicine*

EMILY GRUNDY

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DOROTHY J. SOLINGER

Contesting Citizenship in Urban China: Peasant Migrants, the State, and the Logic of the Market

Berkeley: University of California Press, 1999. xix + 444 p. \$50.00; \$19.95 (pbk.).

The recent rise of migration in China has been characterized as the largest labor flow in human history and the most important socio-demographic change in China in the last two decades. Alarms abound of millions of aimless Chinese peasants "on the move" within China and beyond, leading to massive domestic social unrest and illegal international emigration. Notwithstanding a recent rise in the scholarly literature on the subject, only with the publication of Solinger's book can one point to a single authoritative source for understanding recent Chinese migration. This original analysis addresses all the common issues a demographic study would contain, but within a much broader historical and political framework and in greater depth. It is also highly readable.

The three key words in the title of Solinger's book, citizenship, state, and market, capture the main institutional elements involved in understanding peasant

migrants' behavior. Citizenship defines the status of the different actors, while the state and the market furnish the relevant institutional contexts. The state may be considered the main culprit in the creation of the two types of citizenship—urban and rural—but it is also simultaneously an engineer of and an obstacle to market reforms. The market, which was largely introduced by state reforms in the last two decades, is now a major driving force for migration.

One may question whether it is appropriate to employ the term citizenship in dealing with a single national population. But as Solinger documents and explains succinctly and convincingly (in the Introduction and in Chapter 2), citizenship, especially in its civil and social senses (identity/membership and distributive rights), applies well in this context. The two kinds of citizenship, urban and rural, that were created during the era of state socialism now form the basis of the broadest kind of social inequality in China. Whereas urban Chinese citizenship comes with full provision of social welfare, rural citizenship, which all peasant migrants share, essentially entails self-responsibility in food supply, housing, employment/income, and lacks most of the welfare benefits enjoyed by urban Chinese. Chinese peasants belong to what Solinger characterizes as half-citizenship or second-class citizenship. Peasants' migration into cities is, therefore, a process of contesting their citizenship status.

Following a useful section on the definition and numbers of migrants (inserted immediately following the introduction and awkwardly labeled as an appendix), the major body of the book is organized into two parts: three chapters devoted to what Solinger calls "Structure" and three to "Agency." Each part contains three parallel chapters, addressing state migration policies, urban bureaucracies, and urban rationing regimes.

In "Structure," Solinger focuses on the role of the state in turning peasants into subjects and analyzes the state bureaucracies that were created in enforcing migration control during this process. Moreover, she examines how the rise of migration has posed a fundamental challenge to the urban establishment, and how urban bureaucrats reacted, rather than acted, in response to the influx of rural migrants. Throughout this process, however, what emerges most clearly is how urban bureaucracies have utilized their powers to control and exploit rural migrants. Recognizing the incompetence of the old urban bureaucracies and confronting an emerging market economy, bureaucrats began to try to control migrants by the use of market forces—allowing full play to the influences of supply and demand. The result has been what Solinger calls the "commodification of transients."

Chinese peasant migrants, however, like migrants elsewhere, are proactive in charting their own lives. In the section on "Agency," Solinger examines why and how Chinese peasant migrants departed from their places of origin and what they encountered in the cities. These chapters, like those in the preceding part on "Structure," are based not only on Solinger's thorough understanding of the Chinese political structure but also on the author's numerous interviews of migrants, scholars, and officials in the 1990s. Her accounts contain rich information and analyses on the roles played by geography, ecology, and custom in forming different migrant streams. They cover a wide range of subjects, including migrants' social networks, remittances, and labor market experiences, and depict how peasant mi-

grants cope outside of the urban rationing regime and how they attempt to alter their status as half-citizens.

What Solinger concludes concerning Chinese peasants' efforts to achieve full citizenship via migration is rather pessimistic. The pessimism is based on Solinger's understanding of the small steps the state has made so far in granting such status and on the tenacity of the existing social and political arrangements in China. This conclusion and other insightful analyses in the book serve as important lessons for scholars and policymakers. They illustrate how a socialist development policy has resulted not in decreased but increased social inequality. They elucidate why and how migration has to be understood within the political and social context. And they highlight the enormous challenges still faced by the Chinese reforming state in its so-called transition to a market economy.

*Department of Sociology
University of California, Irvine*

WANG FENG

SHORT REVIEWS

by John Bongaarts, Martin Brockerhoff, Paul Demeny, Susan Greenhalgh, Geoffrey McNicoll

TOM ATHANASIOU

Divided Planet: The Ecology of Rich and Poor

Boston: Little, Brown, 1996. x + 385 p. \$16.95 (pbk.).

In this vigorous account, part digest, part deft dissection, part polemic, Tom Athanasiou lays out the themes and politics of the environmental debate. It was written in "an odd and bitter moment" in the history of the green movement, in the aftermath of the Rio Earth Summit. The author's position might be described as distributionist: the world's environmental crises and possibilities for their resolution are intricately bound up with North-South issues. He is critical both of mainstream opponents of environmentalism among economists and industry lobbyists and of many among his own ranks who are seen as naive, politically reactionary, or uselessly radical. These latter categories include deep ecologists and environmental catastrophists, and, quite prominently, those who trace environmental problems in some measure to overpopulation. Indeed, Athanasiou tries to remove population from the environmental debate. He complains that environmentalism "has

been deeply marked as a Malthusian, apocalyptic science,” which he sees as “a crippling slant” that blames victims and overlooks injustice. “The population fetish debilitates the environmental movement . . . hiding difficult political truths behind biologic pseudoexplanations” and exposing the green movement “to cheap attacks by progrowth, sky’s-the-limit ‘cornucopians.’” Paul Ehrlich is the main object of this attack, portrayed as a reductionist and pilloried for losing the resource-price bet with Julian Simon. Yet the author’s dismissal of the population factor in Ehrlich’s “IPAT” equation is followed by a calculation of how a transition to sustainability can be attained in terms of a reduction in the environmental impact of consumption to a small fraction of its present level—a thoroughly Ehrlichian exercise. In setting out his own beliefs, Athanasiou is often eloquent. “Ecological fear is heavy with the decay products of impotence—frustration, anger, and paranoia—and with the contingencies of class and social position.” And elsewhere: “Left to their own devices, markets shift ecological and social costs into the ‘commons,’ and destroy both nature and human communities in the process.” Index.—G.McN.

ESTER BOSERUP

My Professional Life and Publications 1929–1998

Copenhagen: Museum Tusulanum Press, 1999. 62 p. \$15.00.

This slim hard-bound volume, with a cover design that will be familiar to *PDR*'s readers from Ester Boserup's last contribution to this journal (“Development theory: An analytical framework and selected applications,” September 1996), offers a review by the author of her seven decades of professional work and writing. The book contains nine chapters, each with brief commentary on the various issues that her work addressed, accompanied by bibliographical citations to published work and to selected manuscripts—a total of more than 70 items.

Born in Copenhagen in 1910, Boserup graduated from the University of Copenhagen in 1935. The earliest citation in the bibliography is from 1934, the last (the present volume) is from 1999. She began her career in the Danish civil service as an economist, dealing with practical problems related to trade policy and regulatory issues. In 1947 she moved to Geneva, having taken a position with the newly established United Nations Economic Commission for Europe. The move marked the beginning of several decades of work in various international posts, assignments, and consultancies in the field of development economics, including long stays in India and Africa and involving extensive participation in international meetings, conferences, and committees. Living in Brissago, Switzerland, she remained active in the latter capacity until the early 1990s and as a productive scholar through her remaining years.

Boserup rose to international prominence as an eminent social scientist and a major intellectual figure with the publication, in 1965, of her book *The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure*. It was a contribution that challenged the dominant Malthusian paradigm on the relationship between population growth and technical progress by arguing that population pressure can lead to agricultural intensification and to the adoption of improved methods of production. As Boserup notes in the present volume (p. 21),

“my conclusion was the opposite of the general opinion at that time, when it was believed that the carrying capacity of the globe was nearly exhausted and that the ongoing demographic transition in developing countries would result in soaring food prices and mass starvation.” Two highly influential (and also widely translated) books followed: *Woman’s Role in Economic Development* (1970) and *Population and Technological Change: A Study of Long-Term Trends* (1981). A selection of Boserup’s major essays, *Economic and Demographic Relationships in Development*, appeared in 1990. Reviewing that volume in the December 1990 issue of this journal, Vernon Ruttan commented (p. 775): “Ester Boserup’s writings have had a major impact over the last quarter century on the evolution of thought in anthropology, demography, economics, and sociology about the interrelationships among economic, demographic, and technical change.” The present volume will help to maintain and amplify her intellectual influence.

Since 1977 Ester Boserup served on the Advisory Board of *Population and Development Review*. Between 1976 and 1996 seven contributions of hers appeared in *PDR*’s regular issues or in the journal’s Supplement volumes.

Ester Boserup died on September 24, 1999, at the age of 89.—P.D.

JOACHIM VON BRAUN, TESFAYE TEKLU, AND PATRICK WEBB

Famine in Africa: Causes, Responses, and Prevention

Baltimore and London: The Johns Hopkins University Press, 1998. xvii + 219 p. \$39.00.

Famine in Africa makes an important contribution to a better understanding of the causes of hunger in developing societies, while also providing the most thorough assessment to date—through a synthesis of empirical research—of policies implemented to prevent and mitigate famine in poor countries. On the basis of findings from six African countries in particular, the authors argue against single-cause explanations of famine (for instance, by application of Sen’s concept of household “entitlements”). Instead, they propose an ambitious model of the determinants of famine that underscores the linkages between (1) policy, institutional, and organizational failures; (2) resource poverty and climate shocks; and (3) rural population pressure. From this multi-causal framework with synergistic influences, one can conclude, for instance, that recent famines in Ethiopia, Sudan, and elsewhere in Africa are “largely the result of military conflicts that arise due to oppressive, unaccountable, and nonparticipatory government,” while also maintaining that famine is “inseparable from chronic poverty and risk.” An unhappy conclusion is that few hunger-related policies and programs can work in politically unstable, war-torn environments (a description that characterizes about half of the countries in the region). More positive evidence points to the growing potential of early warning systems to alert governments and the international community to the possibility of famines before they emerge.

The cursory discussion of demographic forces underlying famine, and of urban food insecurity, is likely to confuse population scholars. The authors dismiss the Malthusian scenario of famine driven by accelerated person/cropped-land ratios on the basis of a weak relationship observed in a few countries over time

between nutritional status and cultivable land per capita. They proceed, however, with a simulation analysis of famine risk in a small region of Rwanda (the Giciye commune) that predicts an untenable Malthusian situation of no-food/no-jobs/high population growth rates by 2005. Similarly, consistent evidence is presented from 13 countries that urban children are better nourished than rural children, but is then declared invalid because the urban data “do not distinguish between children living in slums and shantytowns and those in the more prosperous, middle-class areas”; most urbanites in Africa, in fact, live in small towns. High urban growth rates in Africa, the authors assert, are “largely due to the influx of people from rural regions (particularly areas affected by war, drought, and famine).” To the contrary, the most recent data from the United Nations indicate that natural increase is the main component of urban growth in Africa, and few urbanites in the region are actually refugees or displaced persons. The consideration of demographic factors as an influence on famine is a welcome addition to this study, but it reveals the need for continued dialogue between demographers and food policy researchers to avoid inaccurate generalizations regarding the influence of population change on food security.—M.B.

JOHN BROTCHE, PETER NEWTON, PETER HALL, AND JOHN DICKEY (EDS.)
East West Perspectives on 21st Century Urban Development: Sustainable Eastern and Western Cities in the New Millennium

Aldershot, England: Ashgate Publishing Ltd., 1999. xiv + 432 p. \$78.95.

The 15 chapters of this book are organized around a central theme: The new global economy, based on the rapid flow of information and capital, is creating new forms of prosperous, “networked” cities in Southeastern Asia, cities that increasingly resemble those of America’s northeastern corridor. While this transformation promises benefits for most residents of Asia—such as raising incomes to Western levels—it also carries unprecedented challenges for urban and regional planning. This is evident from Peter Hall’s characterization of the Pearl River Delta region of southern China. This string of cities and urbanized zones has experienced the fastest economic growth in the world since around 1980, but growth has been dependent on heavy inflows of foreign direct investment and temporary migrant labor from the countryside—both of which could relocate quickly to more promising economic areas. Terry McGee is optimistic that the priority policy objectives of mega-urban regions—commitment to better governance (that is, decentralized management and community participation in planning), promoting environmental sustainability, developing rapid transport systems that do not bypass intermediate villages—can be achieved. McGee warns, however, that the volatile nature of globalization can increase the vulnerability of the urban poor, as in Indonesia, with “grave consequences to the social stability of these mega-urban regions.” Cities face growing international competition, and Michael Lindfield and Robert Stimson argue that their success in the twenty-first century will require them to assume a form of “dispersed economic nodes linked by massive networks of airports, highways and communications, no longer dependent on central cities, but

on global networks of cities.” Peter Newton and Peter Manins conclude that “compact cities,” whose populations reside densely in an inner ring of suburbs, are the most fuel-efficient of all urban forms, and must replace the “business as usual” form of urban development that has generated sprawling suburbs with unacceptable levels of energy consumption and pollution. Case studies of several urban areas—including Jabotabek in Indonesia, the US National Capital Region, Tokyo, Adelaide, and Stockholm—further illustrate shortcomings of urban planning and suggest potential solutions to planning problems that can be applied to cities of both Asia and the West.

On the whole, this book should prove informative to specialists in population studies who seek greater understanding of emerging policy and planning issues in very large cities.—M.B.

ALEX DE SHERBININ AND VICTORIA DOMPKA (EDS.)

Water and Population Dynamics: Case Studies and Policy Implications

Washington, DC: American Association for the Advancement of Science, 1998. iv + 322 p.

Among the array of potential constraints on population size and wellbeing, natural resources, by and large, have steadily lost favor. But there are a few exceptions: some resources have retained or even increased their claim to significance. Water—more strictly, availability of fresh water—is chief among them. Its relationship to population change, however, is intricate. Direct human water consumption competes with agricultural and industrial demands, and these together compete with the maintenance requirements of the broader ecosystem. Supply fluctuations for human use can be smoothed by dams and other management schemes, but often at a high ecological cost. Technological options such as waste water treatment or drip irrigation may offer large increases in supply or economies in consumption, impeding any simple calculation of water-based human carrying capacity. And supply constraints may be masked, as in many situations of unsustainable use of aquifers. Arrayed over these complexities are human social and political systems, managing water allocation with more or less consideration of needs. This volume, the report of a 1996 workshop organized by the World Conservation Union (IUCN) in Montreal, examines these issues through a series of case studies: of aquatic ecosystems in Guatemala, Jordan, and Zambia; of cross-national river basin management of the Ganges, Senegal, Niger, and Zambia rivers; and of local community participation in water management in Karnataka (India), Sindh (Pakistan), and Morocco. A more general case study by Basia Zaba and Ndalhwa Madulu, of water resources in Mwanza (Tanzania), is presented in an overview section. These authors caution that “Gloomy prognoses which show that ‘ideal’ consumption standards will not be met if population continues to grow at a certain rate often fail to note that these standards have never been universally attained in the past, are not realized now for a large majority of people, and possibly are not even aspired to.” The full text of the volume is available online through www.aaas.org/international. A summary of the workshop’s findings and recommendations was issued as a Population Reference Bureau booklet, *Water and Population Dynamics: Local Approaches to a Global Challenge* (1997).—G.McN.

PAMELA FELDMAN-SAVELSBERG

Plundered Kitchens, Empty Wombs: Threatened Reproduction and Identity in the Cameroon Grassfields

Ann Arbor: University of Michigan Press, 1999. xviii + 257 p. \$49.50.

In this beautifully crafted study of procreative communication and context in Cameroon, anthropologist Pamela Feldman-Savelsberg argues for the demographic importance of attending to the ways women talk about reproductive fate and fortune. In this high-fertility society, she found, the women of Bangangté are preoccupied with threats to their reproductive health. They tell stories of stopped-up fallopian tubes, wombs robbed of babies, and royal nurseries short of children. Like their counterparts in other central and east African societies, the Cameroonian women she studied use metaphors of kitchen and cooking to depict childbearing: the womb is represented as cooking pot, the ova and sperm as ingredients, giving birth as serving a meal. Far from being mere curiosity or idiom, the author argues, the ways women talk about such matters have practical consequences, shaping their decisions about everything from marriage to sex, childbearing, and reproductive health care. More ambitiously, the author connects the talk to larger changes taking place in Cameroon. She suggests that the narratives of infertility also reflect women's struggles to find a way to comment on the effects of large-scale political and economic change on their bodies, health, and lives. In her sensitive reading, the idiom of reproductive suffering is a barometer of a many-layered anxiety: over personal reproductive fate, the future of the kingdom, and the security of cultural identity in a time of unsettlingly rapid social change. A signal contribution of this book is its successful juxtaposition of two specialized anthropological literatures that few have managed to join. Wedding the medical anthropologist's concern for the effect of childlessness on individual lives with the demographic anthropologist's interest in the role of culture in high-fertility societies, Feldman-Savelsberg makes reproductive talk central to both by showing how it provides the crucial link between social structure and demographic outcome. Based on extensive ethnographic and documentary research conducted throughout the 1980s, this book offers an engaging and informative narrative that should inspire more research on reproductive idiom in other parts of Africa and beyond. Notes, glossary, references, index.—S.G.

PETER H. GLEICK

The World's Water 1998–1999: The Biennial Report on Freshwater Resources

Washington, DC: Island Press, 1998. xii + 307 p. \$29.95.

Tapping a narrower market than the widely distributed annual *World Resources*, this factbook is the first of a planned biennial series focusing on a single resource, fresh water. Most of the volume consists of short nontechnical essays by the author discussing water-related topics: the debate over large dams, particular water-borne diseases, particular international water disputes, anticipated effects of climate change, "water bag" technology (for ocean transport of fresh water by tug in large sealed fabric bags), and new laws and institutions. Overall, the tone is matter of fact, acknowledging economic arguments but generally taking an environmen-

talist approach—manifest in a bent against large-scale infrastructure, especially dams, and a strong concern with sustainable development. Nineteen tables assemble international comparative data from a variety of sources, chiefly FAO, UNEP, and WHO, on population, water supplies and withdrawal rates, irrigation, disease incidence, safe drinking water and sanitation, desalination, and hydroelectric capacity. The volume also reprints the texts of the Farakka Barrage treaty between India and Bangladesh and the 1997 UN convention on non-navigational uses of international watercourses—an effort to codify customary principles of international water law. In the gap between this and the next hard copy report in 2000, readers are referred to www.worldwater.org. Peter Gleick is president of the Pacific Institute for Studies in Development, Environment, and Security, a California NGO. Chapter bibliographies, list of water-related web sites, index.

INGE KAUL, ISABELLE GRUNBERG, AND MARC A. STERN (EDS.)

Global Public Goods: International Cooperation in the 21st Century

New York: Oxford University Press for the United Nations Development Programme, 1999. xxxviii + 546 p. \$39.95; \$24.95 (pbk.).

Public goods are goods that are available to one user without lessening their availability to another and that cannot be reserved to any particular group or category of users. Typical examples are flood control, traffic rules, or national defense—goods that markets on their own would not provide enough of (or, in the case of public “bads” like pollution, would provide too much of). By implication, the population to which the benefits accrue is that of a given country or locality. Global public goods, by extension, are those whose publicness applies worldwide. Examples proposed and examined by the contributors to this book include distributive justice, international financial stability, cultural heritage, atmospheric carbon dioxide, infectious disease surveillance, “global health,” knowledge, the Internet, global communications, and peace. Each of course needs careful qualification, and it is not always clear that the public-goods framework is analytically helpful. On health, for example, Lincoln C. Chen and colleagues argue that globalization is blurring the line between public and private health, even in the case of noncommunicable diseases. They instance tobacco-related diseases, exacerbated by \$6 billion spent annually in global marketing campaigns, and illicit-drug-related deaths, a global “bad” byproduct of international trade in narcotics. Health research, like knowledge in general, has a major global-public-good dimension, although some of its tangible results are unaffordable to the poor. By its conspicuous absence from the volume’s discussions, curtailment of world population growth would not appear to be regarded as a significant global public good. Large-scale international migration, however, is so regarded. Ethan B. Kapstein, in his chapter on international distributive justice, writes: “The role of labour mobility and migration in the global economy is an issue of the first order, and it must be addressed in the interests of assuring working people the greatest possible opportunity set.” In their conclusion, the editors, who are with the United Nations Development Programme, propose creation of a UN Global Trusteeship Council to act as a custodian of sus-

tainable development, with a mandate “to advise the Secretary-General when a prisoner’s dilemma threatens to undermine collective action in the long-term interest of all.” Index.—G.McN.

PATRICIA W. LUNNEBORG

The Chosen Lives of Childfree Men

Westport, CT: Bergin & Garvey, 1999. x + 143 p. \$35.00.

As both a demographic and a cultural phenomenon, voluntary childlessness holds considerable interest. In recent years much has been written about women—in the United States, now one in five—who opt to have no children. With the growing concern about men’s role in reproduction and parenting, the neglected issue of male childlessness is beginning to attract attention. Statistics on men who father no children remain woefully inadequate. A pioneering U.S. Census Bureau survey of male fertility revealed that in 1992 some 34 percent of men (and 26 percent of women) 18 years of age and older did not have children. But to what extent that state was voluntary or involuntary we do not know. Nor do we know why some men decided to have no children. In this slim volume, psychologist Patricia Lunneborg reports the results of her conversations with 30 “childfree” men, half American, half British. (The term “childfree” should be understood as a political statement signaling the author’s hope to remove the stigma placed on women who opt to have no children. The conventional term, “childless,” stigmatizes by suggesting a lack.) The men were mostly white, well educated, and partnered. They ranged in age from 27 to 55. With a nonrandomly selected sample of such small size, the study must be considered exploratory rather than statistically informative. Yet the results hold substantial interest, for they tell us not only about men’s experiences of childlessness, but also about the great gap between the experiences of “childfree” men and women.

Because women bear children and society assigns childcaring primarily to women and stigmatizes those who do not follow societal conventions, a woman’s decision not to have a child is fraught with significance. That decision, moreover, requires her to forge an alternative feminine identity and to continuously reconstruct and defend that identity throughout life. By contrast, for at least this group of men, not having children was “no big deal.” For most of the men studied, whether to have children was, for most of their lives, not even an issue seriously pondered. Whereas women feel pronatalist pressure from family, society, and the media, men who opted to be childfree felt neither pressured to have children nor discriminated against for not having any. To the contrary, their male friends and colleagues were either supportive of their decision or unconcerned about it.

Despite their preference not to sire a child, only one-third of the men studied had undergone a vasectomy. The diffidence about sterilization was rooted in a variety of factors: a certain squeamishness about the procedure, reluctance to talk about a taboo subject, the view that contraception was women’s responsibility, a desire to leave future options open, and a feeling of threat to their virility. Many factors underlay the men’s decision to forgo parenthood. Most saw childrearing as

a responsibility that they did not want to assume. The typical respondent enjoyed his work and was an “aficionado of adult activities.” He was a “lifelong learner” who wanted time for further education and travel (p. 130). He did not want to be tied down by dependents. Over half the men said that they did not like children. Roughly one-half were influenced by their own fathers. All the men whose fathers had been abusive vowed early on to have no children themselves. About half of those whose fathers had been uninterested parents decided against parenting on that account. Twenty percent gave global overpopulation as the principal reason for not having children, all of them Americans.

Clearly, this book represents just one of the first words on this fascinating subject. Much more research is needed to ascertain the demographic dimensions of male infertility, by race, class, age, and other social attributes, as well as the larger historical, cultural, political, and economic contexts in which male childlessness becomes a demographically and culturally significant phenomenon. Lunneborg’s book is essentially a research report that lacks in-depth analysis of any of these issues. While one may not want to lend a copy of the book to one’s neighbor, as the author proposes in her conclusion, for the social scientist the study provides an eye-opening look at an underexamined subject and suggests a wealth of hypotheses to guide future research. References, index.—S.G.

THOMAS GALE MOORE

Climate of Fear: Why We Shouldn't Worry About Global Warming

Washington, DC: Cato Institute, 1998. 175 p. \$19.00; \$10.00 (pbk.).

The prospect of a rise in world temperature as the result of human actions has led to a contentious debate about the likely extent of global warming, the seriousness of potential adverse consequences of this warming, and the feasibility and desirability of taking corrective action. Environmentalists are concerned about the projected negative effects of warming, such as a rise in the sea level, an increase in violent storms, the disruption of ecosystems, and damage to agriculture. They therefore call for urgent and vigorous action to halt and, if possible, reverse the rise in emissions of greenhouse gases such as carbon dioxide. The international protocol negotiated in Kyoto in 1997 represents an important step toward curbing these emissions. A contrary view is held by a small but vocal group of critics who claim that the evidence for global warming is weak, that any global warming is likely to have only a modest net impact, and that proposed remedies are undesirable, too expensive, and not cost-effective. This volume summarizes the perspective of such critics. Successive chapters cover the historical association between human well-being and climate variation; the health, environmental, and economic effects of global warming; and the costs of curbing greenhouse gas emissions. The author’s main conclusion is that, for most of the world, warming over the next century would either cost very little or provide an actual benefit. Most informed readers are likely to be unpersuaded by this analysis. A key shortcoming is that much of the discussion focuses on the United States and other industrialized countries located in temperate climates. Little is said about the tropics and subtropics, where

much of the world's population lives and where even small disruptions of agriculture can have large adverse effects. It is also surprising that the author mentions but does not elaborate on the views of fellow economists—most notably William Nordhaus and William Cline—whose work strongly supports action to slow emissions. Although the arguments presented in this volume are one-sided, they may be useful for readers who wish to become more familiar with the wide spectrum of views in the debate about efforts to slow global warming.—J.B.

UNITED NATIONS, DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS,
POPULATION DIVISION

*World Population Prospects: The 1998 Revision. Volume I: Comprehensive Tables;
Volume II: The Sex and Age Distribution of the World Population*

New York, 1999. 627, 883 p. \$95.00.

The United Nations first published a set of world population estimates and projections in 1951 and since 1978 has been issuing revised versions biennially. The series is the standard, indispensable source of comprehensive world, regional, and national demographic data in a comparative format. It is distinguished from the *Demographic Yearbook* of the UN Statistics Division not only in timeliness and user-friendliness but also by its distancing from national statistical offices and its imposition of internal consistency and judgments of reasonableness on the data presented. The time series begin in 1950; in the 1998 Revision the estimates extend to 1995, the projections to 2050. The projections by five-year age groups, in Volume II, now include ages between 80 and 100. Detailed data are given for 184 "countries and areas" with 1995 populations exceeding 150,000, a terminology that allows for inclusion of (for example) East Timor, Gaza Strip, and Guadeloupe. (UN rules nevertheless intrude: Hong Kong and Macao appear separately, Taiwan is folded into China; and alphabetized under T, between Thailand and Togo, is The former Yugoslav Republic of Macedonia.) A more limited array of data is given for each of 228 countries and areas of the world, down to Pitcairn (population 46).

A brief introduction giving highlights of the data replaces the detailed description of results, methods, and sources that prefaced the 1996 Revision. However, this material is forthcoming in a promised third volume. Overall changes in estimates and expectations in the last two years are in the direction of more moderate population increases. Average annual world population growth in 1995–2000 is put at 78 million instead of 81 million; the medium-variant 2050 population is 8.9 billion instead of 9.4 billion. The total fertility rate of the more-developed regions, currently around 1.6, recovers only to 1.8 by 2050 in the medium variant, instead of to replacement level. Mortality assumptions are little altered. (The demographic effects of the AIDS epidemic were already considered in the 1996 Revision.)

The material is also available in somewhat elaborated form on diskettes. The content of the two volumes, expanded to annual rather than the mainly quinquennial intervals of the hard copy, is on one diskette, priced at \$500; age patterns of fertility (age-specific fertility rates and births by age of mother)—data not included in the volumes—are on another at \$100.—G.McN.

US AGENCY FOR INTERNATIONAL DEVELOPMENT AND US DEPARTMENT OF
COMMERCE

*World Population Profile: 1998, with a Special Chapter Focusing on HIV/AIDS in
the Developing World*

Washington, DC: US Government Printing Office, 1999. 165 p. \$21.00.

This volume summarizes the main findings from the most recent global population projection exercise undertaken by the U.S. Census Bureau. Introductory chapters provide concise overviews of population trends and related issues, while the bulk of the report consists of tabulations of projection results for population size and other demographic variables at the country, regional, and world level. Principal results for projections to 2025 are included, and further details including projections to 2050 are available on the web site of the Census Bureau. A special section on HIV/AIDS discusses estimates and projections of the epidemic's demographic impact to 2010 in 28 developing countries.

The projection exercise of the Census Bureau is similar in nature and scope to those undertaken by the United Nations and the World Bank. While modest differences in assumptions lead to some differences in projections, the results from the different agencies are in broad agreement. For example, the population size of the world is expected to be 9.3 billion in 2050 according to the U.S. Census Bureau, while the UN and World Bank each expect a slightly lower number: 8.9 billion. This difference exists despite the somewhat higher AIDS impact projected by the Census Bureau.

Four appendixes include detailed tables, a description of projection methodology, references, and a glossary.—J.B.

CDC on Infant and Maternal Mortality in the United States: 1900–99

As part of a series consisting of ten reports discussing public health achievements in the United States during the twentieth century, the Centers for Disease Control and Prevention (CDC) issued a summary description of the evolution of infant and maternal mortality, and of public health action and social and technological developments shaping that evolution. (The CDC is an agency of the US Department of Health and Human Services.) This document, titled “Achievements in public health, 1900–1999: Healthier mothers and babies,” appeared in the Morbidity and Mortality Weekly Report (a publication of the CDC), 48 (38), 1 October 1999. It is reproduced below in full. (For two earlier issues in this series, one discussing the effect of vaccines on children’s health, and another reviewing the evolution of infectious diseases, see the Documents sections of the June and September 1999 issues of PDR.) The main findings and the contents of the report are succinctly described in the report’s opening paragraph.

At the beginning of the 20th century, for every 1000 live births, six to nine women in the United States died of pregnancy-related complications, and approximately 100 infants died before age 1 year (1,2). From 1915 through 1997, the infant mortality rate declined greater than 90% to 7.2 per 1000 live births, and from 1900 through 1997, the maternal mortality rate declined almost 99% to less than 0.1 reported death per 1000 live births (7.7 deaths per 100,000 live births in 1997) (3) (Figure 1 and Figure 2). Environmental interventions, improvements in nutrition, advances in clinical medicine, improvements in access to health care, improvements in surveillance and monitoring of disease, increases in education levels, and improvements in standards of living contributed to this remarkable decline (1). Despite these improvements in maternal and infant mortality rates, significant disparities

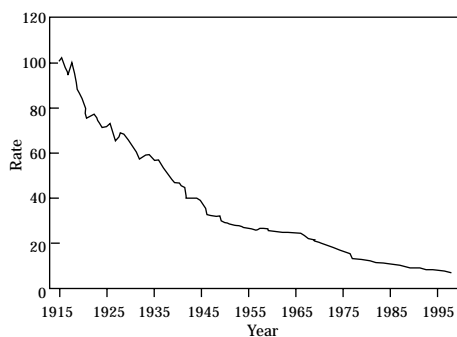
by race and ethnicity persist. This report summarizes trends in reducing infant and maternal mortality in the United States, factors contributing to these trends, challenges in reducing infant and maternal mortality, and provides suggestions for public health action for the 21st century.

Infant mortality

The decline in infant mortality is unparalleled by other mortality reduction this century. If turn-of-the-century infant death rates had continued, then an estimated 500,000 live-born infants during 1997 would have died before age 1 year; instead, 28,045 infants died (3).

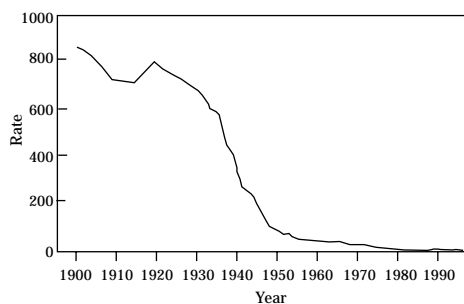
In 1900 in some U.S. cities, up to 30% of infants died before reaching their first birthday (1). Efforts to reduce infant mortality fo-

FIGURE 1 Infant mortality rate,* by year—United States, 1915–1997



*Per 1000 live births.

FIGURE 2 Maternal mortality rate,* by year—United States, 1900–1997



*Per 100,000 live births.

cused on improving environmental and living conditions in urban areas (1). Urban environmental interventions (e.g., sewage and refuse disposal and safe drinking water) played key roles in reducing infant mortality. Rising standards of living, including improvements in economic and education levels of families, helped to promote health. Declining fertility rates also contributed to reductions in infant mortality through longer spacing of children, smaller family size, and better nutritional status of mothers and infants (1). Milk pasteurization, first adopted in Chicago in 1908, contributed to the control of milkborne diseases (e.g., gastrointestinal infections) from contaminated milk supplies.

During the first three decades of the century, public health, social welfare, and clinical medicine (pediatrics and obstetrics) collaborated to combat infant mortality (1). This partnership began with milk hygiene but later included other public health issues. In

1912, the Children's Bureau was formed and became the primary government agency to work toward improving maternal and infant welfare until 1946, when its role in maternal and child health diminished; the bureau was eliminated in 1969 (1). A proponent of the Children's Bureau was Martha May Eliot. The Children's Bureau defined the problem of infant mortality and shaped the debate over programs to ameliorate the problem. The bureau also advocated comprehensive maternal and infant welfare services, including prenatal, natal, and postpartum home visits by health-care providers. By the 1920s, the integration of these services changed the approach to infant mortality from one that addressed infant health problems to an approach that included infant and mother and prenatal-care programs to educate, monitor, and care for pregnant women.

The discovery and widespread use of antimicrobial agents (e.g., sulfonamide in 1937 and penicillin in the 1940s) and the development of fluid and electrolyte replacement therapy and safe blood transfusions accelerated the declines in infant mortality; from 1930 through 1949, mortality rates declined 52% (4). The percentage decline in postneonatal (age 28–364 days) mortality (66%) was greater than the decline in neonatal (age 0–27 days) mortality (40%). From 1950 through 1964, infant mortality declined more slowly (1). An increasing proportion of infant deaths were attributed to perinatal causes and occurred among high-risk neonates, especially low birth weight (LBW) and preterm babies. Although no reliable data exist, the rapid decline in infant mortality during earlier decades probably was not influenced by decreases in LBW rates because the decrease in mortality was primarily in postneonatal deaths that are less influenced by birth-weight. Inadequate programs during the 1950s–1960s to reduce deaths among high-risk neonates led to renewed efforts to improve access to prenatal care, especially for the poor, and to a concentrated effort to establish neonatal intensive-care units and to promote research in maternal and infant health, including research into technologies to improve the survival of LBW and preterm babies.

During the late 1960s, after Medicaid and other federal programs were implemented, in-

TABLE 1 Percentage reduction in infant, neonatal, and postneonatal mortality, by year—United States, 1915–1997*

Year	Percentage reduction in mortality		
	Infant (aged 0–364 days)	Neonatal (aged 0–27 days)	Postneonatal (aged 28–364 days)
1915–1919	13%	7%	19%
1920–1929	21%	11%	31%
1930–1939	26%	18%	35%
1940–1949	33%	26%	46%
1950–1959	10%	7%	15%
1960–1969	20%	17%	27%
1970–1979	35%	41%	14%
1980–1989	22%	27%	12%
1990–1997	22%	17%	29%
1915–1997	93%	89%	96%

*Percentage reduction is calculated as the reduction from the first year of the time period to the last year of the time period.

infant mortality (primarily postneonatal mortality) declined substantially (5). From 1970 to 1979, neonatal mortality plummeted 41% (Table 1) because of technologic advances in neonatal medicine and in the regionalization of perinatal services; postneonatal mortality declined 14%. During the early to mid-1980s, the downward trend in U.S. infant mortality slowed (6). However, during 1989–1991, infant mortality declined slightly faster, probably because of the use of artificial pulmonary surfactant to prevent and treat respiratory distress syndrome in premature infants (7). During 1991–1997, infant mortality continued to decline primarily because of decreases in sudden infant death syndrome (SIDS) and other causes.

Although improvements in medical care were the main force for declines in infant mortality during the second half of the century, public health actions played a role. During the 1990s, a greater than 50% decline in SIDS rates (attributed to the recommendation that infants be placed to sleep on their backs) has helped to reduce the overall infant mortality rate (8). The reduction in vaccine-preventable diseases (e.g., diphtheria, tetanus, measles, poliomyelitis, and *Haemophilus influenzae* type b meningitis) has reduced infant morbidity and has had a modest effect on infant mortality (9). Advances in prenatal diagnosis of severe central nervous system defects, selective termination of affected pregnancies, and improved surgical treat-

ment and management of other structural anomalies have helped reduce infant mortality attributed to these birth defects (10,11). National efforts to encourage reproductive-aged women to consume foods or supplements containing folic acid could reduce the incidence of neural tube defects by half (12).

Maternal mortality

Maternal mortality rates were highest in this century during 1900–1930 (2). Poor obstetric education and delivery practices were mainly responsible for the high numbers of maternal deaths, most of which were preventable (2). Obstetrics as a speciality was shunned by many physicians, and obstetric care was provided by poorly trained or untrained medical practitioners. Most births occurred at home with the assistance of midwives or general practitioners. Inappropriate and excessive surgical and obstetric interventions (e.g., induction of labor, use of forceps, episiotomy, and cesarean deliveries) were common and increased during the 1920s. Deliveries, including some surgical interventions, were performed without following the principles of asepsis. As a result, 40% of maternal deaths were caused by sepsis (half following delivery and half associated with illegally induced abortion) with the remaining deaths primarily attributed to hemorrhage and toxemia (2).

The 1933 White House Conference on Child Health Protection, Fetal, Newborn, and Maternal Mortality and Morbidity report (13) demonstrated the link between poor aseptic practice, excessive operative deliveries, and high maternal mortality. This and earlier reports focused attention on the state of maternal health and led to calls for action by state medical associations (13). During the 1930s–1940s, hospital and state maternal mortality review committees were established. During the ensuing years, institutional practice guidelines and guidelines defining physician qualifications needed for hospital delivery privileges were developed. At the same time, a shift from home to hospital deliveries was occurring throughout the country; during 1938–1948, the proportion of infants born in hospitals increased from 55% to 90% (14). However, this shift was slow in rural areas and southern states. Safer deliveries in hospitals under aseptic conditions and improved provision of maternal care for the poor by states or voluntary organizations led to decreases in maternal mortality after 1930. Medical advances (including the use of antibiotics, oxytocin to induce labor, and safe blood transfusion and better management of hypertensive conditions during pregnancy) accelerated declines in maternal mortality. During 1939–1948, maternal mortality decreased by 71% (14). The legalization of induced abortion beginning in the 1960s contributed to an 89% decline in deaths from septic illegal abortions (15) during 1950–1973.

Since 1982, maternal mortality has not declined (16). However, more than half of maternal deaths can be prevented with existing interventions (17). In 1997, 327 maternal deaths were reported based on information on death certificates; however, death certificate data underestimate these deaths, and the actual numbers are two to three times greater. The leading causes of maternal death are hemorrhage, including hemorrhage associated with ectopic pregnancy, pregnancy-induced hypertension (toxemia), and embolism (17).

Challenges for the 21st century

Despite the dramatic decline in infant and maternal mortality during the 20th century,

challenges remain. Perhaps the greatest is the persistent difference in maternal and infant health among various racial/ethnic groups, particularly between black and white women and infants. Although overall rates have plummeted, black infants are more than twice as likely to die as white infants; this ratio has increased in recent decades. The higher risk for infant mortality among blacks compared with whites is attributed to higher LBW incidence and preterm births and to a higher risk for death among normal birth-weight infants (greater than or equal to 5 lbs, 8 oz [greater than or equal to 2500 g]) (18). American Indian/Alaska Native infants have higher death rates than white infants because of higher SIDS rates. Hispanics of Puerto Rican origin have higher death rates than white infants because of higher LBW rates (19). The gap in maternal mortality between black and white women has increased since the early 1900s. During the first decades of the 20th century, black women were twice as likely to die of pregnancy-related complications as white women. Today, black women are more than three times as likely to die as white women.

During the last few decades, the key reason for the decline in neonatal mortality has been the improved rates of survival among LBW babies, not the reduction in the incidence of LBW. The long-term effects of LBW include neurologic disorders, learning disabilities, and delayed development (20). During the 1990s, the increased use of assisted reproductive technology has led to an increase in multiple gestations and a concomitant increase in the preterm delivery and LBW rates (21). Therefore, in the coming decades, public health programs will need to address the two leading causes of infant mortality: deaths related to LBW and preterm births and congenital anomalies. Additional substantial decline in neonatal mortality will require effective strategies to reduce LBW and preterm births. This will be especially important in reducing racial/ethnic disparities in the health of infants.

Approximately half of all pregnancies in the United States are unintended, including approximately three quarters among women aged less than 20 years. Unintended pregnancy is associated with increased morbidity and mortality for the mother and infant. Lifestyle factors (e.g., smoking, drinking alcohol, unsafe sex practices, and poor nutri-

tion) and inadequate intake of foods containing folic acid pose serious health hazards to the mother and fetus and are more common among women with unintended pregnancies. In addition, one fifth of all pregnant women and approximately half of women with unintended pregnancies do not start prenatal care during the first trimester. Effective strategies to reduce unintended pregnancy, to eliminate exposure to unhealthy lifestyle factors, and to ensure that all women begin prenatal care early are important challenges for the next century.

Compared with the 1970s, the 1980s and 1990s have seen a lack of decline in maternal mortality and a slower rate of decline in infant mortality. Some experts consider that the United States may be approaching an irreducible minimum in these areas. However, three factors indicate that this is unlikely. First, scientists have believed that infant and maternal mortality was as low as possible at other times during the century, when the rates were much higher than they are now. Second, the United States has higher maternal and infant mortality rates than other developed countries; it ranks 25th in infant mortality (22) and 21st in maternal mortality (23). Third, most of the U.S. population has infant and maternal mortality rates substantially lower than some racial/ethnic subgroups, and no definable biologic reason has been found to indicate that a minimum has been reached.

To develop effective strategies for the 21st century, studies of the underlying factors that contribute to morbidity and mortality should be conducted. These studies should include efforts to understand not only the biologic factors but also the social, economic, psychological, and environmental factors that contribute to maternal and infant deaths. Researchers are examining “fetal programming”—the effect of uterine environment (e.g., maternal stress, nutrition, and infection) on fetal development and its effect on health from childhood to adulthood. Because reproductive tract infections (e.g., bacterial vaginosis) are associated with preterm birth, development of effective screening and treatment strategies may reduce preterm births. Case reviews or audits are being used increasingly to investigate fetal, infant, and maternal deaths; they focus on identifying preventable deaths such as those resulting from health-

care system failures and gaps in quality of care and in access to care. Another strategy is to study cases of severe morbidity in which the woman or infant did not die. More clinically focused than reviews or audits, such “near miss” studies may explain why one woman or infant with a serious problem died while another survived.

A thorough review of the quality of health care and access to care for all women and infants is needed to avoid preventable mortality and morbidity and to develop public health programs that can eliminate racial/ethnic disparities in health. Preconception health services for all women of childbearing age, including healthy women who intend to become pregnant, and quality care during pregnancy, delivery, and the postpartum period are critical elements needed to improve maternal and infant outcomes (see Appendix).

Reported by: Division of Reproductive Health, National Center for Chronic Disease Prevention and Health Promotion, CDC.

Appendix

Opportunities to reduce maternal and infant mortality

Prevention measures to reduce maternal and infant mortality and to promote the health of all childbearing-aged women and their newborns should start before conception and continue through the postpartum period. Some of these prevention measures include the following:

Before conception

- Screen women for health risks and pre-existing chronic conditions such as diabetes, hypertension, and sexually transmitted diseases.
- Counsel women about contraception and provide access to effective family planning services (to prevent unintended pregnancies and unnecessary abortions).
- Counsel women about the benefits of good nutrition; encourage women especially to consume adequate amounts of folic acid supplements (to prevent neural tube defects) and iron.
- Advise women to avoid alcohol, tobacco, and illicit drugs.
- Advise women about the value of regular physical exercise.

During pregnancy

- Provide women with early access to high-quality care throughout pregnancy, labor, and delivery. Such care includes risk-appropriate care, treatment for complications, and the use of antenatal corticosteroids when appropriate.
- Monitor and, when appropriate, treat pre-existing chronic conditions.
- Screen for and, when appropriate, treat reproductive tract infections including bacterial vaginosis, group B streptococcus infections, and human immunodeficiency virus.
- Vaccinate women against influenza, if appropriate.
- Continue counseling against use of tobacco, alcohol, and illicit drugs.
- Continue counseling about nutrition and physical exercise.
- Educate women about the early signs of pregnancy-related problems.

During postpartum period

- Vaccinate newborns at age-appropriate times.
- Provide information about well-baby care and benefits of breastfeeding.
- Warn parents about exposing infants to secondhand smoke.
- Counsel parents about placing infants to sleep on their backs.
- Educate parents about how to protect their infants from exposure to infectious diseases and harmful substances.

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The HIV/AIDS Epidemic at the End of 1999

The status of the global HIV/AIDS epidemic is summarized in a report entitled AIDS Epidemic Update: December 1999, issued by the United Nations Programme on HIV/AIDS (UNAIDS) and the World Health Organization. The generally bleak but regionally diverse picture is conveyed in the series of bulleted statements at the beginning of the report and in two summary tables, reproduced below. The rest of the report discusses the regional situations in more detail. An earlier UNAIDS and WHO surveillance report (June 1998) was excerpted in the Documents section of PDR 24 (3).

The AIDS epidemic in the 21st century—a widening gap

As the 20th century draws to a close, some 33.6 million men, women and children face a future dominated by a fatal disease unknown just a few decades ago. According to new estimates from the Joint United Nations Programme on HIV/AIDS (UNAIDS) and the World Health Organization (WHO), 32.4 million adults and 1.2 million children will be living with HIV by the end of 1999.¹

- Over the course of the year, some 5.6 million people became infected with the human immunodeficiency virus (HIV), which causes AIDS.

- The year also saw 2.6 million deaths from HIV/AIDS—a higher global total than in any year since the beginning of the epidemic, despite antiretroviral therapy which staved off AIDS and AIDS deaths in the richer countries. Deaths among those already infected would continue mounting for some years even if prevention programmes managed to cut the number of new infections to

zero. However, with the HIV-positive population still expanding—there were 5.6 million new infections this year alone—the annual number of AIDS deaths can be expected to increase for many years before peaking.

- Around half of all people who acquire HIV become infected before they turn 25 and typically die of the life-threatening illnesses called “AIDS” before their 35th birthday. This age factor makes AIDS uniquely threatening to children. By the end of 1999, the epidemic had left behind a cumulative total of 11.2 million AIDS orphans, defined as those having lost their mother before reaching the age of 15. Many of these maternal orphans have also lost their father.

- The overwhelming majority of people with HIV—some 95% of the global total—live in the developing world. That proportion is set to grow even further as infection rates continue to rise in countries where poverty, poor health systems and limited resources for prevention and care fuel the spread of the virus.

- HIV is still a challenge in industrialized countries. There is evidence that safe sexual behaviour is being eroded among gay men in some Western countries, perhaps because of complacency now that life-prolonging therapy is available. If this is the case, the complacency is misplaced. The disease remains fatal, and information from North

¹This appears to be a relatively small rise over the global HIV totals at the end of 1998. The real rise is larger, however. Improved surveillance now suggests that national infections in a few populous countries of Latin America and Asia were over-estimated in 1998.

America and Europe suggests that the decline in number of deaths due to antiretroviral therapy is tapering off.

- HIV infections in the former Soviet Union have doubled in just two years. Injecting drug use gave the Eastern European and Central Asian region the world's steepest HIV curve in 1999. Drug-injecting is also a major concern in the industrialized countries, as it is in the Middle East, where total AIDS cases are still relatively low but drug-injecting accounted for two-thirds of cases in Bahrain, half in the Islamic Republic of Iran and over a third in Tunisia.

- Some Latin American countries are managing to expand efforts to provide treatment to those infected. However, there is evidence that infections are on the rise in Central America and in the Caribbean basin—which has some of the worst HIV epidemics outside Africa.

- Strong prevention programmes seem to have reduced HIV risk and lowered or stabilized HIV rates in some countries of Asia, such as Thailand and the Philippines. Other Asian countries have raised warning flags after collecting new information showing that injecting drug use is spreading and that condom use is uncommon, including among clients of prostitutes and men who have sex with men. In many places prevention efforts are hampered by the shame and stigma attached to AIDS.

- Sub-Saharan Africa continues to bear the brunt of HIV and AIDS, with close to 70% of the global total of HIV-positive people. Most will die in the next 10 years, joining the 13.7 million Africans already claimed by the epidemic and leaving behind shattered families and crippled prospects for development.

- Because of AIDS, companies doing business in Africa are hurting and are bracing

[TABLE 1] Regional HIV/AIDS statistics and features, December 1999

Region	Epidemic started	Adults and children living with HIV/AIDS	Adults and children newly infected with HIV	Adult prevalence rate ²	Percent of HIV-positive adults who are women	Main mode(s) of transmission ³ for adults living with HIV/AIDS
Sub-Saharan Africa	late '70s–early '80s	23.3 million	3.8 million	8.0%	55%	Hetero
North Africa and Middle East	late '80s	220 000	19 000	0.13%	20%	IDU, Hetero
South and South-East Asia	late '80s	6 million	1.3 million	0.69%	30%	Hetero
East Asia and Pacific	late '80s	530 000	120 000	0.068%	15%	IDU, Hetero, MSM
Latin America	late '70s–early '80s	1.3 million	150 000	0.57%	20%	MSM, IDU, Hetero
Caribbean	late '70s–early '80s	360 000	57 000	1.96%	35%	Hetero, MSM
Eastern Europe and Central Asia	early '90s	360 000	95 000	0.14%	20%	IDU, MSM
Western Europe	late '70s–early '80s	520 000	30 000	0.25%	20%	MSM, IDU
North America	late '70s–early '80s	920 000	44 000	0.56%	20%	MSM, IDU, Hetero
Australia and New Zealand	late '70s–early '80s	12 000	500	0.1%	10%	MSM, IDU
Total		33.6 million	5.6 million	1.1%	46%	

²The proportion of adults (15 to 49 years of age) living with HIV/AIDS in 1999, using 1998 population numbers.

³MSM (sexual transmission among men who have sex with men), IDU (transmission through injecting drug use), Hetero (heterosexual transmission).

themselves for far worse as their workers sicken and die. According to a survey of commercial farms in Kenya, illness and death have already replaced old-age retirement as the leading reason why employees leave service. Retirement accounted for just 2% of employee drop-out by 1997.

- Life expectancy at birth in southern Africa, which rose from 44 years in the early 1950s to 59 in the early 1990s, is set to drop to just 45 between 2005 and 2010 because of AIDS. In contrast, South Asians, who could barely reach their 40th birthday in 1950, can expect by 2005 to be living 22 years longer than their counterparts in AIDS-ravaged southern Africa.

- New information suggests that between 12 and 13 African women are currently infected for every 10 African men. There are a number of reasons why female prevalence is higher than male in this region, including the greater efficiency of male-to-female HIV transmission through sex and the younger age at initial infection for women.

- In 1999, an estimated 570 000 children aged 14 or younger became infected with HIV. Over 90% were babies born to HIV-positive women, who acquired the virus at birth or through their mother’s breastmilk. Of these, almost nine-tenths were in sub-Saharan Africa. Africa’s lead in mother-to-child transmission of HIV was firmer than ever despite new evidence that HIV ultimately impairs women’s fertility: once infected, a woman can be expected to bear 20% fewer children than she otherwise would.

In short, the huge gap in HIV infection rates and AIDS deaths between rich and poor countries, and more particularly between Africa and the rest of the world, is likely to grow even larger in the next century. Likely, but not certain. Massive national and international efforts may yet help to end the stifling silence that continues to surround HIV in many countries, to explode myths and misconceptions that translate into dangerous sexual practices, to expand prevention ini-

[TABLE 2] Global summary of the HIV/AIDS epidemic, December 1999

People newly infected with HIV in 1999	
Total	5.6 million
Adults	5 million
<i>Women</i>	2.3 million
Children <15 years	570 000
Number of people living with HIV/AIDS	
Total	33.6 million
Adults	32.4 million
<i>Women</i>	14.8 million
Children <15 years	1.2 million
AIDS deaths in 1999	
Total	2.6 million
Adults	2.1 million
<i>Women</i>	1.1 million
Children <15 years	470 000
Total number of AIDS deaths since the beginning of the epidemic	
Total	16.3 million
Adults	12.7 million
<i>Women</i>	6.2 million
Children <15 years	3.6 million

tiatives such as condom promotion that can reduce sexual transmission, to create conditions in which young children have the knowledge and the emotional and financial support to grow up free of HIV, and to devote real money to providing care for those infected with HIV and support to their families. A trail of successful responses has already been blazed by a small number of dedicated communities and governments. The challenge for the leaders of Africa and their partners in development is to adapt and massively expand successful approaches that make it harder for the virus to spread, and that make it easier for those affected to live full and rewarding lives.

Smallpox in Nineteenth-Century India

JAYANT BANTHIA
TIM DYSON

This study uses the large, but neglected, body of Indian historical demographic and health data to show that smallpox was a major killer in past times. At the start of the nineteenth century roughly 80 percent of India's population had no effective protection against the disease, and in these circumstances virtually everyone suffered from it in childhood. The main exception was Bengal, where the indigenous practice of inoculation greatly limited the prevalence of the disease. Smallpox case fatality in India was high—around 25–30 percent in unprotected populations—and significantly higher than estimated for unprotected populations in eighteenth-century Europe. Although vaccination reached India in 1802, the practice spread slowly during the first half of the nineteenth century. From the 1870s onward there were considerable improvements in vaccination coverage. The study demonstrates a close link between the spread of vaccination and the decline of smallpox. Whereas at the start of the nineteenth century the disease may have accounted for more than 10 percent of all deaths in India, by the end of the century smallpox had become a comparatively minor cause of death as a result of improved vaccination coverage.

The Global and Regional Impact of Mortality and Fertility Transitions, 1950–2000

PATRICK HEUVELINE

During the second half of the twentieth century, world population grew at a record pace, both in absolute and relative terms, from 2.5 billion to 6 billion (or 1.75 percent annually).

Demographers have long identified rapid mortality declines as the main explanation. This article finds that one-fourth of today's world population is alive because of mortality improvements since mid-century. Very rapid growth is unlikely to continue as substantial fertility declines also occurred in recent decades. This article finds that already by the year 2000, these fertility declines have almost exactly compensated for the impact of mortality declines from mid-century levels. This result may suggest homeostasis, but analyses of underlying trends contradict this impression. First, the impact of fertility declines will soon and significantly exceed that of mortality declines. Second, that mortality and fertility declines jointly affect the size of the world population by less than one percent conceals a significant impact on the population's age composition as well as on regional population sizes.

The Persistence of Outmoded Contraceptive Regimes: The Cases of Mexico and Brazil

JOSEPH E. POTTER

Two of the most striking characteristics of contraceptive practice in the world today are the wide variation in patterns of use across countries and the tendency of the distribution of use by method to persist or narrow, even as new methods become available. The argument advanced in this article is that the disposition to commit to a reduced range of methods results from positive feedback in the process of contraceptive choice, and follows the logic of path dependence. The positive feedback derives, in large part, from social interaction among both the providers and the users of contraceptive methods. The persistence of outmoded contraceptive regimes is illustrated with the experience of Mexico and Brazil. In each case, it is argued that the conditions, events, and policies in the early

stage of the adoption process have had a determinant bearing on the contraceptive practice prevailing in the late 1990s.

Longer Life and Population Growth

JOSHUA R. GOLDSTEIN
WILHELM SCHLAG

Enthusiasm about the prospect of large increases in human life expectancy is often dampened by fears that lower mortality will increase population size, hence population pressure. A simple mathematical model of life-cycle stretching demonstrates that if increased longevity is accompanied by later childbearing, a trend that is already underway, future declines in mortality will not increase population size.

The Long-Term Effect of the Timing of Fertility Decline on Population Size

BRIAN C. O'NEILL
SERGEI SCHERBOV
WOLFGANG LUTZ

Existing long-range population projections imply that the timing of the fertility transition has a relatively unimportant effect on long-term population size when compared with the impact of the level at which fertility is assumed eventually to stabilize. However, this note shows that the effect of the timing of fertility decline is a function of the eventual fertility rate: the lower the eventual fertility rate, the greater the effect of the

timing of the transition becomes. This finding has important implications for projection methodology, as well as for policies related to the consequences of long-term levels of population size.

Urban Growth in Developing Countries: A Review of Projections and Predictions

MARTIN BROCKERHOFF

Comparison of the United Nations' earliest and most recent projections to the year 2000 suggests that urban and city growth in developing regions has occurred much more slowly than was anticipated as recently as 1980. A modified "urban population explosion" in developing countries since the 1970s conforms to explanatory models of urban growth developed by economists around 1980. Trends in productivity and terms of trade, in particular, have been highly favorable to agriculture as compared to manufacturing, presumably slowing migration to urban centers. Increases in national population growth rates have produced less than commensurate increases in rates of city growth, further supporting an economic and migration-related explanation for unexpectedly slow recent urban growth. Despite the efforts of the United Nations to maintain reliable statistics on urban and city populations, urban population projections should be interpreted with caution because of inadequacies of the data on which they are based. Moreover, current projections that virtually all world population growth in the future will occur in urban areas of developing countries may be misconstrued, if the forces that have retarded urban growth in recent years persist.

La variole en Inde du dix-neuvième siècle

JAYANT BANTHIA
TIM DYSON

La présente étude utilise la grande banque de données historiques sur la démographie et la santé en Inde, afin de démontrer que la variole y était autrefois un tueur important. Au début du dix-neuvième siècle, environ 80 pourcent de la population de l'Inde ne jouissait d'aucune protection efficace contre la maladie, et pratiquement tout Indien en a souffert au cours de son enfance. Le Bengale était la grande exception, cependant, car la pratique indigène d'inoculation y a limité sensiblement la prévalence de la maladie. Le taux de létalité attribuable à la variole était élevé en Inde—environ 25 à 30 pourcent parmi les populations non protégées—et beaucoup plus élevé qu'on ne l'avait estimé pour les populations sans protection en Europe du dix-huitième siècle. Même si la vaccination est apparue en Inde en 1802, la pratique s'est répandue lentement au cours de la première moitié du dix-neuvième siècle. À partir des années 1870, on a noté des améliorations considérables dans la couverture vaccinale. La présente étude démontre un lien étroit entre la propagation de la vaccination et la régression de la variole. Alors qu'au début du dix-neuvième siècle la maladie était sans doute responsable de plus de 10 pourcent de tous les décès en Inde, à la fin du siècle la variole ne comptait que pour un faible pourcentage des décès, grâce à l'amélioration de la couverture vaccinale.

L'incidence mondiale et régionale des transitions de mortalité et de fécondité, de 1950 à 2000

PATRICK HEUVELINE

Au cours de la deuxième moitié du vingtième siècle, la population mondiale s'est accrue à une vitesse record, tant en termes absolus que relatifs, passant de 2,5 milliards à

6 milliards (ou 1,75 % annuellement). Depuis longtemps, les démographes reconnaissent que la baisse rapide du taux de mortalité en est la principale cause. Le présent article révèle qu'un quart de la population mondiale actuelle est en vie à cause de la baisse du taux de mortalité depuis les années 1950. Une croissance démographique rapide n'en résultera vraisemblablement pas, étant donné la baisse des taux de fécondité également survenue au cours des dernières décennies. Le présent article indique que dès l'an 2000, cette baisse des taux de fécondité a presque exactement compensé pour l'incidence de la baisse des taux de mortalité depuis les années 1950. Il se pourrait qu'il y ait homéostasie mais l'analyse des tendances sous-jacentes contredit cette impression. D'une part, les effets de la baisse des taux de fécondité excéderont bientôt, et de façon importante, les effets de la baisse des taux de mortalité. D'autre part, le fait que la baisse des taux de mortalité et de fécondité aient ensemble un impact de moins d'un pourcent sur les effectifs de population à l'échelle mondiale masque un impact important sur la composition par âge et sur les effectifs de population à l'échelle régionale.

La persistance des méthodes contraceptives dépassées : les cas du Mexique et du Brésil

JOSEPH E. POTTER

Deux des caractéristiques les plus frappantes dans la pratique contraceptive actuelle sont les nombreuses variations du mode d'utilisation dans les différents pays du monde et la tendance de la répartition de l'utilisation par méthode à persister ou à se serrer, même lorsque de nouvelles méthodes deviennent disponibles. L'argumentation proposée dans le présent article est la suivante : la décision de se soumettre à un éventail réduit de méthodes repose sur la rétroaction positive du processus du choix de la méthode contraceptive et suit la logique de la dépendance du parcours (« path dependence »). La rétroaction positive provient, en grande partie, de

l'interaction sociale des fournisseurs et des utilisateurs des méthodes contraceptives. L'expérience du Mexique et du Brésil démontre bien la persistance des méthodes contraceptives dépassées. Dans chaque cas, les conditions, les événements et les politiques prévalant au tout début du processus d'adoption ont eu un effet déterminant sur la pratique contraceptive vers la fin des années 1990.

Vie plus longue et croissance démographique

JOSHUA R. GOLDSTEIN
WILHELM SCHLAG

L'enthousiasme provoqué par la perspective d'augmentations importantes de l'espérance de vie humaine est souvent modéré par les craintes qu'un taux de mortalité à la baisse augmentera les effectifs de population, et par le fait même, la pression démographique. Un simple modèle mathématique de l'allongement du cycle de vie démontre que lorsque l'allongement de la vie humaine est accompagné d'un âge de procréation tardif – tendance déjà amorcée – les futures baisses des taux de mortalité n'entraîneront pas de hausse des effectifs de population.

Effet à long terme de la configuration temporelle de la baisse du taux de fécondité sur les effectifs de population

BRIAN C. O'NEILL
SERGEI SCHERBOV
WOLFGANG LUTZ

Les projections démographiques actuelles à long terme supposent que la configuration temporelle de la transition du taux de fécondité a un effet relativement insignifiant sur les effectifs de population au cours d'une longue période en comparaison à l'incidence du niveau de stabilisation éventuel du taux de fécondité. Toutefois, le présent article indique que l'effet de la configuration temporelle de la transition du taux de fécondité est fonction du taux de fécondité éventuel: plus le taux de fécondité éventuel est bas, plus l'ef-

fet de la configuration temporelle de la transition du taux de fécondité est grand. Cette conclusion a des répercussions importantes pour la méthodologie prévisionnelle ainsi que pour les politiques propres aux conséquences des niveaux des effectifs de population à long terme.

Croissance urbaine dans les pays en voie de développement : récapitulation des prévisions et prédictions

MARTIN BROCKERHOFF

La comparaison des toutes premières prévisions des Nations Unies avec les toutes dernières jusqu'à l'an 2000 suggère que la croissance urbaine dans les régions en développement s'est produite beaucoup plus lentement qu'on ne l'avait anticipé dès 1980. Une « explosion démographique urbaine » modifiée dans les pays en développement depuis les années 1970 concorde avec les modèles explicatifs de la croissance urbaine élaborés par des économistes dans les années 1980. Les tendances de la productivité et des conditions du marché, en particulier, ont été très favorables à l'agriculture en comparaison du secteur manufacturier, et ont probablement ralenti la migration vers les centres urbains. Les augmentations des taux de croissance démographiques à l'échelle nationale n'ont pas été suivies des augmentations proportionnelles des taux de croissance urbaine, ce qui rend encore plus convaincante l'explication par des causes économiques et migratoires de la récente croissance urbaine faible. Malgré les efforts des Nations Unies pour maintenir des statistiques fiables sur les populations urbaines, les projections sur les populations urbaines doivent être interprétées avec prudence, étant donné les insuffisances dénotées dans les données sur lesquelles elles sont fondées. En outre, il se pourrait que les prévisions courantes voulant que pratiquement toute la croissance démographique mondiale se produise à l'avenir dans les régions urbaines des pays en développement aient été dénaturées, si les forces qui ont retardé la croissance urbaine au cours des années récentes persistaient.

La viruela en la India del siglo XIX

JAYANT BANTHIA
TIM DYSON

En este estudio se utiliza el considerable, pero escasamente tenido en cuenta, cuerpo de datos históricos sobre población y salud de la India para poner de manifiesto que, en el pasado, la viruela era un agente mortífero de gran magnitud. A comienzos del siglo XIX, aproximadamente el 80 por ciento de la población de la India carecía de protección eficaz contra esta enfermedad y, en esas circunstancias, casi todas las personas contraían la viruela durante la infancia. La gran excepción fue Bengala, donde la práctica de vacunar a la población limitó considerablemente la incidencia de la enfermedad. En la India, la mortalidad a consecuencia de la viruela era elevada—aproximadamente entre el 25 y el 30 por ciento de la población no vacunada—y considerablemente mayor a las estimaciones para poblaciones europeas no vacunadas en el siglo XVIII. Si bien la vacuna contra la viruela llegó a la India en 1802, la práctica de la vacunación se extendió lentamente durante la primera mitad del siglo XIX. A partir de la década de 1870, la vacunación se extendió con mucha mayor rapidez. En el estudio se demuestra la estrecha relación existente entre la ampliación del alcance de la vacunación y la disminución de la viruela. En tanto a comienzos del siglo XIX la enfermedad podría haber sido la causa de más del 10 por ciento de todos los fallecimientos en la India, a fines de siglo la enfermedad había pasado a ser una causa de muerte de relativamente menor importancia debido al aumento del alcance de la vacunación.

Las repercusiones regionales y mundiales de las transiciones de mortalidad y fecundidad en el período 1950–2000

PATRICK HEUVELINE

En la segunda mitad del siglo XX, la población mundial creció a un ritmo sin preceden-

tes, tanto en cifras absolutas como relativas, de 2.500 a 6.000 millones de personas (o sea, un crecimiento del 1,75 por ciento anual). Desde hace mucho tiempo, los demógrafos han establecido que la principal causa de ese crecimiento ha sido la rápida disminución de la mortalidad. En este artículo se determina que una cuarta parte de la población mundial actual está viva debido a los avances que redujeron la mortalidad desde mediados del siglo. Es improbable que la población siga creciendo muy rápidamente, pues en las últimas décadas también ha disminuido considerablemente la fecundidad. En este artículo se establece que ya para el año 2000 esa disminución de la fecundidad habrá contrarrestado casi exactamente los efectos de la disminución de la mortalidad de los niveles de mediados de siglo. Esta conclusión podría dar a entender un efecto homeostático, pero el análisis de las tendencias subyacentes contradice esa hipótesis. En primer lugar, la disminución de la fecundidad tendrá rápidamente efectos de mucha mayor importancia que la disminución de la mortalidad. En segundo lugar, el hecho de que la combinación de las disminuciones de la mortalidad y la fecundidad apenas modificará el tamaño de la población mundial en menos del uno por ciento oculta el considerable efecto que habrá de tener en la composición por edades y en el tamaño de la población a nivel regional.

La persistencia de las prácticas anticonceptivas anticuadas: los casos de México y Brasil

JOSEPH E. POTTER

Dos de las características más destacadas de la utilización de métodos anticonceptivos en el mundo actual son la amplia variación de prácticas entre los distintos países y la tendencia de la distribución del uso de un método a persistir o reducirse, aun cuando se pueda recurrir a métodos nuevos. En este artículo se comienza explicando que la disposición a limitarse a un conjunto reducido de métodos obedece a la respuesta positiva

que se ha obtenido en el proceso de elección del método anticonceptivo, y luego se dan razones que indican una dependencia de la elección hecha en el pasado ("path dependence"). La respuesta positiva deriva, en gran medida, de la interacción social entre los proveedores y los usuarios de los métodos anticonceptivos. La persistencia de prácticas anticonceptivas anticuadas se ilustra con la experiencia de México y Brasil. En cada caso, se afirma que las condiciones, los hechos y las políticas existentes en la etapa inicial del proceso de elección han tenido una importancia decisiva en las prácticas anticonceptivas prevaletentes a fines de la década de 1990.

manera relativamente insignificante en el tamaño de la población cuando se compara con los efectos del nivel al cual se estima que, a la larga, habría de estabilizarse la fecundidad. Con todo, en esta nota se señala que el efecto de la oportunidad en que se registra la disminución de la fecundidad está en función de la tasa de fecundidad que se haya alcanzado: cuanto más baja sea la tasa de fecundidad alcanzada, mayores repercusiones tendrá la oportunidad en que se registre la transición. Esta conclusión entraña importantes consecuencias para la metodología de las proyecciones, así como para las políticas relacionadas con las consecuencias de los niveles a largo plazo del tamaño de la población.

El aumento del número de años de vida y el crecimiento de la población

JOSHUA R. GOLDSTEIN
WILHELM SCHLAG

El entusiasmo que provoca la perspectiva de un gran incremento en la esperanza de vida del ser humano suele verse empañado por los temores de que la disminución de la mortalidad produzca el aumento de la población, lo que a su vez aumentaría la presión demográfica. Un simple modelo matemático de la prolongación del ciclo vital demuestra que si el aumento de la esperanza de vida va acompañado de una tendencia a procrear a edad más avanzada, lo cual ya está ocurriendo, la disminución de la mortalidad en el futuro no causaría el aumento de la población.

El crecimiento urbano en los países en desarrollo: examen de las proyecciones y predicciones

MARTIN BROCKERHOFF

La comparación de las más tempranas y las más recientes proyecciones de las Naciones Unidas para el año 2000 sugiere que el crecimiento urbano y de las ciudades en las regiones en desarrollo se produjo de manera mucho más lenta de lo que se había previsto incluso en 1980. La modificación de la tendencia hacia la "explosión demográfica urbana" en los países en desarrollo desde la década de 1970 se ajusta a los modelos explicativos del crecimiento urbano elaborados por los economistas hacia 1980. Las tendencias en materia de productividad y de relación de intercambio, en particular, han favorecido muchísimo más a la agricultura que a la industria manufacturera, lo que presumiblemente habría provocado el enlentecimiento de la migración hacia los centros urbanos. El aumento en las tasas nacionales de crecimiento de la población ha distado de producir aumentos concomitantes en las tasas de crecimiento de las ciudades, lo cual reafirmaría los argumentos que aducen razones económicas y relacionadas con la migración para explicar el inesperadamente lento crecimiento urbano registrado últimamente. A pesar del empeño de las Naciones Unidas por mantener estadísticas confiables sobre la población de las ciudades y los centros urbanos, las proyecciones so-

La oportunidad en que se registra la disminución de la fecundidad y su efecto a largo plazo en el tamaño de la población

BRIAN C. O'NEILL
SERGEI SCHERBOV
WOLFGANG LUTZ

Las actuales proyecciones de largo alcance en materia de población sugieren que, a largo plazo, la oportunidad en que se registra la transición de la fecundidad repercute de

bre la población urbana deben interpretarse con cautela debido a la insuficiencia de los datos en que se basan. Además, las actuales proyecciones de que, en el futuro, prácticamente todo el crecimiento demográfico

mundial habrá de registrarse en zonas urbanas de los países en desarrollo podrían interpretarse erróneamente, si persistieran las fuerzas que han retardado el crecimiento urbano en los últimos años.

AUTHORS FOR THIS ISSUE

JAYANT BANTHIA is Registrar General and Census Commissioner, India.

MARTIN BROCKERHOFF is Associate, Policy Research Division, Population Council.

TIM DYSON is Professor of Population Studies, London School of Economics.

JOSHUA R. GOLDSTEIN is Assistant Professor of Sociology and Public Affairs and Faculty Associate, Office of Population Research, Princeton University.

PATRICK HEUVELINE is Assistant Professor, Department of Sociology and the College, University of Chicago, and Research Associate, Population Research Center, NORC and the University of Chicago. e-mail: p-heuveline@uchicago.edu

WOLFGANG LUTZ is Leader of the Population Project, International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria.

BRIAN C. O'NEILL is Assistant Professor (Research), Watson Institute for International Studies and Center for Environmental Studies, Brown University.

JOSEPH E. POTTER is Professor of Sociology and Faculty Research Associate, Population Research Center, University of Texas at Austin.

SERGEI SCHERBOV is Researcher and Lecturer, Population Research Centre, Faculty of Spatial Sciences, University of Groningen, Netherlands.

WILHELM SCHLAG is Assistant Professor, Department of Mathematics, Princeton University.

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