The Psychological Consequences of the Chernobyl Accident—Findings from the International Atomic Energy Agency Study

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Synopsis ....

In October 1989, more than 3 years after the nuclear power plant accident at Chenobyl, in the Ukraine, the Government of the Union of Soviet Socialist Republics requested that the International Atomic Energy Agency (IAEA) evaluate the medical and psychological health of residents living in areas identified as being contaminated with radioactive fallout. The IAEA designed and conducted a collaborative study to examine whether there were any measurable effects of exposure to the low levels of ionizing radiation resulting from the accident. The study, using structured interviews and IAEA laboratory equipment, collected data on more than 1,350 residents of 13 villages.

IAEA clinical staff members concluded that they could not identify any health disorders in either the contaminated or nearby (uncontaminated) control villages that could be attributed directly to radiation exposure. The clinical staff, however, did note that the levels of anxiety and stress of the villagers appeared to be disproportionate to the biological significance of the levels of IAEA-measured radioactive contamination.

Almost half the adults in all the villages were unsure if they had a radiation-related illness. More than 70 percent of persons in the contaminated villages wanted to move away, and approximately 83 percent believed that the government should relocate them. The IAEA effort indicates that the villagers need to be educated about their actual risks, and they need to understand what types of illnesses are, and are not, associated with exposure to radioactive contamination. Unfortunately, the villagers' needs may exceed the available resources of their local and central governments.

ALMOST 15 YEARS HAVE PASSED since the first major civilian nuclear power plant accident, at Three Mile Island (TMI), Pennsylvania in 1979, and almost 7 years have passed since the disaster at the nuclear power plant at Chernobyl, Ukraine, in 1986. Both accidents have had a clear and extensive impact on the communities located near these power plants as well as on the national and international communities.

While TMI is the prototypic model for understanding what happens to a community and a nation that must deal with the medical, social, and legal issues following an acute accident involving the potential for uncertain harm (*1-11*), Chernobyl is the prototypic model for understanding what happens to local communities, a nation, and the world community when there is actual and extensive harm from a nuclear power plant accident (*12-21*).

The fears of undetected or underreported damage and radioactive exposure among the Soviets, the Europeans, and others subjected to wind and rain borne radioactive contamination were extensive (*22-29*). Even more than at the time of TMI, the credibility of the Soviet government scientists and the politicians, and of their successors was, and continues to be, challenged by those who believe that they were directly and adversely affected. The psychological stresses associated with the TMI accident are well described (*30-39*) but, until recently, little has been written, at least in the available English or Western European literature, on the psychological stresses associated with the Chernobyl accident (*12-20,40-44*); abstracts are available (*45-49*) as well as presentations (*50-52*) and privately translated articles.

The International Atomic Energy Agency (IAEA), a United Nations agency, designed, in part, to monitor nuclear power plants throughout the world, determined that an independent study, conducted by an international team of medical and scientific experts, might be able to reassure those directly or indirectly affected by the Chernobyl accident. The reassurance would be in the form of an accurate and complete description of the medical and psychological sequelae of the Chernobyl nuclear power plant accident by the direct physical and laboratory examination of a random stratified sample of Soviet citizens living in areas reported to be contaminated by the accident. A control group would be drawn from neighboring communities that were determined by IAEA not to have been contaminated with radioactive material. This paper is a review of the results of the IAEA study as they relate to mental health and related issues (*12,13*).

Background

A nuclear power plant accident occurred in Reactor Number 4, at Chernobyl, Ukraine, on April 26, 1986. There was an initial explosion and fire and a subsequent graphite fire that combined to produce gases and aerosols containing large quantities of radioactive material. During the 10-day period required to contain the fires, the products of the fires and explosion were widely dispersed. Areas of the then Byelorussian Soviet Socialist Republic, the Russian Soviet Federated Socialist Republic, and the Ukrainian Soviet Socialist Republic were directly contaminated from the clouds of radioactive material.

The Soviets considered an area contaminated if the ground radiation level of radioactive cesium (^{137}Cs) was in excess of 1 curie (Ci) per square kilometer (km^2) or 37 kilo becquerels per square meter (kBq/m^2). They divided the contaminated areas into three zones, based on their estimates of potential harm from exposure to radioactive contaminants: the radiation levels in the first zone were between 5–15 Ci/km^2 (185–555 kBq/m^2); in the second, 15–40 Ci/km^2 (555–1,480 kBq/m^2); and in the third, greater than 40 Ci/km^2 (greater than 1,480 kBq/m^2). Special financial and food supplements were provided to people living in zones 2 and 3. Those living in the most contaminated zone (>40 Ci/km^2) received more supplemental assistance than those living in the less contaminated zones. The Soviets estimate that 825,000 people are living in areas where the contamination exceeded 5 Ci/km^2 (185 kBq/m^2); 45 percent reside in Byelorussia, 24 percent in the Russian Republic, and 31 percent in the Ukraine.

The location of contaminated areas within the three republics was based on ground surveys designed to determine the estimated levels of radioactive contamination. The actual distribution of the radioactive materials was a function of the prevailing winds, the rain, and the surface characteristics of the surrounding countryside. Thus, it is possible for a town close to Chernobyl to have less radioactive material in its fields than another town two or three times further from the accident site. There are significant discrepancies between the results of mapping the contaminants reported by the Soviets and those reported by the various groups of international scientists. The degree of risk to a given family was, and remains, a function of where they work, and the source(s) of their fresh fruit, vegetables, milk and milk products, and meat products.

For a prolonged period after the accident, the nature and extent of the damage to the reactor, and the area(s) of contamination were not revealed by the Soviet government. Maps indicating which towns and areas were contaminated with radioactive material from the nuclear power plant accident were not officially published until March 1989, nearly 3 years after the accident.

"Liquidators" or cleanup workers were imported from the civilian populations of the various republics then comprising the Soviet Union. Military units from throughout the Union of Soviet Socialist Republics transferred to the Chernobyl area to participate in the post-accident cleanup. The exact numbers of civilians and military personnel who participated in the multiyear cleanup operations are said to be unknown; Soviet government estimates are between 400,000 and 600,000 people. The Soviet government did not provide the cleanup workers with individual dosimetry devices. Therefore, there was no means of precisely estimating the radiation dose received by an individual worker during his or her participation in the cleanup activities. Soviet photographs of the cleanup operations indicate that there was relatively limited use of protective clothing during the cleanup operations. Equipment was washed prior to leaving the zone of exclusion. No containment of the resultant waste water occurred.

The IAEA Study

Background. The World Health Organization (WHO) in 1989 (*20*), and the League of Red Cross and Red Crescent Societies (Red Cross) in 1990 (*16*), conducted independent surveys of the affected areas. Their conclusions were similar with regard to their concern about the potential psychological problems that might be afflicting those living in the contaminated and uncontaminated villages proximate to Chernobyl. Both reports noted that scientists who were attributing various biological and health effects to radiation, when there were little or no data to substantiate that conclusion, might themselves be causing significant psychological harm to the very people they were attempting to help.

The two international organizations were cognizant of the fact that there were insufficient baseline clinical data to determine whether the incidence of any of the ailments and conditions being reported as a direct or indirect result of exposure to radioactive contamination were occurring at rates that were greater than those preceding the nuclear power plant accident. Further, many of the conditions being reported as having been caused or aggravated by radioactive contamination from the Chernobyl accident have not been previously reported as a consequence of exposure to elevated levels of radiation. The Red Cross report stated (*16*):

> Among the health problems reported, it was felt that many of these, though perceived as radiation effects both by the public and by some doctors, were unrelated to radiation exposure. Little recognition appears to have been given to factors such as improved screening of the population and changed patterns of living and of dietary habits. In particular, psychological stress and anxiety, understandable in the current situation, cause physical symptoms and affect health in a variety of ways.

In October 1989, the Government of the Union of Soviet Socialist Republics formally requested IAEA to evaluate the procedures being used by the government to protect those living in the areas affected by radioactive contamination and also to determine whether the health of those living in the contaminated areas had been adversely affected by the nuclear power plant accident.

IAEA proposed an international collaborative study in which villagers residing in contaminated villages and those who lived in similar nearby uncontaminated (control study) villages would be examined to determine whether there were any significant differences in the rates of medical and psychological illnesses. Because the two samples of villagers would be matched by the most significant variables including age, sex, residence in the villages at the time of, and since the nuclear power plant accident, any perceived differences in medical and psychological well-being could be attributed to exposure to the radioactive debris from the nuclear power plant accident (*12,13*).

A cross-sectional sampling technique was used to select five groups of subjects:

1. children born in 1988 (age 2 at the time of the study). These children, born after the accident, were chosen specifically to identify potential problems related to anemia, lead poisoning, possibly rickets, and nutritional deficits.
2. children born in 1985 (age 5 at the time of the study). These children, infants at the time of the accident, were chosen specifically to identify potential problems related to thyroid function secondary to radio-iodine ingestion and nutritional deficits.
3. children born in 1980 (age 10 at the time of the study). These children were chosen specifically to identify potential problems related to endemic goiter and general health status.
4. adults born in 1950 (age 40 at the time of the study).
5. adults born in 1930 (age 60 at the time of the study).

Structured interviews were developed and used to ensure that demographic and clinical findings were collected in a uniform manner. Laboratory studies were either conducted on site or specimens were collected, labelled, prepared, packaged, and shipped to other participating laboratories. The study team used and operated a single Hitachi thyroid ultrasound machine and a single Coulter counter (for hematologic studies) throughout the project. The results of these studies were immediately provided to the physicians at the local polyclinic who were then able to record the data directly into the patient's medical file. Abnormal studies could be identified and repeated, if necessary. The final analysis of data and preparation of the report were arranged by the Project Team Leader, Dr. Fred Mettler, University of New Mexico, Albuquerque.

The matched population study design involved approximately 1,350 persons from the 13 contaminated and control settlements in the three republics. Residents of various ages living in contaminated villages (defined as > 5 ci/km^2) were compared with those living in uncontaminated (control) villages. Data were collected by three different international teams. Each team was composed of medical experts in radiation effects, pediatrics, hematology, thyroid diseases, ultrasound examination, and internal medicine. One team also included an expert in neuropsychological and neuropsychiatric disorders, the author.

The IAEA study recognized that four elements dominate the short- and long-term radiological situation in the affected areas: iodine (primarily ^{131}I), cesium (^{134}Cs, ^{137}Cs), strontium (primarily ^{90}Sr) and plutonium (^{239}Pu, ^{240}Pu). Heavy rainfall combined with other meteorological and geological conditions to create pockets ("hot spots") of exceptionally high surface radioactivity.

Normal environmental conditions caused the migration of contaminated material into the soil and the dispersion of particulate material through the runoff of surface waters. Radioactive sediment settled to the bottom of rivers and lakes. The physical sizes of radioactive particles were in the range of less than 1 micrometer to tens of micrometers. Chemical forms of the released radionuclides were reported to be quite variable. Finally, because of the prolonged evolution of the accident, the dispersion patterns for each of these (iodine, cesium, and strontium) and other radioactive nuclides are not congruent.

^{131}I decays almost completely within 3 months. The area of the Ukraine around Chernobyl, however, is known to be an iodine-poor region, where endemic goiter is common. Therefore, a larger than expected percentage of ^{131}I may have been absorbed by the iodine-deficient population. Preliminary data from Minsk suggest that the prediction that long-term effects of such an exposure will increase the level of thyroid disease in the population appears to be valid (*53,54*). Other radioactive nuclides, such as cesium and strontium, have long half-lives and persist in the food chain. Cesium has an ubiquitous distribution throughout all tissues (it is a potassium congener). Cesium, unlike strontium (which is a calcium congener), is not strongly retained in the body. Cesium has a biological half-life of approximately 3 months (*55*).

Radiation exposure. The IAEA researchers concluded that the methodologies used by the Institute of Biophysics, Moscow, tended to overestimate the internal and external exposure to radioactive cesium and strontium by a factor of 2 to 3. IAEA workers also determined that their whole body measurement estimates of exposure to radiation were significantly lower (8 to 30 times) than the Moscow Institute's environmental transfer model estimates. The lower actual readings are attributed, in part, to restrictions imposed on the consumption of food products produced in the contaminated villages. The environmental transfer model assumes no restriction on local food consumption and, therefore, it would tend to predict higher levels of cesium and strontium exposure. Thus, the Moscow Institute's data are a "worst case" scenario that discounts alterations in food sources and consumption patterns.

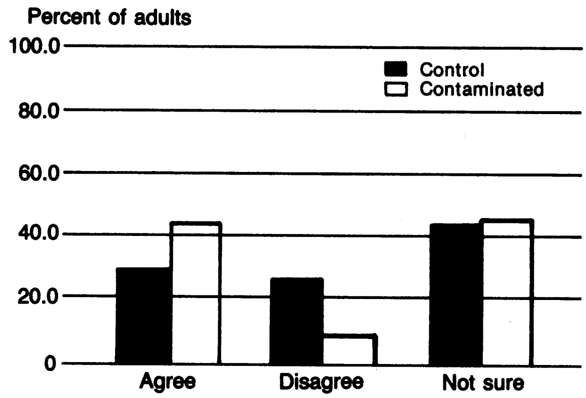
'There are significant discrepancies between the results of mapping the contaminants reported by the Soviets and those reported by the various groups of international scientists. The degree of risk to a given family was, and remains, a function of where they work, and the source(s) of their fresh fruit, vegetables, milk and milk products, and meat products.'

Health effects. IAEA clinical staff members examined a total of 1,356 persons. The staff members concluded that they could not identify any health disorders that could be attributed directly to radiation exposure in either the contaminated or the control villages. The immune systems of those living in either contaminated or control villages do not appear to have been affected. No statistically significant differences were found in the size of the thyroid gland or in the size and distribution of thyroid nodules when the contaminated village population was compared with the control village population or when both were compared with populations from other nations. The IAEA clinicians did, however, identify significant nonradiation-related health disorders among the adult population. Untreated hypertension was particularly prevalent in both types of villages.

No elevation in serum blood lead levels were found in the children from either the contaminated or control villages. Following the explosion, several tons of lead had been "dropped" into the reactor fire in an attempt to prevent the nuclear core from going "critical." Because of the high temperature of the fire, it was assumed that some percentage of the lead was vaporized and later deposited in the surrounding communities during subsequent rains.

The IAEA report states that the reported cancer incidence rate in the Soviet Union had been rising for the last decade, that is, prior to the Chernobyl

Figure 1. Responses (in percentages) to "I think I have an illness due to radiation" of 236 adults from control villages and 263 adults from contaminated villages



nuclear power plant accident. The IAEA team considered that there had been incomplete reporting of the incidence of newly diagnosed cases of cancer, and therefore they could not assess whether the increase in incidence that is being reported is due to an actual increased incidence, methodological differences, better techniques of detection and diagnosis, or other factors. The available data did not indicate an increase in the occurrence of leukemia or thyroid tumors since the accident. The tumor classification system that is used within the former Soviet Union, and other factors, however, prevent the total exclusion of the possibility that there is an increased incidence in solid tumors. Chromosomal and somatic cell mutation assay studies on residents of both the contaminated and control villages showed no significant differences. High infant and perinatal mortality rates preexisted the nuclear power plant accident. The IAEA report noted that the infant and perinatal mortality rates have decreased since the accident, suggesting overall better medical care.

Mental health effects. IAEA clinical staff members noted, from an analysis of the symptom-check list data and their clinical examinations, that a significant amount of anxiety and stress was related to the Chernobyl accident. The levels of anxiety and stress appeared to be disproportionate to the biological significance of the radioactive contamination. High levels of stress based on sleep disturbance reports, subjective complaints identified in the completed symptom check lists, and alcohol consumption patterns were also found in the control villages. Almost half of the adults in the contaminated villages sample (46 percent), and in the control villages sample (44 percent) reported that they were unsure as to whether they had a radiation-related illness (fig. 1). A greater proportion of the villagers living in the contaminated villages (44.5 percent), however, believed that they did have an illness related to radiation as compared with 29.7 percent of those living in the control villages. Thus, only 9.1 percent of those adults living in contaminated villages and 26.3 percent living in the control villages believed that they did not have an illness related to radiation (P = .001).

These findings are consistent with the nearly identical responses, throughout control and contaminated villages, about whether their milk supplies are contaminated. Slightly more than half (52.9 percent) of those in the control villages and slightly less than half of those in the contaminated villages (49.6 percent) believed that their family still drinks contaminated milk. The basis for these beliefs is that they cannot be sure that the cows furnishing the milk have not been grazed on contaminated pastures. This uncertainty also was found to be the case after the Chernobyl accident (*56,57*).

Overall, the villagers' general morale and confidence in the future was low. In addition to the Chernobyl accident, there are a multitude of life-changes transpiring—governments changing, availability and prices of food widely gyrating, and unemployment increasing (in part because of the demobilization of the Soviet military forces). Therefore, it is not surprising that the villagers reported signs and symptoms generally associated with depression. For instance, 66 percent of the adults in the contaminated villages and 52 percent of the adults in the control villages reported that they were too tired in the morning to get up.

Radiophobia, a Soviet psychiatric term used to describe an inappropriate fear of radioactive material, does not appear to be either a clinically useful or clinically relevant concept. Those examined did not understand how radiation caused illness; what types of illness were associated with short-term acute or long-term low-level radiation; were not informed as to the degree of contamination of their homes, farms, and food; and had difficulty in believing the "official" Soviet reports, especially when they conflicted with republic or oblast (district) or foreign reports. Their anxiety and concerns about radioactive material were and are understandable in view of the conflicting and incomplete data that they are receiving.

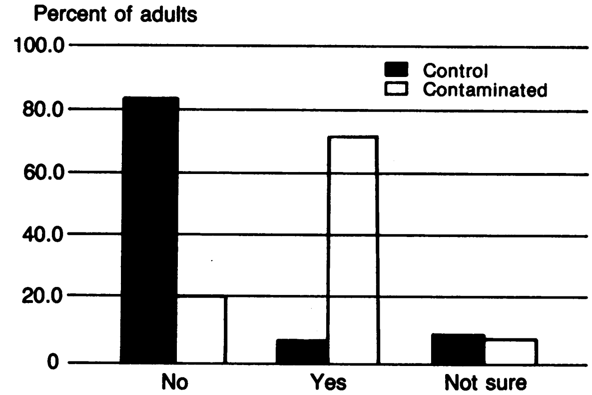
Further, many villagers were concerned about the significant changes in their government, the apparent disintegration of the Soviet Union, and what effect the evolving Soviet and republic reorganizations would have on their villages, their families, and their own futures. This uncertainty, coupled with the concerns about the future health of their children and themselves, appeared to contribute significantly to their worries and physical complaints.

Answers given by the villagers to questions concerning relocation (figs. 2 and 3) strongly suggest that those living in the contaminated villages want to be relocated. More than 70 percent percent (71.8 percent) of those living in the contaminated villages want to move, compared with the 83.3 percent of those living in the control villages who do not want to move. Approximately 9 percent of those in all communities are unsure about whether they want to relocate. Fig. 3 shows that 83.3 percent of those living in the contaminated villages believe that the government should relocate everyone in the village; 20.3 percent of those living in the control villages believe that the government should relocate them; however, 31.8 percent of those living in the control villages are unsure about whether the government should relocate the villagers as compared with only 3.8 percent of those living in the contaminated villages.

Based on prior experience in the Soviet Union, Armenia, and elsewhere, relocation of individual families to a number of different communities is extremely disruptive and may precipitate severe emotional stress. Attempts to keep neighborhoods together during the relocation process should be considered. Finally, the disruptive social effects of relocation need to be balanced against the anticipated health benefits—this is an important consideration, especially in light of the overall health findings of the IAEA study.

The IAEA study attempted to examine the attitudes and beliefs about radiation and its future impact on their communities among those living in the contaminated and control villages. Slightly less than 7 percent of those in the contaminated villages and slightly less than 6 percent of those in the control villages reported that they believed that the level of radiation was decreasing in their communities. Almost twice as many (41.5 percent versus 22.5 percent) of those living in the contaminated villages believed that the level of radiation was not going down; thus, the overwhelming majority of the residents in the contaminated villages (71.6 perecent) and a simple majority of the residents in the control villages (51.7 perecent) were just "not sure." The concept of "half-lives" of radioactive elements is little understood by the villagers. They did not understand that the various radioactive materials disintegrate at different rates ($^{134}Cs \approx 2$ years; $^{137}Cs \approx 30$ years; $^{90}Sr \approx 28$ years; $^{239}Pu \approx 24{,}400$ years; $^{240}Pu \approx 6{,}575$ years) and that thyroid problems, for instance, could only develop among those exposed to radioactive iodine within months of the explosion.

Figure 2. Responses (in percentages) to "Do you want to move from village?" of 234 adults from control villages and 262 adults from contaminated villages



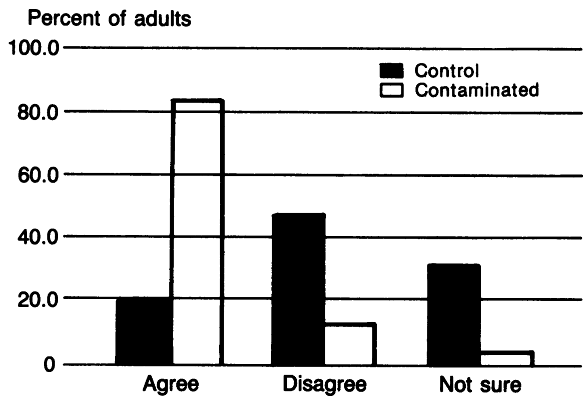
Those living in contaminated villages are more likely to believe that a small amount of radiation is not safe (34.5 percent versus 24.6 percent); almost half of the residents (48.9 percent versus 53.4 percent), however, reported that they were "not sure." The concept of a threshold dose is also a very alien concept for the villagers to comprehend; more than 90 percent of the adult villagers have less than a 10th grade education.

The majority of all villagers are uncertain about whether the problems associated with Chernobyl will be solved within the next decade. Because of the present political circumstances in their respective republics, this view may be more realistic than pessimistic.

Comments

There is no doubt that the Chernobyl nuclear power plant accident on April 26, 1986, had a significant impact on villagers living east and north of the facility. There also can be no doubt that worldwide attitudes toward the use of nuclear energy for the production of power significantly changed in the days and months that followed the accident. The radioactive contamination was not limited to the immediate surrounding areas. Clouds, wind, and rain moved significant amounts of radioactive waste throughout the world. Mead-

Figure 3. Responses (in percentages) to "Should the government relocate all persons living here?" of 236 adults from control villages and 264 adults from contaminated villages



ows in distant nations (for example, Scotland) were seeded with radioactive waste and rendered unusable for the foreseeable future.

Persons in Byelorussia, Russia, and the Ukraine directly affected by the explosion and radioactive fallout have reported an array of problems, some of which *may* be related to exposure to high levels of radioactive contamination. By and large, it appears that the chronic effects of low level exposure to the radioactive material dispersed during and after the nuclear power plant accident did not have a significant medical effect on those living in the contaminated or control villages. (It is possible that those living in the control villages were inadvertently exposed to radioactively contaminated food.)

Residents of both contaminated and control villages, however, have experienced high levels of psychological stress. The degree to which this stress can be traced to the nuclear power plant accident, being subject to repeated medical studies, or related to the internal political tumult is, as yet, not totally resolved. The direct scientific link between the nuclear power plant explosion and the psychological aftermath may be difficult to establish beyond a degree of medical certainty; however, the existence of post-accident psychological dysfunction certainly needs to be more carefully examined.

The villagers have concerns, and their concerns appear to be rational. They need to be educated about their actual risks. They need to learn about the types of illnesses that are and are not associated with the radioactive debris from the nuclear power plant accident. They need to understand how much is known, and how much is unknown, about the long-term effects of low dose exposure to radioactive material. Unfortunately, their needs may exceed the current ability of their local and central governments to address and resolve them.

While most nations may not be in a position to render significant financial assistance to those living in areas that may have been affected directly by the Chernobyl nuclear power plant accident, they should attempt to limit the villagers' exploitation. Otherwise, all the villagers could become political pawns in the international debates on the use of nuclear energy as a source of electrical power.

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Cirrhosis Hospitalization and Mortality Trends, 1970-87

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Synopsis

The decline in cirrhosis mortality in recent years in light of increases in cirrhosis morbidity, as reflected in hospital discharge data, is examined. Although there does not appear to be a single explanation for the decline in mortality, it is suggested that increased identification and treatment, as measured by substantial increases in the rates of hospitalization involving cirrhosis, may be a contributing factor.

If, as suggested by hospitalization data that indicate a decreasing proportion of patients with cirrhosis die during their hospital stay, a major portion of the increase in cirrhosis admissions was for patients with less severe cases, these patients would be more responsive to treatment and would have a relatively better prognosis.

The identification of contributing factors that may be responsible for the decline in cirrhosis mortality can provide support for the continuation of early diagnosis and treatment in already identified populations. The same kind of support can be extended to other population subgroups that have yet to show the same decline in cirrhosis mortality.

THE RATE OF DEATH from cirrhosis of the liver rose steadily in the United States after prohibition was repealed until it peaked in 1973 at an age-adjusted rate of 15.0 deaths per 100,000 population. Between 1973 and 1983, cirrhosis mortality declined by about one-third (32 percent) to 10.2 deaths per 100,000. The decline continued through 1987, when the death rate was further reduced to 9.2 per 100,000 (*1*) (see chart).

Although the downward trend in cirrhosis mortality is clear, there is no single adequate explanation. A number have been suggested, including advancements in medical treatment and the success of prevention programs (*2,3*). After reviewing some of these explanations, we present data that address the decline in cirrhosis mortality by showing that increasing detection and hospital treatment of persons with cirrhosis may be one contributing factor. We also analyze data on trends in cirrhosis diagnoses and outcomes of hospital stays.

Our review of the explanations for the decline in cirrhosis mortality focuses on two areas: (*a*) trends in alcohol consumption and (*b*) changes in cirrhosis case management. The link between chronic alcohol consumption and cirrhosis is well established, although other factors, such as lifestyle and genetic predisposition, also influence this relationship (*4*). At the aggregate level, national trends show some