ECOLOGIC DETERMINANTS OF POPULATION GROWTH[1]

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DEATH rates always have tended to fall more promptly than birth rates in response to an improved environment. This holds whether the changes are incident to the modern industrial and sanitary revolution or in groups making the transition from nomadic to agricultural life. Vance (21) has named the disparity between birth and death rates the "demographic gap." As long as it exists a population increases in numbers.

Many biological and social forces act to keep a society alive, through protecting its members from death by disease, by violence, or by lack of essentials such as food. Modern public health procedures have the capacity to lower the death rate of almost any country from an uncontrolled rate of more than 30 per 1,000 to less than 10 per 1,000 (16).

By contrast, birth rates change slowly. Most cultures have a well established tradition favoring large families because of the need to balance losses from wars, famines, and especially communicable diseases. Success in reducing the death rate produces no immediate change in cultural patterns producing a high birth rate, especially where high fertility is endorsed by religion. A slow spontaneous reduction in numbers of births has often been advantageous to developing urbanization and

[1] From the Department of Epidemiology, Harvard School of Public Health, Boston, Massachusetts. This essay is a revised version of a memorandum originally commissioned by the Committee on Preventive Medicine and Social Science Research. The Committee has been established by the Social Science Research Council to define and develop areas of mutual interest to public health and social science. The Committee and the writers recognize that efforts to limit population represent only one of many possible approaches to the complex problem of improving the balance between population, health, and means of subsistence in certain regions of the world. Following the Committee's request, the authors have addressed the problem of studying fertility dynamics with special attention to particular regions familiar to them. Within this limitation the writers have developed their topic as they saw fit.

industrialization because the demographic gap produced extra people to populate the cities and man the new industries.

Economic development tends to stimulate population growth and to raise the standard of living. If the population side of the equation pushes ahead there is similar pressure to increase economic production. In the process a lag is common, and severe shortages in goods and in necessities of life may occur. To establish a workable equilibrium spontaneous cultural changes take place, with reduction of birth rates being a usual outcome. In Ireland the population increased so rapidly in the eighteenth and early nineteenth centuries that the country was highly vulnerable to famine when potato blight struck. Fragmentation of family land holdings contributed to the precarious state of the national economy. Large scale emigration gave temporary relief. Birth rates declined because of compensating cultural changes which delayed the marriage of women until about the age of thirty years, while those never marrying increased to almost 30 per cent. (14) (17) Cultural groups in other countries have accepted various methods of family planning. In particular situations, drastic procedures have been practiced such as abortion in Japan during recent years. (20)

The ultimate decision to limit family size rests with parents. Families are usually responsive to the economic and social influences which determine the capacity of a society to accommodate greater or fewer numbers of children. Within the limits of their psychological and social needs, parents ordinarily will wish to have the number of children they can properly care for. Modern medical science makes it possible for parents to determine with some assurance the number of children they are going to have and when they will be born. The objective is a pattern of fertility more nearly in accord with the needs and capacity of current social and economic conditions, than that dictated by a cultural tradition of past generations.

In many countries the carrying capacity of the local economy

is sufficient to sustain a reasonable population growth. In more than half of the world, however, social need requires attention to the numbers of children added to the population, and to the spacing within families that they may receive proper care. (8)

Sciences Concerned with Population Dynamics

A number of scientific disciplines contribute actively to knowledge of fertility. Population growth can be studied at three levels; in the laboratory, or clinically in respect to the individual person, or with the community or population under natural conditions in the field. Laboratory workers include biologists, physiologists, biochemists, and pharmacologists. Clinical study of the individual is variously by obstetricians, psychiatrists, endocrinologists, and others. At the group or population level are demographers, sociologists, anthropologists, economists, and public health workers. An understanding of the functions of the several disciplines contributes to coordinated effort.

Biologists, Physiologists, and Pharmacologists. The complexity of the population problem commonly requires that specific questions be taken to the laboratory to reduce the number of variables. Much has been learned there about the physiology of reproduction. Fundamental sexual functions, the factors which influence conception, and those that determine the outcome of pregnancy have had attention.

The principles of human reproduction are sufficiently defined to provide measures for increasing or decreasing chances of conception. Until recently, attempts to avoid pregnancy were directed mainly toward preventing the sperm by local or mechanical methods from reaching the ovum. Newer studies (15) suggest the usefulness of preparations which modify ovulation or disturb the endocrine balance governing successful implantation of the ovum in the uterine mucosa. The methods are not sufficiently established to warrant general use.

Clinical Approach. A sharp distinction between laboratory

and clinical approaches cannot be made because clinical investigation these days commonly includes laboratory techniques. Many basic questions related to menstruation, ovulation, conception, sterility, and the diseases and physiologic states which modify fertility can be studied to advantage with clinic patients. Endocrinological influences and their fluctuations often are best observed in individuals who show aberrations. Furthermore, the biological effectiveness of contraceptive methods desirably is tested first by laboratory methods and then by clinical trial before field studies are considered.

From the standpoint of service and of medical care, clinics have had their greatest usefulness in meeting the needs of urban populations, especially in Western countries; they have had limited application in rural populations.

Preoccupation with contraception should not cloud the opposite problem of helping mothers who want children but have difficulty in conceiving. Research on sterility is largely clinical, but also a function of laboratory investigation. Fruitful study is also directed toward pregnancy wastage and fetal development.

Demography. The major contribution of demography is in tracing fluctuations in population growth and decline, and in defining the principles concerned. Mainly a descriptive science, it has developed sound statistical procedures for projecting population trends.

Demography has given special attention to environmental factors responsible for changes in birth and death rates. It has established correlations between fall in birth rates and such factors as urbanization, education, desire to retain land holdings in agricultural societies, and desire for modern facilities, such as automobiles and better education of children.

Social Sciences and Economics. Although once primarily descriptive, these disciplines are concerned increasingly with attempts to produce changes in social structure, sometimes termed social engineering. The difficulties are great because in a democratic society groups often react in unpredictable and

uncontrolled fashion. Advertising can induce people to switch to a new brand of toothpaste, but to influence a young couple in their decision of whether to buy a car or have a baby is more difficult. An Asiatic country can stimulate urbanization by building factories in cities to attract village people, but the total shift in rural-urban population, with some notable exceptions, is commonly small and slow.

Populations grow as social and economic conditions improve. The demographic gap that comes almost invariably as death rates start to fall, even with prompt efforts to reduce birth rates, is usually sufficient to permit a sizable population increase. As a consequence much of the benefit from agricultural and industrial expansion is neutralized in caring for the added numbers. (8)

Public Health Approach. Epidemiology is the diagnostic discipline of public health. Public Health Practice (5) is the discipline responsible for applying the principles and techniques developed by epidemiology. Often defined as medical ecology (4), epidemiology is thus a part of human ecology, a science specifically concerned with interaction between a population and its environment. One of the earliest interests of plant and animal ecologists was the matter of numbers. It is thus particularly appropriate that epidemiological methods be turned to population dynamics. (6)

Public health has been blamed for the population problem through "irresponsible" lowering of death rates. (22) Public health workers in turn are increasingly aware of the ways in which population pressures are influencing the health of the public. In countries such as Japan and India an attempt to lower the birth rates is recognized as an obligation of public health, using the community approach so effective in lowering death rates. The work of private doctors and birth control clinics with individual patients and the encouragement of changes in social conditions such as urbanization and education are other parts of a general program.

Clinics and private practitioners have contributed appreci-

ably to family planning in Western countries, because medical services are available to enough of the population to have an overall effect. Countries such as India have little prospect, within a reasonable time, of reaching the bulk of the population through existing or projected clinic programs. Family planning clinics may have a contribution to make in the cities, but there are not enough doctors and nurses to reach the 85 per cent of the population living in the villages. Where protection of the individual is the immediate consideration, methods giving maximum protection often are applicable even though expensive and bothersome to the person concerned. This holds whether the problem is protection against communicable disease or this question of too many people.

In public health, the objective is satisfactory service for a whole population rather than high grade service to a few. The technical method selected may be a procedure somewhat less effective than that used clinically, but better suited to general use because of cost or safety. Economic feasibility and social acceptability must be balanced against biological efficiency.

The methods of social engineering do not appear to provide the immediate answer in countries such as India. The social sciences have demonstrated the influence of spontaneously altered social forces on population numbers, but to induce these changes where communications are poor and political control is limited is decidedly difficult. A primary consideration is the spread of information about contraceptive methods. Without direction, such information tends to spread by hidden routes and not always reliably. Urbanization, education, and other social changes favor more rapid spread because people get together more, read more, and talk more. Supply lines are also better. A public health approach brings discussion of contraceptive methods into the open and provides for direct communication between experts and the public about preferences, needs and the practicability of procedures.

Health problems, such as the venereal diseases, alcoholism, and mental illness, are being included increasingly among re-

sponsibilities of official public health agencies. All have an important social component along with problems of morals, ethics and religious beliefs. The practicing physican has long been concerned with these problems in individual patients. Neither the social, clinical, or public health approach by itself has been able to meet these problems; together they can more effectively fulfill the community need.

The Epidemiologic Method in Study of Population Dynamics. Epidemiology today is concerned with all health problems of a population. The original concern with communicable diseases largely had to do with dramatic epidemics. Events were surveyed, recorded, and analyzed in terms of time, place, and person; data on host and environmental relationships were collected and evaluated; the balancing of multiple factors became the standard approach to causality. Eventually epidemiologic methods had wider application in the study of infections as they occurred under ordinary circumstances and as persisting problems of a community. As the communicable diseases came under control these same techniques were applied to noncommunicable conditions, starting with the deficiency diseases of pellagra, scurvy, and endemic goiter. The present range of interest includes diabetes, heart disease, cancer, mental illness, accidents, and many others.

In recent years epidemiology has extended its interests to considerations of health. Fluctuations in health are not due solely to an absence of disease. Growth and development, adequate nutrition, a proper functioning and use of body parts, together with the related mental adjustment, are recognized as parts of personal hygiene. Physiologic fluctuations in health incident to the cyclic changes accompanying menstruation have had attention from clinicians, but not from epidemiologists. Pregnancy is clearly a normal physiologic state and as a mass phenomenon has an important part in an epidemiology of health. The frequency, variations, complications, and end results of pregnancy as they affect groups of people are basic to an epidemiological study of human reproduction.

The standard epidemiological approach to health and disease as they affect populations of people is to gather information on contributing factors relating to the host population and to the environment. The attempt then is to demonstrate correlations bearing on causality. Remedy rests in specific measures directed toward identified and significant factors. Possible factors in fertility of populations are now considered.

Host Factors

Genetic Factors. The differences in fertility between races and among families can be studied to determine if a tendency to large families is an inherited characteristic. This factor is particularly difficult to isolate from cultural patterns which appear to be the stronger determinant.

Physiological Factors. The cyclic changes associated with menstruation bring multiple changes in endocrine balance. Ovulation, preparation of the uterus for reception of the ovum, and such apparently minor matters as changes in consistency of mucus of the uterine cervix (1) have been shown to be important factors in successful fertilization and conception. Improved methods for contraception require better understanding of reproductive physiology. (9) (13)

The biological fact that a woman is only susceptible to fertilization during a few days each month has the same practical significance as if resistance to infection lapsed for a similar period. Calculations of probability of pregnancy, and conversely of protection from pregnancy, should be based on this limited chance each month of becoming pregnant. Field studies to provide more information on menstrual cycles and the factors which influence ovulation are clearly needed. The rhythm method of birth control depends on the regularity of menstruation under normal conditions. One irregular period or ovulation a year conceivably could neutralize careful calculations and assiduous self-control.

Psychologic Factors. A possible relation between psychological state and fertility has engendered many speculations,

one of which is that a good way for a sterile couple to have a baby of their own is first to adopt one. The basic sexual drive, however, is highly overlaid and modified by complicated motivations of cultural origin.

Environmental Factors

Physical Environment. Physical environment is not known to directly affect fertility. Some evidence (10) suggests that age at onset of menstruation varies with climate although other factors such as nutrition have not been controlled. Fertility is said to be low among American Indian tribes living high in the Andes. (11)

Climate appears to affect fertility indirectly through influence on sleeping habits. During the hot summer weather in the Punjab, women commonly sleep on the roofs where there is little privacy if the husband is at home; often he sleeps in the fields to guard his grain. During winter months husband and wife sleep together under covers inside the house. Birth rates rise consistently in the autumn months.

Biologic Environment. Certain diseases, especially the venereal infections, produce pathological changes which decrease chances of conception. Gonorrhea is an important cause of sterility in women by causing salpingitis and cervicitis, with the added probability that purulent discharges in the vagina are spermicidal. The male suffers the acute effects of urethritis and the chronic effects of orchitis and epididymitis. Syphilis limits successful pregnancies by causing abortion and miscarriage, as do malaria and other major febrile illnesses. Fibrosis of the testicles is common in advanced stages of leprosy. Recent work on congenital anomalies proves that viruses are a hazard to the developing fetus. (7) Communicable disease control therefore contributes to population growth more subtly than through the generally recognized reduction of death rates: birth rates which would otherwise start a downward trend may be kept up or actually increase.

DeCastro (3) and his theories to the contrary, no evidence

supports the assertion that starvation and malnutrition increase fertility. The correlations advanced between high fertility and low protein diet are better explained by social and cultural differences. (8) People with poor diets also tend to have low standards of living and education, factors directly correlated with high fertility. On the other hand, clinicians who specialize in sterility believe that obesity tends to reduce fertility. Optimal nutritional state probably is conducive to fertility to the extent that it promotes general physiological function.

The folklore and empirical medical practice of many cultures give bits of information on various plant products of presumed contraceptive action. Sanyal's extract of garden peas (18) is an example of several preparations being tested in India and elsewhere.

Social Environment. Factors of the social environment are interwoven with those of the physical and biological environment, in general accord with ecologic principle. Of themselves they warrant major attention, if for no other reason than that they are less well defined.

Considerable information has been gathered by anthropologists on the fertility patterns of small and isolated tribal groups. Studies of large general populations are particularly needed, with appropriate attention to social groupings within the population and their varying beliefs and attitudes.

Ideas about the mechanisms involved in conception and birth vary greatly from one society to another. In the Punjab, the relationship between menstruation and pregnancy is described in analogy between the uterus and a field. Each month the fallow uterus receives the necessary products for the development of a fetus. If not used, the accumulated wastes are discharged during menstruation, with the uterus left like a plowed field waiting for seed. After menstruation the cervix is thought to remain open for a week or more and then gradually to close. The greatest chance of pregnancy is believed to be immediately after menstruation. A practice of rhythm

method of birth control was based on these ideas. Scientifically correct presentation of the physiology of reproduction challenged these beliefs and jeopardized the relations between the health workers and the people. A common reaction was that the health workers knew little of the "real facts of life."

Semen occupies an important place in the Indian value system, for it is considered the most precious fluid of the body, each drop representing a distillate of one hundred drops of blood and thus a high concentration of the vital forces of man. It should be conserved to maintain health and strength; thus an athlete abstains from intercourse. Urethritis and vaginitis are much feared because they represent a constant drain of the vital force. Communication with village people on family limitation and the contraceptive methods best suited to their cultural pattern would be inhibited by failure to appreciate these beliefs.

In most cultures babies are born ordinarily to married couples, and marriage signals the start of reproductive life. Age at marriage therefore influences the length of time a woman is exposed to pregnancy. However, an increase in minimum age at marriage does not necessarily result in a lower birth rate. Observations from the Punjab suggest that women who marry between the ages of 18–24 years actually have more children than women married at ages 14–18 years. In Ireland (17) delayed marriage of women has contributed significantly to lower birth rates, but only after the average age increased to about 30 years.

Cultural patterns also act in determining the number of women who remain unmarried. The range is from less than 10 per cent of women of marriageable age in India to more than 30 per cent in Ireland. The number who remain single after widowhood or divorce is another important variable.

Frequency of intercourse has an obvious bearing on the likelihood of pregnancy, for short intervals increase the chance of intercourse at the time of ovulation. In Puerto Rico (19) a man likes to have many children to show his prowess, while in

most of India it is considered desirable to conserve semen. The different fertility patterns among groups practicing polygamy, polyandry, monogamy, and modified celibacy are not known. Muhsam (12) reports that polygamous marriages among the Bedouins produced fewer children per married woman than did single marriage, although he recognized infertility of a wife as one of the reasons for polygamy.

The frequency of extramarital births varies greatly among different cultures. Puritanical cultures presumably have a high proportion of births within the family. The casual attitude in other cultures is typified by the Jamaican maid in Panama who once told us she was "making a baby for a friend." A third cultural pattern permits more sexual freedom to men than to women, an attitude often lending a tinge of immorality to use of contraceptives.

Most cultures place a high value on children and their proper rearing. High mortality rates in childhood favor keeping the number of births up to compensate for expected losses. It is part of national policy of some governments to encourage deliberately large families in order to increase manpower.

Some religions have firmly established tenets against contraception. This may be no more than a general policy that each family should have as many children as possible in order to increase the number of believers. A few religious groups have specific doctrinal prohibition of certain types of contraceptives. Others completely endorse contraception in family planning. The Lingayats, a subgroup of Hinduism in South India and numerous other cultures have prescribed religious rituals attached to sexual practices.

Under pressure of population increase, India and Japan have set up government programs to foster family planning. Voluntary health agencies are active in many countries. Newspaper and other propaganda for family planning are exerting a noticeable effect on popular attitudes.

The success of family planning programs depends a good deal on who makes the family decisions. In cultures where the hus-

band is the acknowledged authority, a lack of communication between the married couple may make it difficult for the wife even to express opinions. The usual pattern is for decision to be made jointly by husband and wife; under such conditions a family planning program must reach both.

The introduction of new practices in as intimate a matter as sex requires caution and a sensitive understanding of the attitudes of people. Mass advertising may produce resentment among conservative members of a community, thereby blocking accomplishment. Practices generally are easier to change than beliefs, which emphasizes the value of presenting a new practice in terms of established cultural concepts. This principle is recognized in health education as "starting where the people are." Experience in health education as applied to the population problem leads to the conclusion that family planning is developed most readily and unobtrusively as a part of a general health program.

The view is commonly held that limitation of family size through family planning leads to improved social and economic conditions. This assumption often is offered in justification of family planning, and of itself appears reasonable. Proof, however, is lacking, and indeed difficult to obtain because of other factors recognizably active. Long term studies of population control seemingly provide opportunity to acquire solid information, but first more precise methods of measuring economic and social change will have to be made available. The effect may well differ in agrarian and industrialized communities.

A more specific problem is the cost to the community of children who die before they are economically productive. Such deaths are frequent in countries with high birth and death rates which are just entering a phase of economic development. Another sort of economic problem rests in the increased proportion of children in the nonproductive age groups during a surge of population growth; sometimes the 1–15 age group includes more than half the population. This can be

expected where deaths decline sharply in response to modern health measures.

Field Trials of Methods of Contraception

Well over a half of the world population is found in countries with large populations, an agrarian economy and such density of inhabitants that increased food production is problematical. These countries are engaged in programs of industrial, economic, and agricultural development designed to produce resources sufficient for more people, and for better care of them. Production must forge ahead of reproduction if national development is to follow.

Death rates in Japan and Ceylon declined after World War II, from over 20 per thousand to about 10 per thousand, largely because of improved public health practices. The numbers of people in these countries have increased alarmingly. Where the demographic gap is large, a reduction of birth rates in this decade by even a few points will have a greater long term value than a much greater decrease 10 or 20 years from now, because of the geometrical progression in rate of population increase. (2)

The practical need is to use presently available methods and materials in nationwide family planning rather than to wait for better methods presumably to be had from future research. Whether or not existing methods will produce a gainful result is to be determined by field trials applied to general populations in countries such as India. This is a research problem to which the methods of epidemiology are particularly suited. Social and cultural factors enter into success of such programs and need to be evaluated along with biologic considerations. Such studies are a necessary prerequisite to administrative organization of a countrywide approach.

Acceptance. The first consideration is a contraceptive method acceptable to the people which fits their habits, beliefs, and facilities. A method that gives 90 per cent protection against pregnancy is of little value on a population basis if

only used by 10 per cent of the people; the net result is a 9 per cent decline in birth rates. A method only 50 per cent effective but used by 40 per cent of the people will give a 20 per cent decline. Statistical refinements aside, the broad general effect is obtained by multiplying biological efficiency by acceptance. Acceptance is therefore as important a consideration as biological efficiency in evaluating a contraceptive method. The conditions influencing acceptance are variously cultural, social, and administrative.

Field workers from the same culture as the population to be studied are of decided advantage in establishing rapport and understanding. Our experience leads to no general agreement on the qualifications of field workers who are to present family planning methods. Both men and women have been used. Trial has been made of health educators, social workers, public health nurses, and school teachers; of village level workers as used in the Indian Community Development Projects; and of intelligent persons provided with a brief training in village work and the specific problem but with no professional background. Single persons, married persons, and married couples have been employed. In general, older persons tend to generate more confidence and authority, particularly if they have children of their own. There are administrative advantages in having a married couple especially when workers are stationed permanently in a village. There are also disadvantages; rarely do the two have equal capabilities. In general the choice rests not so much on specific training as on aptitude which is hard to predict.

The innate characteristics of a contraceptive measure largely determine its acceptance. People are averse to something which is a nuisance, particularly under the circumstances where a contraceptive is used. People of the Punjab where we have worked commonly express a preference for oral methods, particularly a pill or tablet to be taken once a month or better every six months, or lacking that an injection. No such preparation is known. To take a pill once a day for the major part

of the intermenstrual period would doubtless prove too much trouble for the ordinary villager. That was the experience in programs of chemoprophylaxis against malaria in military practice, and in use of vitamins. Indian practitioners of Ayurvedic medicine advertise powerful pills and potions which are popular, but extravagant claims are common. One Vaidya said that one of his pills would prevent conception for a year, two taken together would prevent conception for two years and three would make a woman permanently sterile. Although most village people discount such claims, they are accustomed to think of and demand agents of dramatic effectiveness. It was also found that village women have difficulty in keeping track of dates for the rhythm method of contraception. A general desire for a preventive measure directly related to the act of intercourse favors vaginal methods. Some few prefer sterilization once the desired family is attained; others, especially in Japan, prefer to take the risk of pregnancy and then resort to abortion.

Even among the most primitive cultures esthetic requirements influence acceptability of a contraceptive method. With a choice available, decision is influenced by features well recognized by advertising experts such as neatness of package, ease in use, and absence of what might be termed messiness. These matters often outweigh the practical criteria of efficiency.

Village women do not have bathrooms with running water to permit douching in privacy. A practical problem is to find a place to store materials used. A classic story in India is of a family planning enthusiast who visited a home to find a child of the family using a diaphragm as a toy cup. One of our village women hid her contraceptive materials under a pile of peanuts.

A source of supply must be readily available, if materials are to be used widely and consistently by village people, and yet assure that they can be procured casually and in reasonable privacy. The means of distribution should reach even isolated communities.

Poverty is extreme in most areas where the population problem is greatest. A method must be sufficiently inexpensive for use by the poorest people. Even with government subsidy, costs are a consideration because of the numbers involved.

Methods used must be free from side effects; even mild local irritation leads to strenuous objection. Men particularly object to anything interferring with normal sexual intercourse.

Keeping qualities under adverse climatic conditions are an important consideration in the tropics. Rubber goods deteriorate from heat, and chemical products develop fungus growth or liquify because of the high humidity.

Biological Efficiency. Unless a product has demonstrated efficiency in interrupting conception there is no point in trying to get people to use it. No preventive measure is free from failures. Too many failures early in a program may discredit all methods, and undue numbers thereafter will have the expected result that people will not continue a method which clearly does not work.

The primary value of a method is determined under controlled laboratory conditions, mainly through ability to immobilize sperm and the lack of toxicity and other undesirable physical characteristics. The next step is to test the method clinically. Modifications in pregnancy rates of patients are observed and the safety of the method evaluated. A fair estimate of biological efficiency and some idea of acceptability is to be had. Test subjects ordinarily are not representative of the general population; clinic patients usually have more incentive to cooperate than do people from the general population.

The final test of efficiency and acceptance is through field trials under conditions typical of those where the method is to be used. People differ in the ease with which they learn to use a specific method. An initial reluctance or antipathy or plain lack of understanding commonly results in carelessness in following instructions. The simpler the method the better suited it is to public health use in family planning; there will be less error in application.

Summary

The increasing population resulting from the difference between rapidly declining death rates and more stable birth rates is a critical problem in large areas of the world today. Problems of human reproduction are complex and require study by a variety of disciplines. The epidemiologic method is suited to field research in population dynamics. The information from such studies may be expected to provide the facts necessary for operational programs of family planning which are logically a responsibility of official agencies of public health.

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