seedlings. Much of this work is being done in collaboration with peasant colleagues on communes. A paleobotany laboratory is doing work on fossil ginkgos and also palynological work in connection with oil exploration.

12. The Microbiological Institute has 400 workers, including 300 researchers; most are university graduates, and the others are from factories, communes, or the PLA. We were guided on our visit by Professor Fang Sinfang, Associate Professor S. I. Lu, who also acted as interpreter, and Wei Jang Chun, chairman of the Revolutionary Committee. The culture preservation laboratory has 10,000 cultures preserved on agar at 4°C, under mineral oil at 15°C, or by lyophilization. This collection is mainly of organisms isolated in China and is used to supply cultures all over the country. The classification and identification laboratory was mainly concerned with yeasts, for which they were making popular guides for laymen and factory workers. They do some chemical and metabolic studies in their yeast identification. The bacterial identification laboratory was studying mainly spore-forming *Lactobacillus, Pseudomonas,* and *Brevibacterium.* An analytical laboratory had excellent chromatography, electrophoresis, and high-voltage electrophoresis equipment. Their aim is to understand the microbiological resources of their country in chemical terms. The antibiotics laboratory had produced kasugamycin, an antibiotic that protects against rice blast. It is applied at 40 ppm by aerial spray to seedlings or adult plants, which absorb it and translocate it. Its use is becoming extensive, since it does not seem to be toxic and does not get into the rice grain. Its use is economically sound, since one application usually suffices and the cost is only 80 cents (Chinese) per mu (1/6 acre). In another laboratory, improved strains of *Corynebacterium glutamicum* were being used to make monosodium glutamate. At the suggestion of a worker, insoluble enzymes (such as amylase from *Aspergillus niger* coupled to diethylaminoethyl Sephadex) were being used to obtain longer-lasting and more effective conversion of cornstarch to glucose that was destined to be used for intravenous feeding. Recovery of enzyme activity after coupling to the carrier is only 20 percent, but the resulting preparation can be used for nearly 320 hours, and yields a dextrose equivalent of 93 percent. They also diazotize the enzymes and then couple them to other carriers. The bacteriophage laboratory was working with *Bacillus polymyxa,* for which they had obtained four different serological types of phage. Since the Cultural Revolution, they had shifted to *Corynebacterium* and have tried to minimize phage problems in production.

13. At Chungsan University entomologists were studying pest control, the herbarium prepared a collection of useful plants for reference, pharmacologists were testing medical herbs for hemostatic properties, and an electron microscopy laboratory was studying morphology of sulfur-metabolizing bacteria. Student laboratories were testing herbal extracts for hemostatic and anticoagulant activity and studying elementary chemistry.
14. "Integration of Research and Practice," *BBC World Summary Broadcast, Far East,* FE/3586/B/5 [from Peking Home Service, 6 January 1971, translation of broadcast by Chinese Academy of Sciences (Academia Sinica)].
15. J. S. Horn, *Away With All Pests* (Monthly Review Press, New York, 1971).
16. The hospital is one of more than 80 large hospitals in Peking, of which three medical hospitals and one dental hospital are affiliated with the medical college. Founded in 1958 as a polyclinic, it has departments of medicine, surgery, obstetrics, pediatrics, neurology, otorhinolaryngology, and ophthalmology. There are 700 staff, of whom 160 are doctors and 260 are nurses, for the 606 beds. Including barefoot doctors, medical personnel in this district of the city is 1.1 percent of the population.
17. The clinic has a staff of 60 (including 20 doctors) for the 6000 workers. It includes outpatient clinics and patient wards, operating and delivery rooms, diagnostic and x-ray laboratories, and a pharmacy well stocked with both Western and traditional medicines.
18. A. Topping, *New York Times,* 24 May 1971.
19. S. Rosen, *ibid.,* 1 November 1971; E. G. Dimond, *J. Amer. Med. Ass.* **218**, 1558 (1971).
20. J. Sigurdson, *Natural Science and Technology in China,* Report No. 154 (Swedish Academy of Sciences, Stockholm, 1968).
21. M. Macioti, "Hands of the Chinese," *New Sci. Sci. J.,* 10 June 1971, pp. 636–639.

Health Care Experiment at Many Farms

A technological misfit of health care and disease pattern existed in this Navajo community.

Walsh McDermott, Kurt W. Deuschle, and Clifford R. Barnett

Medicine and the other health professions are undergoing wide-ranging scrutiny as parts of a total health care system. One part is the system for primary health care (*1*) consisting of a university-connected health center manned full time by physicians and nurses, with the aid of well-trained, indigenous, auxiliary personnel who work both at the center and in the homes. A chance to measure the impact of such a system on the endemic disease pattern of a poverty-stricken, rural, and traditional tribal society was provided as part of a larger series of studies on a Navajo community (*2*). Naturally, the human support components of medical care were heavily involved in this activity. However, these aspects have been purposely excluded from this analysis, which is concerned solely with the influence of the technology. By technology is meant the capability to alter disease in a predictable fashion by such entities as drugs, vaccines, diagnostic equipment, or surgery. In a community with satisfactory health services, those services delivered to the individual and those delivered to the group operate simultaneously; hence it is difficult to separate their respective effects. Such a separation is necessary, however, if rational choices are to be made in setting up systems of medical care in communities where the existing systems are ineffective or nonexistent. In the present study, the circumstances were such that the influence of one of the systems—in which the technology is selectively applied by a clinical physician to one patient at a time—could be evaluated free from significant influence by the other system—in which the technology is applied by a variety of professionals to the community as a group.

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Background and Methods of Study

The Navajo–Cornell Field Health Research Project was organized by the Navajo Tribe, Cornell University Medical College, and the U.S. Public Health Service in 1955, when the responsibility for the health of the U.S. Indian was transferred to the Department of Health, Education, and Welfare. The stated purposes were fourfold: to develop effective methods for the delivery of modern medical services to the Navajo people; to see to what extent these methods could be applied to other people in similar socioeconomic circumstances; to study discrete diseases, particularly in light of their possible shaping by Navajo culture;

and to find out whether the sudden apposition of modern biomedical science and technology and the disease pattern of a nontechnological society could provide valuable knowledge in the attack on contemporary medical problems.

The research on these questions covered a wide range. There were studies of such familiar entities as infant feeding (*3*), congenital hip disease (*4*), coronary heart disease (*5*), tuberculosis (*6*), and accidents. There were also studies of an immediately practical nature, such as effective cross-cultural training for paraprofessional field health workers and the development of a manual to be used as a text in training them (*7*). Finally, there were studies in such sharply focused areas as the discovery of a new, genetically determined transferrin (*8*) and ethnolinguistics (*9*).

It is unlikely that any of this research, with its requirement of continued and enthusiastic community participation, could have been conducted in a remote, non-English-speaking tribal society unless there were clearly visible, immediate benefits to the people living there (*10*). Indeed, without the capability of supplying substantial benefits, it would have been inappropriate even to propose the project. The procedure chosen, therefore, was to create a comprehensive system of primary health care and, as a major corollary, to organize various programs of research (*11*). Thus, the introduction of a complete system of personal medical care to a community in which only a rudimentary system had existed became, in itself, one of the major experiments.

A natural and political unit of some 800 square miles, known as the Many Farms–Rough Rock community (hereinafter called Many Farms), near the center of the 23,000-square-mile Navajo reservation was selected jointly by project and tribal representatives. The community was considered to be reasonably representative of Navajo society and was thought to contain about 2000 people.

The System

The system of primary health care was in actual operation from May 1956 to July 1962. It included a well-equipped health center for ambulatory care, a rudimentary satellite facility, and several automobiles with two-way radiotelephones for visits to the homes. The medical and nursing services were supplied by two field physicians, two nurses, one Navajo teacher, and four Navajo auxiliary health workers. The staff in residence received guidance from resident social scientists, and a steady flow of consultants in the various professions and disciplines was available from the parent university. Patients were usually seen in the central facility, but, when necessary, they were seen in their homes. Transportation to the government hospital 90 miles away, or to the mission hospital 55 miles away, had to be on an improvised basis over the corduroy dirt roads. Critically injured persons could be removed by light airplane in the daytime, weather permitting.

Over 90 percent of the population were examined in the central facility at some time during the study, and approximately two-thirds sought care at least once a year during those 6 years. Evidence exists that the health care delivered was of a consistently high standard; but since that evidence does not lend itself to a brief presentation, we can merely state our conviction that the results observed are representative of what happens when medical care from a large university medical center is made available to an impoverished rural society in the general circumstances of Many Farms.

The Society at the Start

The Navajo society at Many Farms was one of a nonliterate, non-English-speaking people who lived in extended families in one-room, windowless, log and mud dwellings with dirt floors. These dwellings were separated from each other and from any supply of water by one or more miles of intermittently impassable dirt roads (*11*). The water was pure at the source, but was easily contaminated through the communal dipper in the home. There was no refrigeration. The climate was one of harsh extremes of winter cold (averaging −4°C) and summer scorching (reaching highs of 43°C during the day and dropping 22° or more at night). Rainfall averaged 12 to 15 inches per year. Six or seven, and occasionally as many as 15, persons might sleep in a single, large, poorly ventilated room, usually on sheepskins or the dirt floor. A wood stove, sometimes made from a kerosene drum, supplied the heat and was used for cooking. The meals were not usually served on a table, but were eaten while sitting on the floor. There were no latrines or privies; horses wandered up to the hogan door and dogs roamed freely.

The economy consisted of a little dry farming, sheepherding, the weaving of wool rugs, some silver work, and occasional laboring jobs, usually farther than an overnight trip from the home. The average cash income for a family of four was estimated to be $586 per year, or $147 per capita per year (*12*). Of this income, 82 percent was earned and 19 percent was from various sources of welfare. There was a federally supported, tribally administered supplemental food program. Primary school children would learn to speak English, but it was not spoken in the home; not all children of school-age actually attended school.

Poor as these people were in a material sense, they did not show the apathy and lack of community feeling that Oscar Lewis describes as characteristic of the "culture of poverty" (*13*). On the contrary, the Navajo culture was fairly well maintained, and included an indigenous curing system run by medicine men, who were highly respected. This gave the Navajos a kind of "regal poverty," in that they were well adapted to the harsh circumstances of the environment.

For the way of life, the disease pattern was predictable (*14*). Windowless, one-room homes, when the winters are bitter cold, favor airborne transmission of tubercle bacilli and other agents of respiratory disease. The scarcity of water, the chance of its contamination in the home, the absence of water at the sites of defecation, the serving of meals on the floor, and the potential of horse dung for breeding flies favor the spread of enteric diseases, skin disorders, and trachoma.

Clinical impressions of the disease pattern were largely derived from what had been seen at the reservation's six hospitals. The diseases just mentioned, as well as the severe burns and traumatic injuries of the sort common to primitive rural living were prominent, as were congestive heart failure, gall bladder disease, and arthritis. Infant mortality and the birth rate were thought to be considerably higher than the U.S. average. All observers agreed that the Navajos were a disease-ridden people whose disorders would be largely preventable within a modern society.

Previous Biomedical Influence

Within the Many Farms–Rough Rock community, there were no physicians in residence, nor, as far as is known, had there ever been. The principal medical influences were a quite rudimentary outpatient facility, which was 14 miles from the southern border of the area and was manned by an elderly physician, a mission hospital 55 miles away, and a government hospital some 90 miles away. At both of these hospitals, limited general surgery could be performed. About half of the births were at the hospitals or en route to them; the other half occurred unattended in the hogans. At various times in the past, solitary public health nurses based outside the community had tried to mount immunization programs in the one boarding school or the two day schools. The latter were held in overheated Quonset huts and similar makeshift structures, with outside temperatures in the winter frequently ranging from −23°C to −29°C. As these public health nurses would be responsible for as many as 10,000 people scattered over 4,000 or 5,000 square miles, the field nursing position was understandably vacant more months than it was filled. Most of the community had received smallpox immunization. Any other immunizations were haphazard, and no program of tuberculin tests had ever been carried out. Thus, the introduction of primary health care through the clinical physician system was a virtually complete innovation when it was introduced to the community on 19 May 1956 (*2*).

Observations

Although the innovation was made suddenly, its early influence was gradual. Accordingly, the results reported are for a period of five consecutive calendar years in the middle of the total 6-year study. Careful checking of the half-year phase-in and phase-out periods indicates that it is not misleading to concentrate on the middle 5 years. The phase-out itself was accomplished smoothly, and the community was not left without an adequate system of medical care.

The disease pattern was determined by: (i) special examination of structured samples of the population; (ii) a review of all deaths and hospital records; (iii) demographic studies, including an annual census of the community; and (iv) rates of the incidence and prevalence of certain of the common conditions in the two-thirds of the population that sought care each year. Studies made in the later years of the project revealed no evidence of significant illness for which care had not been sought.

Table 1. Major acute microbial diseases observed in 5 years.

Episode	Year				
	1957	1958	1959	1960	1961
Pneumonia	132	125	37*	105	98
Diarrhea	220	314	282	359	247
Otitis media	159	239	224	219	95
Measles	22	139	5	86	53
Impetigo	113	142	157	149	106

* A clear relationship existed between pneumonia and measles for the age group 13 months to 10 years. Had antimeasles vaccine been available then, a substantial portion of the childhood pneumonia *after* infancy presumably would have been prevented.

By actual rates of incidence, the five most common diseases in the population as a whole each year were diarrhea, otitis media, impetigo, pneumonia, and burns. The incidence of fractures and head injuries closely followed that of burns. There were nine instances of purulent meningitis in the entire 5-year period. In Table 1, which is arranged by episode, it may be seen how much of the professional time was occupied by pneumonia, diarrhea, and otitis media. In the second year (1958), these three, along with measles and impetigo, represented a total of 958 episodes among the 1362 patients who sought care. Especially noteworthy, however, is the fact that, except for otitis media in the last year (1961), there is no evidence of a significant decrease in the number of these episodes throughout the 5 years. By contrast, the incidence of otitis media during 1961 can be shown to be significantly lower ($P < .0001$) than the incidence during the previous 4 years.

Turning to three major chronic diseases: in a 50 percent sample of the Many Farms population, the prevalence of congenital hip disease, as determined roentgenographically, was about 200 times greater than it is in the general population (*3*). Although there was no change during the 5-year observation period, there was evidence that both genetic and environmental factors are involved and that change could occur over a longer time period. At the start of the study, trachoma was present in 2.9 percent of the school children under age 10. While there were some indications that the situation might have improved very slightly during the 5-year period, there was no definite evidence of a decrease in incidence.

The prevalence of tuberculous pulmonary disease, determined roentgenographically in a 50 percent sample, was 74 per 1000 (*6*), two to three times that generally obtaining in the U.S. population, and 15 times that found in a rural area of southern Scotland which was studied at approximately the same time (*15*). A community of 2000 persons is too small to reveal significant change in the incidence of tuberculous *disease*, yet it is large enough to show change in the incidence of tuberculous *infection*. One-third of the 5-year-old beginners in school were cutaneous reactors to tuberculin when the study was started; 5 years later, in 1961, only 3 of 55 beginners were positive. This constituted evidence that the transmission of tubercle bacilli from one host to another had declined within the community during the study period.

In the present analysis, that portion of the disease pattern that was treated by surgery is considered as an entity; about 25 persons per 1000 of the population received surgical treatment each year. Another 25 persons per 1000

Table 2. Mortality in the Many Farms–Rough Rock community

	Year					5-year experience*
	1957	1958	1959	1960	1961	
Population	1963	2044	2127	2221	2299	
Deaths	20	15	7	9	14	65 (total)
Infant deaths	11	7	2	7	7	34 (total)
Infant mortality†	115.8	70.0	21.3	66.7	76.1	70.0 (average)
Crude death rate‡	10.2	7.3	3.3	4.1	6.1	6.2 (average)

* The U.S. Public Health Service estimate of crude deaths averaged 7.9 for 5 years before 1957. † Infant deaths per 1000 live births. ‡ Deaths per 1000 population.

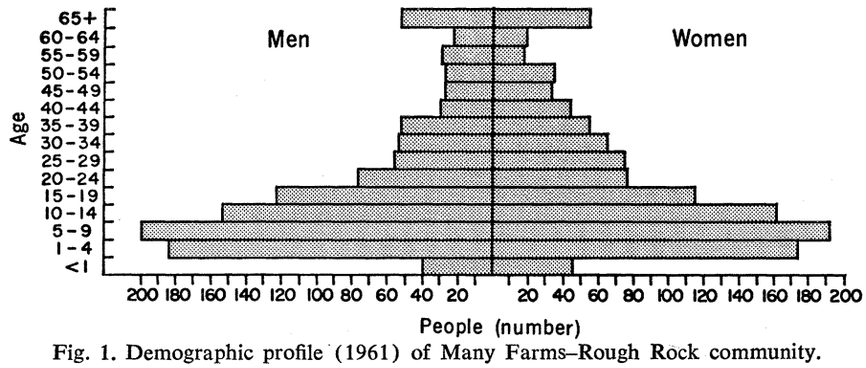

Fig. 1. Demographic profile (1961) of Many Farms–Rough Rock community.

were hospitalized each year for nonsurgical reasons. The surgical conditions involved ranged from cholelithiasis to severe gunshot wounds to hemorrhage and shock complicating pregnancy. Of this total of 50 persons hospitalized per 1000, some 7 to 14 died each year (Table 2). This left 35 to 40 persons per 1000, or 3.5 percent of the total population, who presumably benefited each year from hospital care, whether medical or surgical.

Absent Diseases

The incidence of certain diseases that might be expected was either very low or absent altogether. Credible explanations are at hand for most such cases—for example, coronary heart disease (*5*). The extreme decentralization of the society served as a "firebreak" against the spread of food- or waterborne disease, because the consequences of poor sanitation were largely confined to the individual camp. The absence of tetanus neonatorum is presumably due to the fact that, unlike some other cultures, the Navajos have no harmful practices concerning the umbilical stump. Also not included is the so-called "hidden component" of the pattern—namely, the illnesses recognized as such in the one culture and not in the other. Our observations on this "hidden component" have been presented elsewhere (*2*); suffice it to say that these illnesses presented no real problems in management, largely because they were so well handled by the Navajo medicine men.

Deaths

Examination of mortality affords another measure of the disease pattern at the beginning and throughout the study (Table 3). Two findings are especially noteworthy: 34 (52 percent) of the 65 deaths occurred during the first year of life; and there was only one death beyond the age of 3 that could reasonably be called preventable by contemporary medical science. This polarized pattern of deaths was generally constant; during the fifth year of the study, 50 percent of the deaths occurred in infancy, as had been the case in the first year of this study. Of the 34 infant deaths at Many Farms, 20 were from the pneumonia-diarrhea complex. Thus, the most prevalent disease among the living was also the leading cause of death.

The lack of change in the disease pattern, as revealed by the causes of death, was thus in agreement with the lack of change seen in the most prevalent diseases among the living during the 5-year period (Table 1). However, an important effect of the application of technology might be overlooked if change in the incidence of disease were the principal criterion. The incidence of a microbial disease could remain unchanged, yet the individual episodes could be aborted or readily controlled by specific therapies. It was not possible to measure accurately the therapy-induced curtailment of otherwise self-limited illnesses. From judgments based on well-documented experience with the particular diseases in question, except for otitis, there was no evidence of any widespread effect (*16*).

Table 3. Deaths in the Many Farms–Rough Rock community during 1957.

Age (months)	Deaths	
	Cause	Number
0–12	Pneumonia-diarrhea	8
	Congenital heart	1
	Unknown	2
1–28	None	0
29	Severe trauma	1
46	Post-cholecystectomy	1
46	Myocardial infarction	1
49	Severe trauma	1
75	Anemia, unknown cause	1
81	Congestive heart failure, with pneumonia	1
89	Fractured neck of femur	1
90	Congestive heart failure, with pneumonia	1
91	Pneumonia	1

Change in Crude Death Rates

Theoretically, a measurement of the extent to which lives were saved by the new system would be provided by comparing the crude death rates for the 5-year study period with the rates in the same community for the preceding years. Such rates were indeed determined for the 5 years of the study (Table 2). Unfortunately, however, the only data with which they can be compared are not true rates, but estimates. What is more, they are estimates not for the population of the Many Farms–Rough Rock community, but for the Navajo Tribe as a whole (*17*). The reason for this inadequacy is that, in order to obtain mortality rates, it is necessary to know the size of the population, and no accurate census of the Navajo Tribe by regions or as a whole existed. Because there were no census data and because the recall of infant deaths long afterward is significantly inaccurate, no attempt was made to determine retrospectively the total number of deaths for the community.

The crude death rate for the Many Farms population, calculated from our own exact census data, averaged 6.2 per 1000 population for the 5 years of the study. These data and death rates by individual year are presented in Table 2 (*18*). As may be seen, the Many Farms average and the rates in each of the last 4 of the 5 years were lower than the estimated crude death rates of 7.9 for the whole tribe in the 5 years immediately preceding the study. Our impression is that, in the pre-study period, the Many Farms health situation had been generally similar to that of the tribe as a whole.

Similarly, it is believed that the estimated death rates were probably slightly lower than actual figures because of the known tendency to fail to report the deaths that occurred in the first few days after birth.

This comparison of hard data and estimates based on impressions admittedly leaves the door open for the possibility that the study years were associated with a lowered death rate. Yet without well-established rates for the past, and with the necessity of having very large populations in order for small changes in crude death rates to be significant, it was not possible to establish a significant lowering of overall mortality as a result of the biomedical innovation. A priori, some lives were presumably saved, but there is certainly no clear-cut evidence to that effect (*16*).

The actual data on crude mortality and on infant mortality in the 5 years of the study are given in Table 2. In all but one year, the infant deaths represented at least one-half of the total deaths, and infant mortality averaged 70 per 1000 live births for the 5-year period. As with the crude death rate, the infant mortality rate of 70 was slightly lower than the government estimates for the entire reservation for previous years, but there is no real indication that the rate showed a significant downward trend during the 5 years of the study.

Census

In evaluating the technological effectiveness of a health care system, however, it is not only essential to establish the nature of the diseases prevalent in the community, but also to establish the demographic profile of the community. In order to obtain demographic data about Many Farms, it was necessary to conduct a complete census of the population. This was done by constructing a map that included all households in the area and enumerated every resident therein, and by determining all births and deaths on a continuing basis. The total census was repeated each year.

As may be seen in Table 2, in the first full year (1957) there were 1963 persons in the study area—thus the observed value was close to the estimate of 2000. What had been grossly underestimated, however, was the rate at which the population was growing

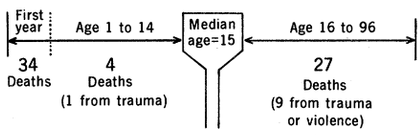

Fig. 2. Mortality in the Many Farms–Rough Rock community (by demographic pattern). Note that 52 percent of all deaths came from 3.7 percent of the population (that is, from infants in the first 12 months).

(Table 4). During the 5 years of the study, the population was actually observed to grow at a rate of 4 percent per year. Observations since the completion of the study have indicated that this extraordinarily high growth rate at Many Farms, and the demographic profile it produced (Fig. 1), were indeed representative of the Navajo population as a whole.

The pool of women in the childbearing period (ages 15 to 44) each year ranged from 363 to 429, and the total live births each year ranged from 92 to 105. The government estimate of the birth rate for the tribe as a whole was 36 for the year 1956 (the present U.S. rate is around 18). The birth rate at Many Farms was 48.4 in 1957 and averaged 45.8 for the 5 years. These sustained high fertility and birth rates resulted in a population with a median age of 15. In any one year, the infants represented only 3.7 percent of the total population, yet they accounted for more than one-half of the total number of deaths and much of the other near-fatal illness (Fig. 2).

Discussion

The 6-year period of this study coincided with a period of "tooling up" for the Public Health Service Indian program and for other tribal and governmental programs in Indian affairs. As a result, during the 8 or 9 years since that time, both Navajo health and certain other aspects of Navajo life, including the quality of life in the Many Farms–Rough Rock community (*19*) have undergone appreciable improvement. During the actual study period, however, there was virtually no change in the living conditions of the people in the Many Farms–Rough Rock community. In these static conditions, with no real change in either the home environment or the level of formal education, the wide application of biomedical science and technology through the clinical physician system resulted in:

1) A definite reduction in the transmission of tubercle bacilli.

2) A definite reduction in otitis media in the fifth year.

3) No reduction in the occurrence of active trachoma.

4) No reduction in the occurrence of the pneumonia-diarrhea complex, which remained the single greatest cause of illness and death.

5) The identification of those individuals who need hospital care (35 to 40 persons per 1000 each year)—that is, the establishment of a medical scan.

6) A possible slight reduction in crude mortality, despite an infant mortality that persisted at three times the national average.

This list of positive and negative accomplishments delineates the "technological substrate"—that is, the fitness of the system's technological component for meeting the disease situation as it actually existed in the community. Thus, an analysis of this list reveals the limits of contemporary biomedical capability in this particular set of circumstances. The first four entities all had a microbial component; two were influenced and two were not. The two that were favorably influenced (tuberculous infection, otitis media) were not in themselves contributors to the total mortality. For this reason, it seems likely that the apparent influence on crude death rate is largely attributable to the health care system's capability for making discriminating use of the hospital facilities. Expressed differently, it appears that items 5 and 6 (hospital referrals and crude death

Table 4. Births in the Many Farms–Rough Rock community.

	Year					5-year average
	1957	1958	1959	1960	1961	
Women (age 15–44)	363	378	390	417	429	395.4
Live births	95	100	94	105	92	97.2
Birth rate*	48.4	48.9	44.2	47.3	40.0	45.8

* Per 1000 population.

rate) bear a direct relationship to each other and are unrelated to the favorable events of items 1 and 2.

The first four conditions on the list have three features in common: they are all microbially linked; they are all especially prominent in various settings of poverty; and they are all either well controlled or actually absent from most of U.S. society. Presumably, therefore, the knowledge of how to control them on a wide scale exists. When this knowledge is analyzed in relation to Many Farms, however, it becomes clear that, depending on their specific biologic nature, diseases vary enormously in their susceptibility to medical management in slum conditions. For example, it has been convincingly demonstrated (*20*) that tubercle bacilli can be transmitted through the air and can remain suspended in the air of an unventilated room for at least an hour or so. At Many Farms, the windowless, one-room dwellings, made of logs chinked against the bitter cold, were ideal transmission chambers. Once tubercle bacilli are introduced to a community with such housing, a self-perpetuating system is set up. The transmission is so widespread that even the small percentage of infected people who ultimately develop the disease represent a large number in absolute terms; and the probability of an encounter between emitter and potential recipients is considerably increased.

The transmission of tubercle bacilli is, thus, greatly facilitated by certain specific characteristics of slum housing. The particular nature of this transmission process, however, is such that it can be easily interrupted without changes in the housing—namely, by exhaustive case-finding followed by self-administered drug therapy.

Before the primary health care system was introduced at Many Farms, the parents of a child with acute otitis understandably tended to try to "sweat it out" before embarking on the long trip necessary for obtaining care. Consequently, ruptured eardrums were commonplace. The advent of primary care would not be expected to alter the incidence of the initial (presumably viral) process, but it would be expected, through antimicrobial therapy, to reduce the incidence of the serious bacterial complication. Such a reduction occurred. Why it was not discernible before the fifth year of primary care is not clear. Possibly it resulted from the frequent practice of administering antimicrobial therapy for the undiagnosed febrile illnesses of children, thereby "curing" some cases of bacterial otitis before they had evolved sufficiently to be clinically recognizable. Such an effect could have been masked earlier by the fact that a substantial, but undefined, portion of the acute episodes were actually exacerbations of chronic otitis, rather than first attacks. With fewer new inputs, this backlog of chronic cases would gradually have grown smaller as the children grew older. The question merits further study because there is a real possibility that the otitis of children can be used as a key indicator of the availability of medical care (*21*).

Trachoma, like otitis and tuberculosis, is caused by a group of microbes that are suspectible to antimicrobial drugs. The beginning of the pathogenic chain could be considered as the multiplication of the trachoma agents in the lesion, which is located in and around the eyes. Theoretically, this pathogenic chain could be severed, as was done with tubercle bacilli, by suppressing the microbe in the lesion with drugs, thus preventing it from being discharged into the environment. Indeed, this was the procedure at Many Farms; but, unlike the situation with tubercle bacilli, the treatment of the active cases of trachoma had little impact on the problem. The reason the chemotherapeutic approach is inadequate is that the transmission of the agents appears to take place by way of the contaminated fingers of those afflicted—usually quite small children. Thus, before the ocular process is brought under final control, the children's fingers are continually contaminated. To decontaminate their fingers (and the communal towels and vessels) would have necessitated a permanent change in such household habits at Many Farms as hand and face washing, the use of soap, individual towels, and precautions in their handling. Experience gained after this study has indicated some promise for the chemotherapeutic approach, but only if it is carried out on everyone in the community simultaneously (*22*).

As in the case of trachoma, there was no reduction in the occurrence of the pneumonia-diarrhea complex, which remained as the single greatest cause of illness and death throughout the 5-year period. The grouping of the pneumonias and diarrheas of early life into a single complex has no biologic justification. Nevertheless, the practice is useful, not only because the two entities frequently occur together, with the pneumonia triggering the diarrhea, but because in every aspect, from genesis to therapy, the nature of the problems presented by these two conditions is essentially the same. The critical feature of the complex is that the syndrome is endemic in the unsanitary home environment; thus recovery from one episode does not mean that another may not occur. It is not always realized that this complex is far and away the single greatest cause of death in economically underdeveloped societies.

The diarrhea, well named "weanling diarrhea" by Gordon and his associates (*23*), has a nutritional component, the precise role of which is unclear. It is definite, however, that, while antimicrobial therapy may be helpful in some instances, it does not predictably and decisively alter the disease. Likewise, acute disease of the respiratory tract (including what has to be rather loosely termed "pneumonia") in this primarily infant age group is caused, in well over 90 percent of the cases, by agents other than the pathogenic bacteria known to be susceptible to the antimicrobial drugs (*24*). Thus, this major portion of the total technological substrate, or potential target of the biomedical technology available for delivery at Many Farms, was largely beyond the capability of that technology to influence in a decisive way.

The sequence of events that make the home environment so hazardous to the infant has been discussed elsewhere (*25*). The remarkable self-correcting mechanisms that maintain physiologic stability at other ages are just in the process of being developed in early infancy, and in primitive home conditions the microbial challenge is virtually constant. In contrast, given the sanitary barriers provided by modern housing managed by educated parents, it is possible both to spread out many of these microbial challenges throughout childhood and adolescence and to artificially substitute warmth special feeding, and fluid and electrolytes for the imperfect homeostasis when the infant is ill. Measures such as these form an essential part of the deliverable technology of modern pediatrics. This technology is hardly deliverable in a house without central heating or insulation against freezing temperatures, with no running water or even a nearby well, and with several other

quite young children requiring the attention of a mother who had only a few grades of primary school education a decade or so ago.

The unique character of the relationship between the infant and its home environment may be seen from the observation at Many Farms that preschool children living in the same homes might fall ill, but fatal illness was extremely rare. In societies with a lower level of health, this phenomenon is less readily perceived because of the continued operation of factors (notably an inadequate supply of protein) that keep both the infant and the preschool child at risk of fatal illness. For example, in Peru in 1968, it was reported that 50 of every 100 deaths occurred in children under age 5, but that only 30 of these 50 deaths occurred during the first year of life (*26*). This contrast between the infant and the 2- or 3-year-old child living in the same sanitarily unprotected home environment merely underlines a highly significant fact: the effectiveness of contemporary medical technologies is far more dependent on the socioeconomic circumstances of the recipient in the case of the infant than it is in the case of older children.

Thus, the delivery of this carefully organized and well-received primary health care system to the Many Farms–Rough Rock community had relatively little influence on disease there. When both the diseases and the demographic profile of Many Farms are examined together, the reason that the accomplishments were only modest becomes evident: it was the nature of the substrate (the particular diseases present in the living and the ages of those afflicted). The high fertility ensured that infants would comprise the major portion of the people that were sick at any one time, and modern medical technology has relatively little to offer infants who are located in an unprotected home environment. It should not be inferred that no attempts were made to change household practices. On the contrary, a variety of programs were conducted for that purpose, and considerable effort was expended in the instruction of mothers in the home. The influence of such programs was sharply limited, however, in the absence of any significant change in the physical environment of the home. The two conditions that did not require changes in household practices for their control—otitis media and the transfer of tubercle bacilli—were significantly influenced, whereas the two that did require such changes were not.

In using the concept of the substrate, emphasis is placed on "disease in the living," because causes of death are imperfect indicators of where medical effort must be expended on a day-to-day basis. The substrate determines the limits of biomedical technology in a community; it also determines how the physician must allocate his time. When a health care system is based on a geographically defined community, it is locked into a situation in which there is no "give" in the matching of technological capability to substrate. Not only was the physician's technology for infants severely compromised at Many Farms, but his technology for the adult population was also limited—because of the population's proportionately smaller size, its relative youth, and certain attributes of rural living (*4*). With the demographic mix of Many Farms, any enlargement of medical coverage to bring in more adults would also have brought in more children in the same high ratio, and there were already enough young children to occupy the major portion of a physician's effort. The mismatches of technology to substrate that occur when a physician's services are allocated on a geographical basis can be managed when a group of physicians with different skills are available. In a rural, economically underdeveloped society, however, such options are not available, and the mismatch causes a waste of precious assets.

Two questions arise: (i) If the technology was of such relatively limited effectiveness at Many Farms, why wasn't the infant mortality much higher, for example, 150 or more?, and (ii) why was the mortality among preschool children concentrated within the first year of life rather than within the first 4 years, as it is in so many other economically underdeveloped areas of the world? The available information simply does not permit of definite answers to these two questions. Nevertheless, it is fairly certain (despite the poor quality of the vital statistics) that in the two decades prior to the study, decades in which there were no significant field health services, the overall Navajo infant mortality had been steadily falling from around 150 to around 85 per 100 live births (*17*). The principal identifiable change in that period is the improved services in the six hospitals that are distributed over the 23,000-square-mile area. In addition, an effective technology, available only in the hospital environment, did exist for important segments of the infant disease pattern. Thus, some potentially effective medical care existed; although it was relatively accessible to some people, it was as far away as 100 miles from others. In much the same way, the low mortality at Many Farms in the second and third years may, to some extent, have been an otherwise unmeasurable result of the primary health service that was innovated there, especially because that service could get the patients into slightly better condition before they were transported to the hospitals (*16*). A generally low mortality in the preschool group was present before the start of the primary health service, however. It is believed that most health professionals with field experience would attribute that low mortality primarily to the fact that the food supply of the community, including the supply of animal protein, appeared to be adequate.

Indeed, a whole combination of circumstances, fortuitous in part, created a situation at Many Farms such that many key health factors could be isolated almost as so many experimental variables, thus permitting inferences concerning the other factors. To a considerable degree, therefore, the situation at Many Farms, in terms of health development planning, was analogous to an "experiment of Nature."

The constant was the presence of unschooled families, with a crude birth rate of 45.8, crowded together in unsanitary premises and grouped in small foci that were scattered over a vast, semiarid land. The observed results could be regarded as characterizing the disease problems that would remain in a rural economically underdeveloped community with unimproved housing *after* there had been introduced (i) an adequate supply of food, including high-quality protein; (ii) control of all protozoan and helminthic diseases such as malaria or hookworm; (iii) a protected water supply at some distance from the home; (iv) effective prevention of cigarette smoking and chemical contamination of the air; (v) community hospital facilities 55 and 90 miles away; and (vi) a system of primary medical care, with a clinical physician, nurses, and indigenous health care workers in residence.

The observed result of "what re-

mained" was an extraordinarily youthful community (median age 15), increasing at an annual rate of 4 percent, with a health status characterized by (i) an infant mortality three times the U.S. average, with the infant deaths representing one-half of all deaths and with other childhood deaths extremely rare; (ii) most noninfant deaths postponed until middle or old age; and (iii) the hemorrhagic complications of pregnancy and the results of trauma representing the principal health problems up to age 45. Once past the first birthday, the individual's prospects for continued health were quite good.

On an ascending scale from the primitive to the modern, the Many Farms pattern of community health is at a relatively high stage. In attaining this stage, the institution of a clinical physician system of primary health care in the community played some role, but clearly not a major one. An analysis of each of the measurable accomplishments of the innovation reveals that these accomplishments could also have been made through a system that did not have a physician to render individual medical care. Such positive achievements as blocking the transmission of tubercle bacilli, reducing otitis media, or starting antishock measures for hemorrhaging patients on the way to the hospital represented activities that did not actually require the presence of a physician. To be sure, the establishment of a medical scan for the community (identifying those individuals who need hospitalization) was presumably more discriminating when conducted by the physician, but the great bulk of patients referred to hospitals were in such obviously acute conditions that they would inevitably have been brought to the hospital, either through nurse referral or patient or family action.

Thus, for Many Farms, a clinical physician system of primary health care was a poor choice, in terms of potential achievement through technology. Some form of the nonclinical or community medicine system, in which the physician did not care for individual patients, would have been more rational. Such a course would be a realistic option for development planners in areas of the world where there are very few physicians and where the economic-ecological situation is such that the attainment of the Many Farms community health pattern would be a tremendous achievement. It must be recognized that, at the Many Farms stage, the community's health would not impede its socioeconomic development; for example, programs to limit family size could be introduced with a reasonable prospect of continued success. However, to attempt to employ a health care system without a clinical physician in a society such as ours, in which physicians are numerous, although not plentiful, would be quite another matter.

It should be emphasized that everyone who participated in the choice of the system introduced at Many Farms was knowledgeable about Navajo health, as seen in the hospitals, and had a store of "conventional wisdom" about it, virtually all of which turned out to be true. All of them were fully confident that the system selected would have a major beneficial impact on the health status of the people. What was not perceived in advance was (i) the extent to which the serious, technologically vulnerable conditions were already being treated in the hospitals outside the community, and (ii) just how much the demographic-disease pattern was skewed toward the diseases of infancy, which are dependent on conditions in the home. In short, the "conventional wisdom" lacked the quantitation essential for such a choice.

Although this article is concerned with technological performance, it should be noted that, in terms of individual and community expectations, the Many Farms experiment was a clear-cut success. The system was set up with full community participation, and there was a mechanism for effective, continued community control. Members of the community repeatedly expressed their satisfaction with the care they received, and the community was left with an operating system. Moreover, it can be safely predicted that, faced with a similar choice today, the community would opt for what was actually introduced there, rather than for a system with a much better technological "fit," if the latter meant no physician in continued residence. And this, the other side of the coin, is wholly understandable.

Popular expectations and misunderstandings of what an individual physician can do operate as a formidable constraint on the rational use of biomedical technology. Indeed, because of the nature of medicine, as a practical matter its technology has to be deployed irrationally. This is largely the consequence of our tradition of having both essentials of medical care—the technology and the human support—administered by the same person, the physician. As a result, the limits on the number of people to whom the physician can offer human support by way of personalized care also largely determine the people to whom he can deliver the technology. Yet important elements of that technology might be more widely useful if applied in some other way.

Thus one of the two essential parts of medicine can act as a significant constraint on the other. This is forming an issue with large implications; clearly, a systematic analysis of both essentials and of who would make their most effective ministers is in order. Yet who can measure the value obtained by those Many Farms parents who could see obviously expert professionals hovering over their child, desperately ill with pneumonia caused by respiratory syncytial virus? They see someone making a fight. To point out that, in the particular circumstances, the penicillin the child is receiving happens to be valueless, in a technological sense, would seem a petty, if not callous, irrelevancy.

References and Notes

1. Primary health care is readily accessible and continuously available health care that is delivered to an individual and is frequently expressed in terms of a defined population.
2. J. Adair and K. Deuschle, *The People's Health: Anthropology and Medicine in a Navajo Community* (Appleton-Century-Crofts, New York, 1970).
3. J. G. French, *Amer. J. Clin. Nutr.* **20**, 375 (1967).
4. D. L. Rabin, C. R. Barnett, W. D. Arnold, R. H. Freiberger, G. Brooks, *Amer. J. Public Health* **55** (Suppl.), part 2, 1 (1965).
5. H. S. Fulmer and R. W. Roberts, *Ann. Intern. Med.* **59**, 740 (1963).
6. A. R. Omran and K. Deuschle, *Amer. Rev. Resp. Dis.* **91**, 215 (1965).
7. K. Deuschle, *Public Health Rep.* **78**, 461 (1963); J. Adair, *Hum. Organ.* (spring-winter, 1960–61), p. 19; B. Loughlin, R. Dennison, E. Mansell, H. Fulmer, *A Syllabus for Teachers in Navajo Health* (Navajo Tribal Council, Window Rock, Ariz., 1960); E. Mansell and B. Loughlin, *Pract. Nurs.* **8**, 13 (1968); B. Loughlin and E. Mansell, *Nurs. Times* (30 January 1950), p. 135; A. D. Wauneka, *Amer. J. Nurs.* **62**, 88 (1962).
8. W. Parker and A. Bearn, *Science* **134**, 106 (1961).
9. H. Landar, in *Studies in Southwestern Ethnolinguistics* (Mouton, The Hague, 1967), p. 117; ———, S. M. Ervin, A. E. Horowitz, *Language* **36**, 368 (1960); H. Landar, *Amer. Anthropol.* **64**, 985 (1962).
10. This is not to say that the desire to develop knowledge of benefit to others was unimportant as a motivating force. On the contrary, the tribal leaders repeatedly expressed their pride in the fact that a study supported by them, and of immediate benefit to only a small portion of their people, would ultimately benefit not only the remainder of the Navajo people, but people elsewhere in the world.

11. W. McDermott, K. Deuschle, J. Adair, H. Fulmer, B. Loughlin, *Science* **131**, 197 (1960).
12. T. Sasaki and H. Basehart, *Hum. Organ.* (winter, 1961–62), p. 201.
13. O. Lewis, *Sci. Amer.* **215**, 19 (1966).
14. J. Adair, K. Deuschle, W. McDermott, *Ann. Amer. Acad. Polit. Soc. Sci.* **311**, 80 (1957).
15. J. B. Cochran, C. Clayson, B. Fletcher, *Brit. Med. J.* **2**, 185 (1957).
16. To be sure, there were individual instances of a child or an adult with a technologically curable bacterial meningitis (nine meningitis cases with three deaths) or an adult with a bacterial pneumonia. All such cases taken together, however, represent a very small group because of the size and demographic characteristics of the population and would have been treated in hospital in any case.
17. R. W. Young, Ed., *Navajo Yearbook*, Rept. No. 8 (Navajo Agency, Window Rock, Ariz., 1961).
18. The higher rate for 1957 is attributable to five deaths from influenza in November of that year.
19. J. V. Young, *New York Times*, 23 June 1968, section 10, p. 1; *Time*, 11 April 1969, p. 67.
20. R. L. Riley, C. C. Mills, W. Nyka, N. Weinstock, P. Storey, L. Sultan, M. Riley, W. Wells, *Amer. J. Hyg.* **70**, 185 (1959); T. V. Hyge, *Acta Tuberc. Scand.* **20–21**, 1 (1946–47).
21. The possible use of otitis media as an "indicator" disease by which to measure the availability and effectiveness of health services in various socioeconomic groups is under study by the National Academy of Sciences Institute of Medicine, David Kessner, study director.
22. G. L. Portney and I. Hoshiwara, *Analysis of Prevalence of Trachoma* (Health Programs Systems Center, Tucson, Ariz., 1969).
23. J. E. Gordon, I. D. Chitkara, J. B. Wyon, *Amer. J. Med. Sci.* **245**, 345 (1963).
24. L. L. Coriell, *Med. Clin. N. Amer.* **51**, 819 (1967).
25. W. McDermott, *J. Med. Educ.* **41**, 137 (1966).
26. *New York Times*, 20 August 1969.
27. The Navajo–Cornell Field Health Research Project was conducted by the Department of Public Health, New York Hospital–Cornell University Medical Center, New York. It received financial support from the Navajo Tribe; the Division of Indian Health; research grant RG-5209, Division of General Medical Sciences, National Institutes of Health, United States Public Health Service; the Russell Sage Foundation; and the Max C. Fleischmann Foundation.

Technological "Shortcuts" to Social Change

Can major segments of contemporary social problems be handled efficiently by technology?

Amitai Etzioni and Richard Remp

The idea that technological developments might be used to reduce the costs and pains entailed in dealing with social problems is appealing. A broad rationale for this approach is suggested by an analogy between the development of modern techniques of producing consumer goods and the search for new techniques of providing social services. Mass production and considerable reductions in cost per unit of consumer goods were achieved by an increased reliance on machines (broadly conceived to include communications satellites and computers) and a decreased reliance on muscle and brainpower, on persons. However, up to now in social services, in which performance is frequently criticized for falling far below desirable levels, most work has been unmechanized. Since the need for services in these areas is great, available resources low, and trained manpower in short supply, it seems useful to consider replacing the "human touch," at least in part, by new technologies (*1*).

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A Methodological Note

To explore this question, we reviewed existing studies that evaluate the effectiveness of technological shortcuts in dealing with six distinct social problems (*2*). The term "technology" is construed here to apply to biological and physiological processes, as well as physical processes. This is in accord with R. S. Merrill's use of the term (*3*): "the concept of technology centers on processes that are primarily biological and physical rather than psychological or social processes." "Hard," or physical, technologies are emphasized rather than "soft," or social-psychological, technologies because the shortcuts in question derive their efficiency not from the reorganization, but from the replacement of human services in the handling of social problems.

The technologies and problem areas selected were methadone in controlling heroin addiction; instructional television (ITV) in teaching; Antabuse (disulfiram) in treating alcoholics; gun control in reducing crime; the breath analyzer in highway safety; and the intrauterine device (IUD) in birth control. These technological innovations may be viewed as shortcuts because they either serve as a replacement for manpower (for example, the use of ITV instead of teachers) or they reduce the need for manpower (for example, methadone reduces the need for therapists, social workers, and guards in the treatment of heroin addiction).

The findings reported here are, of course, affected by the developmental status of the technologies studied. If we had selected technologies that were already in routine use, our findings might have been more optimistic. However, few of the technologies routinely used in the human services area aim at the core of the problem (although there are various auxiliary instruments—for example, teaching aids). We focused on procedures that would fundamentally affect the service in question. As a consequence, technologies still in various experimental stages were studied. Technologies other than the six reported were surveyed, although less intensively (such as the use of computers for instruction and cable television for conducting town hall–like dialogues); they do not differ significantly from those selected, from the viewpoint of the issues at hand.

The Main Findings

To the degree that the data permit us to conclude, each of the six technologies "works," in that it allows the