DRAFT REFERENCES TO FOLLOW

Nuclear Radiation Releases into the Environment and Recent Mortality Rises in Switzerland.

E. J. Sternglass* and J. M. Gould #

(I) Introduction

A detailed examination of fallout episodes and releases from nuclear power plants for Switzerland indicates a clear correlation between the rises of fission products in the food chain, and large upward changes in various causes of death during the last forty years. The rises and declines of reactor releases into the food-chain and the subsequent increases in mortality rates due to leukemia, cancer, circulatory and infectious diseases were found to follow the same general pattern as seen after the arrival of fallout from the large-scale atmospheric testing of nuclear weapons during the 1950's and 60's, and to the initial effects of the 1986 Chernobyl fallout.

The most recent upward changes in the death rates following the Chernobyl fallout and the accident at the Muehleberg nuclear reactor later that same year showed a new and potentially even more serious phenomenon with far reaching implications for the future of human health. This is the fact that for individuals born during the period of large-scale atmospheric bomb tests of the 50's and 60's there was a much greater rise in deaths from all infectious diseases combined between 1985 and 1986 when

---

* University of Pittsburgh School of Medicine, Department of Radiology, Pittsburgh, PA 15261.

Radiation and Public Health Project, 163 Third Avenue, Suite 134, New York, NY 10003.

the Chernobyl fallout arrived than for those born before or after the period of heaviest fallout.

Among these infectious disease deaths in 1986, roughly one sixth were due to the AIDS virus. The sudden rise of all infectious disease deaths, especially for those born during atmospheric testing for whom AIDS was the overwhelming cause of death, is consistent with earlier warnings by scientists such as Andrei Sakharov as long ago as 1958 (1) that the massive amounts of Strontium-90 and other radioactive fission products released into the atmosphere by the hydrogen bomb tests would irradiate the bone-marrow and other critical organs of the immune system, causing it to become weakened. Together with an increased mutation rate of viruses produced by the fallout, Sakharov warned that damage to the immune defenses could lead to world-wide epidemics of infectious diseases spread by rapidly mutating, new viruses resulting from bomb testing.

But it is now known that the immune system is especially sensitive during intra-uterine development, early infancy and childhood. As a result, the body's defenses against cancer, bacteria and viruses become deficient for the life of the individual. The sudden manifold increase in all infectious disease deaths that began in 1986 among young individuals in the prime of their lives associated with a relatively weak second exposure to radioactive releases into the environment has very serious implications for the effort to reduce mortality rates from cancer, AIDS, and other infectious diseases, and can therefore not be ignored in any decisions affecting the future operation of nuclear reactors in Switzerland or anywhere else in the world.

(II) Background

Within recent years, there has been growing evidence that small, protracted doses of radiation due to both natural and man-made radioactive elements in the environment have had much greater effects on human health than had previously been believed. Based on nearly a century of experience with the use of X-rays in medicine and the follow-up of of survivors exposed to the atomic bomb radiation in Hiroshima and Nagasaki, it was widely believed that the small doses produced by distant nuclear detonations or normal releases from nuclear plants, typically much lower than either natural background doses or those from diagnostic X-rays, would have no statistically detectable effects.

Thus, the recent findings that leukemia and cancer rates were abnormally high around a series of nuclear plants in the U.K. and the U.S. recently reviewed in a new report by the U.S. Academy of Science (BEIR V, 1990)(2) has been difficult to accept for most of the scientific community, although studies by Stewart, Mancuso and Kneale (3) had previously shown that cancer mortality was higher among workers at the Hanford nuclear plant than expected, even though the recorded doses were well below those presently permissible. However, a very careful recent study of leukemia cases among Mormons living in the area of Utah near the Nevada test-side sponsored by the National Cancer Institute for whom detailed church records were available (4) has concluded that there appears to be a causal relationship between fallout and leukemia for both children and adults. This supports a series of earlier studies that had found such a relationship based on less reliable data obtained from house-to-house interviews for various cancers(5), or vital statistics records on a state-by state basis(5)(6) as well as international data on cancer mortality rates for a series of cancer types (7).

There have also been studies that have found a relationship between childhood cancers and low doses of radiation during intra-uterine development first discovered by Stewart's group at Oxford(8), and a more recent study showing a direct relationship between background radiation and childhood cancers by Stewart and co-workers for England and Wales (9).

With regard to other effects than cancer or leukemia, total mortality increases were first observed for radiologists exposed to fairly high occupational doses in the 1920's and 30's before the advent of the nuclear age resulted in better recognition of the danger and better safety measures (10). In the early 1960's, Moriyama suggested the possibility that both total and infant mortality rates in the U.S. might have been affected by fallout (11)(12). Subsequently, upward changes of fetal and infant mortality on a state-by-state and international basis were found to be correlated with Strontium-90 and other isotopes in pasteurized milk (13)(14). Further indications of unexpectedly severe effects of small amounts of fission products were found in counties around a series of nuclear facilities in the U.S. when higher levels of infant mortality, leukemia and underweight births were found to be correlated with announced radioactive releases and proximity to the plants(14).

More recently, following the arrival of fallout from the accident at Chernobyl, highly statistically significant rises in the monthly total and infant mortality and sharp declines in the number of live births were found to have taken place across the U.S., directly correlated with the measured levels of iodine-131 reported by the EPA for the different regions of the country (15)(16). This was the first time that effects of extremely small amounts of radioactivity on general mortality and specific causes of death could be clearly related to a specific fallout episode in a normal population since the number of individuals exposed was that of the entire United States, there were no nuclear tests that could interfere with the identification of the source of the exposure, and there were no nationwide warnings not to consume the milk and vegetables because of the very low concentrations in the diet.

The most surprising finding was that infectious disease deaths rose most strongly in a matter of weeks as in an air-pollution epidemic, and that the greatest percentage increases in mortality occurred for individuals born during the height of atmospheric nuclear testing. Thus it appears as if the radioactivity in the air and diet acted as another form of stress, accelerating the deaths of individuals who were already ill or had low immune resistance. This is consistent with the observation that the initial rises in monthly numbers of total and infant deaths were followed by abnormal declines. Similarly, the sudden reductions in the number of live births due to miscarriages or premature births were followed by unusual rises in the number of births the following year.

Another important finding was that the form of the dose-response was better fitted by a concave downward or logarithmic form rather than a linear form, explaining why there were not much larger effects in Europe, where the concentrations in the diet were much larger, despite efforts to warn the population. Such a form of the dose-response relation is similar to that found by Stokke and co-workers (17) for the reduction in bone marrow cellularity in laboratory studies of rodents given very small doses of strontium-90 in the millirem range comparable to those from fallout. It is also the same form of dose-response found subsequently by Petkau (18)(19)(20) for the action of free radical oxygen on cell-membranes produced by low dose-rate, prolonged exposures where the indirect chemical action of radiation begins to dominate over the direct-hit mechanism that produces most of the DNA damage in the case of short, high dose exposures to external x-rays or gamma rays from the flash of a nuclear detonation (21). Apparently the efficiency of free-radical induced damage becomes hundreds to thousands of times greater at very low dose-rates or concentrations of these active molecules than at high doses and dose-rates, thus explaining a much greater biological damage at extremely low doses from internal emitters such as occur from the inhalation or ingestion of radioactive fission products.

The resulting increase of biological effects at very low doses far above that expected from a linear extrapolation of high dose, high dose-rate effects as occurred at Hiroshima and Nagasaki has not only been seen in laboratory studies of mutation rates of human genes (22) but has also been observed in the dose-response curve for cancer risk among atomic workers (23) and for the A-bomb survivors (24), where the dose-rate as well as the absolute dose decreases with distance from the bomb for a given duration of the flash. In view of the discovery that transplant patients develop tumors at a high rate when their immune systems are suppressed (24), combined with the laboratory evidence that rodents given small amounts of radioactive strontium show a suppression of the normal (NK) killer-cell function of the immune system (25), one can begin to understand why low-dose exposures to internal bone-seeking isotopes or very small doses of internal beta emitters to key organs of the immune and hormonal system can have far greater effects than short external exposures of the same total dose. The crucial role of the immune system in the protection against the spread of cancer has more recently been brought out by the successful treatment of some carcinomas such as malignant melanoma by enhancing the body's own immune defenses (26).

To this must now be added the growing recognition that free-radicals such as O_2^- appear to play a much larger role in a large number of infectious and chronic diseases than previously recognized (26), including those of the respiratory, blood-forming and cardio-vascular systems, thereby explaining why extremely small concentrations of inhaled or ingested radioactive fission products can produce irritation, inflammation and rupture of cell-membranes, lowered resistance to infections, accelerated cancer spread, strokes and premature death, sometimes within a matter of days, weeks or months after exposure for those already ill.

There are, however, still other reasons why internal exposures to fission-products such as strontium-90 and iodine-131 appear to have much larger biological effects than naturally occurring radioactive elements such as radium, on the basis of which present permissible body burdens were established some fourty years ago. It turns out that low-mass elements such as strontium are taken up much more readily from the intestinal organs into the blood stream than heavy elements such as radium or uranium. Furthermore, the powerful beta rays that the fission products emit have thousands of times the range of the dominant alpha particles ejected from the heavy elements. As a result, strontium and other bone-seeking beta-ray emitting elements similar to calcium produced in the fission process are able to irradiate the bone-marrow when lodged in the bone, while most of the alpha particles cannot. Indeed, since human beings had to evolve in an environment where uranium, radium ad radon was quite prevalent, it is not surprising that our species had to evolve an immune system relatively protected from the potentially damaging action of these natural alpha particle emitters, or else we would not have survived to this day.

In hindsight, we can now begin to understand why it was a grave mistake to base the permissible amounts of radioactivity that could be discharged from nuclear reactors into the air and water on either our knowledge of the action of radium on bone, or the action of brief, high dose-rate medical or external exposures from cosmic and gamma rays in the natural environment. Human beings simply did not evolve in the presence of relatively short-lived fission products that are enormously toxic to the hormonal and immune systems, something that was not understood when the existing radiation standards were formulated and the present nuclear plants designed.

Very recently, yet another unexpected serious biological effect of strontium and radio-iodine has begun to be understood, namely their action in producing premature and underweight births. It is now widely recognized that underweight births are the single most important factor in the risk of infant death (27), and that below normal weight is also associated with a greater risk of serious brain damage with its consequent life-long cognitive and psychological problems. Recent studies have shown that an improperly functioning immune system of a pregnant woman raises the chance that she will reject the fetus as a foreign body, thus increasing the risk of miscarriage or premature birth (28). This can now explain the fact that there was a large increase in miscarriages, as well as premature and underweight births during the 1950's (29) when fallout was introduced on a massive scale into the human diet, peaking in the mid-60's when the strontium levels in the milk and bone from the large scale atmospheric testing by the U.S., the U.K. and the U.S.S.R. reached its maximum concentration. It also explains the existence of two peaks in infant mortality rates following an atmospheric release (30). The first is due to the short-lived iodine and strontium-89, while the second peak occurs three to four years later due to the delayed peak in bone concentration of the long-lived strontium-90 after the uptake from the diet begins, as is illustrated particularly well by the long-term Swiss data that will be discussed in Section III.

Furthermore, the link to fallout in the diet explains why populations whose diet is low in dairy products and high in the ratio of calcium to strontium-90 such as the Japanese diet of rice, ocean fish and sea-vegetables, now have the lowest infant mortality in the world. In addition, such a diet also contains large amounts of natural iodine which blocks the uptake of radioactive iodine-131 that damages thyroid function and thereby also contributes to a reduced birthweight and impairment of learning ability (31)(32).

With this background, it becomes clear why Switzerland is particularly vulnerable to the health effects of nuclear fallout and releases from nuclear reactors under both normal and accidental situations. First, of all, the existence of very high mountain peaks where heavy snow and rainfalls take place causes the concentrations in drinking water, soil and vegetation to be very high, since 90% of all fallout comes down with snow or rain. Secondly, the small size of the land area into which the farmland and the population centers are confined by the mountains results in a very high population density, high air concentration of fission products, and unusually close proximity of the nuclear reactors to both dairy farms and cities. Thirdly, the high average income allows a large fraction of the population to afford local dairy products and especially fresh milk that is known to be the single most important vector for the most active short-lived fission products. Furthermore, unlike the island nation of Japan, there is no ocean to use for cooling water or the normal discharges of fission products, so they must either be released into streams that serve for drinking water of animals and humans, or into the air of narrow valleys that channel the routine releases towards the low-lying farmlands and population centers. As will become apparent below, these factors do in fact appear to have produced unusually high concentrations of radioactive strontium, cesium and iodine in the diet and the body, followed by sharp rises in mortality rates after the massive atmospheric bomb tests and the known episodes of large releases from Swiss nuclear reactors as documented in the detailed official records (33).

(III) Radioactivity in the environment

In order to detect possible health effects from fission products in Switzerland, it is necessary to recall the history of the various ways in which radioactivity entered the environment, beginning with the start of the large releases from the plutonium production reactors in Hanford, Washington in 1943-44 and the detonation of the first atomic bomb on July 16,1945 in Alamogordo, New Mexico.

Following the two wartime detonations in August of 1945, two more atomic bombs were detonated on the Pacific island of Bikini in 1946 and three more in April 1948 on the island of Eniwetok (34). In August 1949, the first Soviet A-test was held, followed by two more tests in 1951, and the first hydrogen bomb in 1953 at the test-site some 200 miles south-west of the city of Semipalatinsk in Khazakstan.

Beginning in 1951, the U.S. started a series of A-bomb tests in the Nevada desert some 100 miles north of Las Vegas, which continued with increasing frequency every year except 1954 and 1956 until 1958 when a temporary moratorium began. The first fusion-type test was carried by the U.S. in October 1952 on the island of Eniwetok, with an estimated yield of 10 megatons, or 1000 times the yield of the early atomic bombs. The first true hydrogen bomb with a massive mantle of uranium and a yield of about 15 megatons code-named "Bravo" was detonated in February 1954 on Bikini Island, and led to the first public awareness of the existence of widespread fallout as a result of the accidental exposure of Japanese fishermen, and Marshallese people on the island of Rongelap. This one "dirty" bomb produced as much strontium-90 and other radioactive elements as 1500 Hiroshima bombs, spreading around the northern hemisphere in a matter of a few weeks.

The temporary moratorium that took effect in 1959 did not apply to France, which detonated its first atomic weapon in 1960 and whose fallout was clearly detected in the peaks of cesium-137 and strontium-90 in the rainwater at Locarno, Switzerland, as shown in Figure 3(a) of the Swiss review article (33). Figure 3(b) of the same article also discloses a rise of tritium in rainwater in 1959 when no bomb tests took place. This was presumably due to releases from the new French plutonium production reactors and separation plant UP-1 (Marcoule) near Bagnols-sur Ceze less than 200 kilometers (120 miles) upwind to the south-west from the Swiss border at Geneva.

The test moratorium was broken by the U.S.S.R. in 1960 with the detonation of the largest single bomb ever detonated, with a yield of 50 Megatons equivalent to 5000 Hiroshima bombs. The U.S. countered with the largest bomb-test series of any year, so that in 1962, a total of 200 Megatons were detonated, as a result of which total beta activity in the air at Locarno rose to some one-thousand times the lowest values ever measured there. As a result, by 1963 strontium-90 levels in the milk at Murren and Davos high in the mountains soared to between 80 and 90 picoCuries per liter (pCi/l) or about 3 Bq/l as shown in Figure 10(a) of Ref.33. As listed in the United Nation's reports (UNSCEAR) (35), Switzerland recorded the highest average concentrations in all of Europe, as shown in Fig.1, with 55pCi/l, compared with 19 in the U.S., 15 in Japan, and only 8 in India.

The resulting radiation dose to the whole body produced by the 50 Mt Soviet bomb was estimated to have been about 250 millirads (36), the equivalent of an abdominal x-ray to every woman and developing fetus in the northern hemisphere. Today such a dose is known to be about twice that needed to double the risk of childhood cancer and leukemia during early pregnancy, according to both the 1970 study of Stewart (8) and the most recent results correlating background radiation with childhood malignancies (9). As indicated in the Swiss summary report (33), the total megatons detonated in the atmosphere by all the nuclear powers when all atmosheric testing ended with the last Chinese test in 1980 was between 500 and 600 Megatons. As reported by Segi (37) and plotted in a recent review article on the likely effects of Chernobyl by one of the present authors (38), the cancer and leukemia mortality rate for 5-9 year old children in Japan rose 600% between 1949 and 1966, in rough agreement with expectations based on theoretical dose calculations and Stewart's most recent findings.

With the signing of the atmospheric test-ban treaty by the U.S., the U.S.S.R. and the U.K. in 1963, the strontium-90 levels in the milk began to drop sharply everywhere as shown for the U.S. and Switzerland in Figures 2 and 3. Paralleling the decline in milk levels, there was a decline of strontium-90 in the bones of newborn babies as indicated by the concentrations in milkteeth plotted in Figure 12(a) of Ref.33, with a 4 year delayed decline in the average human bone as measured in Lausanne (33).

Although the U.S.,U.K. and U.S.S.R. atmospheric tests stopped in 1963, peaceful tests with numerous detonations near the surface releasing large quantities of fission products continued in the U.S. and U.S.S.R. Deeper underground tests also released radioactivity into the atmosphere, either as a result of accidents or in the course of drilling into the cavities and recently into the test test-tunnels.

In 1964, the first Chinese atmospheric tests began, with the first H-bombs being detonated in 1966-68 , resulting in a peak rate of 3 megatons per year until 1970,and declinig in frequency until they ended in 1980. French atmuspheric tests were shifted to Muruora in the South Pacific and continued there until the mid-1970's. Since then, only underground tests have been taking place,but with continuing accidents and planned releases when test-tunnels had to be vented in order to examine the results of various experiments.

In 1968, a new source of fission product releases into the environment of Switzerland was added with the start of the first small power reactor at

Lucens in the Canton Vaud, located in the southwest of the country 27 kilometers (17 miles) north of Lausanne. The reactor had an electrical power output of 8.5 Megawatts, and was of a graphite moderated type with a series of individual tubes holding the uranium fuel elements, somewhat similar to the U.S. Hanford N-1 reactor and the Soviet reactor at Chernobyl.

The Swiss reactor had been in operation for only a year when on January 21, 1969 it experienced a serious accident that produced overheating of a fuel element, a fire, and the destruction of a portion of the reactor core so that the reactor had to be dismantled (33)(34). Although the reactor had been located inside a mountain and the main entrance was immediately sealed-off, radioactive fission products from 40 kilograms of uranium fuel escaped into the cavern and a portion of the fission gases escaped through a ventilation stack from an adjacent chamber that had been accidentally left connected to the reactor cavity (34).

Although filters in the stack retained most of the so-called "particulates" such as Cesium, Iodine, Strontium, Barium and Plutonium, the radioactive rare gasses such as Krypton and Xenon escaped, some of which subsequently decayed to far more toxic materials such as rdioactive Strontium-89. Likewise, some 100 curies of tritium escaped into the air, a very large amount since this represents 100 trillion picocuries, believed to have resulted in a dose of about 5 millirems to people living nearby. The accident was not believed to have resulted in significant exposures to the public at the time, but some emissions continued during a long period of ventilation, clean-up, and dismantling of the reactor.

That same year, the first large commercial power reactor began to operate at Beznau, some 25 kilometers northwest of Zurich near the town of Wurenlingen where the Swiss Federal Institute for Reactor Research was located and two smaller research reactors had been in oeration beginning in 1957 (33). It was a Westinghouse Pressurized Water Reactor (PWR) rated at 350 Megawatt electrical output capacity, similar in type but larger than the first U.S. reactor at Shippingport near Pittsburgh, Pennsylvania.

In 1972, a second reactor of the same type and size was added at Beznau, and the following year a General Electric Boiling Water type reactor (BWR) went into operation at Muhleberg, some 15 kilometers east of Bern, with a capacity of 306 Megawatts electrical output, similar to the reactors at Dresden near Chicago, Millstone I near New London, Connecticut and Pilgrim near Boston.

A much larger Pressurized Water Reactor of 920 Megawatt capacity was placed in service in 1979, 15 kilometers east of Aarau near Goesgen and Daniken, located about half-way between Zurich and Basel on the Aare river. The last large power reactor built in Switzerland with a capacity of 942 Megawatts began operation in 1984 near Leibstadt, about 10 kilometers north from the Beznau reactor on the Aare river, close to the German border. Thus, a total of 2868 Megawatts of nuclear electrical capacity came into operation in a period of 15 years, all located within 20 miles of the largest cities and their adjacent sources of drinking water, farm and dairy products.

As described in detail in the annual reports of the Swiss Federal Radioactivity Surveillance Commission (39) and the summary article of Volkele published in 1989 (33), the Beznau and Muhleberg reactors had a series of fuel and filter problems that resulted in large releases into the environment, just as their American counterparts examined in (14) and (40). For the period 1975 to 1986, Table 4 of the Volkele article (33) shows that large doses were calculated from the emissions of iodine-131 to the thyroids of individuals consuming the milk and inhaling the air near the Muhlenberg and the Beznau reactors as plotted in Fig.4 of the present paper. It is seen that peak doses of 220 micro Sievert per year (22 mr/yr) occurred for the case of Beznau in 1982 and 190 micro Sievert per year (19 mr/yr) for the Muhleberg plant, exceeding even the large maximum dose permitted for Muhleberg of 250 micro Sievert (25 mr/yr) , or 475 times the lowest value reported in 1984.

Since the local milk is shipped within a matter of a day or two to the nearby cities and towns, these doses reflect also the thyroid doses of close to half of the population of Switzerland, heavily concentrated around Bern, Basel and Zurich. Since the fetal thyroid is much smaller than the child thyroid for which these calculations were carried out, the doses to the developing fetus are some 10 times larger, or some hundred times greater than for the adult (41). These fetal thyroid doses of the order of 200mr/yr greatly exceed the average doses from cosmic rays of 40mr/yr or terrestrial gamma rays of 55 mr/yr in Switzerland (33), and are comparable to the yearly fallout doses received during the period of large atmospheric bomb tests.

Indeed, the plot of the iodine-131 milk concentration in a farm located near the Muhleberg reactor for a typical summer (Fig. 15 of Ref. 33) shows a rise to about 1300 mBq/l (35 pCi/l) within a few days after a release began from the plant. This is comparable to the peak milk concentration measured in New Jersey following the Chernobyl accident in 1986, when the monthly infant and total mortality increased across the U.S. in direct relation to the measured iodine-131 in pasteurized milk (15)(16).

The detailed breakdown of radioactivity emitted in both gaseous and liquid form for the case of the Muhleberg reactor given in the Annual Reports of the Surveillance Commission show that significant amounts of the biologically important strontium-90, strontium-89, barium-140, cobalt-60 and cesium-137 were also discharged when fuel failures and filter failures occurred. Thus, in the case of Muhleberg in 1976 when the peak of Iodine-131 occurred with a total of 0.75 Curies or 0.75 Trillion pCi into the air, Table 3 of Report No. 20 lists a total of 0.38 Curies (0.38 Trillion pCi) Strontium-90 discharged into the Aare river.

That large quantities of Strontium-90 escaped into the environment from the Muhleberg reactor is further indicated by the high concentrations in river sediment shown in Fig.9 of the summary paper (33), where the 1976 data show 90 Bq/kg near Muhleberg compared with 23 in the Aare river near the Goesgen-Daniken reactor then not yet in operation, and only 3.2 at Goesgen by 1985. Likewise, Strontium-90 in grass samples rose near Muhlenberg from a low of 8 Bq/1 in 1972 to a new high of 15 after showing a rapid decline following the end of the largest H-tests in the 1960's.

But most disturbing is the fact that after the large releases by both the Muhleberg and Beznau reactors for 1975 and 1976, Strontium-90 in the milk not only halted 12 years of decline, but actually started to climb again. This is evident from an inspection of Fig.12(a) of the Voelkele paper (33), which also shows that the previous decline of Strontium-90 in bone ended after 1976 as shown in Fig.5 taken from the Voelkele article (33). The milk data have been extended to 1986 based on the average values reported for the vicinity of the four nuclear plants in the Annual Reports (39) and are shown in Fig.5, indicating a continuing rise that can only be due to releases from nuclear reactors since all atmospheric bomb tests anywhere in the world ended in 1980.

The Chernobyl accident added further large amounts of radioactive fallout to the diet in Switzerland together with a serious accident at the Muhleberg reactor in the fall of 1986 when stack filters failed and large amounts of particulates escaped, as indicated in the detailed 29th Annual Report of the Swiss Surveillance Commission (39). Hardest hit by the Chernobyl fallout was the southernmost part of Switzerland near Locarno in the Canton of Tessin. There, Strontium-90 levels reached 5.2 Bq/kg in Magadino, corresponding to 140 pCi per liter in the milk, 2.5 times as large as the highest level reached following the massive atmospheric nuclear tests of 1962-63. For the northern and central parts of the country, the levels were fortunately 10 times lower, or about 11 pCi per kilogram or liter of milk. Since the bone dose and therefore the dose to the bone-marrow where the cells of the immune system originate will not reach its peak value until four years after 1986, some of the greatest effects on human health must also be expected to be delayed, as will be discussed below.

(IV) Methodology

In order to make a retroactive comparison possible over the entire period of the atomic age without interference from the changes in classifications and terminology, we used the tables for yearly causes of death prepared by the Swiss Statistical Office based on the 1901 nomenclature, as discussed on page 81 of the 1950 edition of the Statistical Yearbook of Switzerland, covering the period 1943 to 1985 on an annual basis (42). Rates were calculated using the yearly population estimates for permanent residents prepared by the Swiss StatisticalOffice updated in July 1989 (43).

For the period 1980 to 1989, we were able to obtain tables of yearly deaths by age, sex and cause of death prepared by the Swiss Federal Office of Statistics (44). Because of the great stability of the Swiss population of permanent residents, and the very slow, steady increase in population as well as the gradual nature of the ageing of the population, the detection of sudden changes in mortality rates as well as changes in the long-term trends is possible without adjustment for changes in age distribution. Furthermore, because more than half the population lives within some 50 kilometers of the first three large nuclear reactors with the largest documented releases that went into operation within the short span of only 4 years between 1969 and 1973, it is possible to use the data for the entire population in an initial search for health effects such as the present one. In this way, changes in the place of residence within Switzerland have no effect, and no arbitrary division into exposed and unexposed groups is necessary, which is in any case impossible because of the widespread distribution of food and dairy products that are known to be the most important vectors for fission products.

Since we are interested in comparing the effects of nuclear weapons related fallout with the effects of similar fission products in the diet released from nuclear plants, and since dietary concentrations as well as concentrations in the human body are only available for an average of the whole population, use of the total population of the country is desirable for our purpose. This is due to the fact that the majority of the total Swiss population of some six million people live in the Swiss Plateau near the large cities and was also exposed to bomb test fallout in the diet at about the same level everywhere. Finally, use of the total population data is not only necessary but also provides the greatest possible statistical sensitivity in the detection of small, brief responses to known events.

This is not to say that there are no significant differences in the regional exposures to fission products in Switzerland that can influence the local pattern of health effects. Thus, the detailed data on radioactivity in rain, soil, grass and milk discussed above clearly show that the rural mountain areas at high altitudes received much larger concentrations during the period of nuclear weapons testing than the more densely populated lower lying areas near the large cities. Conversely, the more distant mountainous regions did not experience as much contamination of their diet from the nuclear reactor releases in the 1970's and 80's. Indeed we have examined the differences in the trends for one age group in the two types of areas for which we were able to obtain data, as will be discussed below.

(V) Cancer Mortality

By far the oldest and most firmly established link between radiation and human illness is the link to cancer, observed within a few years of the discovery of X-rays and radioactivity at the turn of the century. And among all forms of malignancies, leukemia has been most clearly related to nuclear fallout(4)(6)(45)(46) and specifically for the case of acute myeloid leukemia for both children and adults to Strontium-90 by Archer (5).

Fig.7 shows the mortality rate for all types of malignant growths other than carcinoma of epithelial cell type, the 1901 nomenclature used in the historical Swiss data, a category that includes leukemia (42). Inspection of this plot shows a gradual general rise from 1945 to 1979, followed by a sudden, extremely rapid increase from 1979 to 1983. Whereas in the first period, this type of malignancy rose at a rate of only about 1.4% per year, during the 4 years from 1979 to 1983, it rose 60%, or at a rate of 15% per year, ten times the previous rate of rise and thus highly statistically significant.

A detailed examination of the period of massive atmospheric bomb testing between 1945 and 1973 reveals the same pattern of peaks following a known test or test-series found by Archer for the United States. He found that a period of about 5.5 years elapsed between the start of nuclear testing in Nevada, and the first leukemia peak. He also reported that a second peak occurred 5.5 years after the fallout peak of 1957, or in 1962-63. Likewise, a dip in leukemia rates in 1964-65 in the U.S. occurred 5-6 years after the minimal fallout years of 1959 and 1960, the years of the temporary test-moratorium. This dip was found to be followed by a second peak in 1968-69, some 5.5 years after the 1962-64 peak in fallout from the large atmospheric tests by the U.S.S.R. in Asia and the U.S. tests of 1962. After the last leukemia peak, the U.S. rates fell sharply until by 1976-77 it was below the 1950 death rate (5).

As Archer points out, it is well-known that induced leukemia starts appearing in 2-3 years, peaks between 5 and 7 years in children and has nearly disappeareed in 15 years. In adults the latent period is longer and the peak incidence is delayed. Thus Archer concludes that the observed time intervals between the fallout peaks and declines are fully consistent with those known for radiation induced leukemia.

Detailed examination of Fig.7 reveals the same type of pattern for Switzerland as for the U.S. during the period 1949-79 studied by Archer, where the solid arrows indicate the start of major test-series or the onset of reactor operations, while the open arroes indicate known reactor accidents or particularly large releases. The first peak between 1945 and 1950 occurs some 5-7 years after the first large releases from the Hanford plutonium production facility in1943-44 and the first atomic test in Alamogordo, New Mexico in 1945, followed by two wartime detonations in Japan in August of 1945.

The second rise beginning in 1953 and peaking in 1959 follows the beginning of the Nevada tests in 1951 and the Pacific and Siberian tests of hydrogen bombs in 1952-54 by some 5 to 7 years. The next major peak in the period 1968-70 follows the large fallout recorded in Switzerland from the 1961-63 tests (See Fig.3). Smaller peaks in 1974 and 1978 are probably related to the large Chinese H-tests 1968-72.

Thus, the Swiss data strongly support the conclusion arrived at by Archer and a number of other investigators that small amounts of radioactivity from nuclear fission are able to induce leukemia at externally measured doses close to normal background levels in the range of only a few millirems, previously believed to have been undetectable. Thus it appears that much if not most of the excess leukemia seen in the U.S. and now in Switzerland is attributable to nuclear fallout in the diet.

Turning next to the period after 1979, we know from the detailed reports of releases from the Swiss nuclear reactors and the measurements of strontium-90 in the environment discussed in Section III above and illustrated by Fig.4 that large releases occured from the Beznau and Muhleberg reactors in 1975-76. We see that some 5-6 years later, or in 1980-81 a totally unprecedented rise in non-epithelial type malignancies occurred in Switzerland, consistent with the earlier rises from similar increases of fission products in the environment from bomb-tests.

As indicated by the data in Fig.4, a second series of large releases occurred in these reactors in 1981-82. This release was followed by another rise that can just be seen to begin in 1985 in Fig.7, and much more clearly in Fig.8, where the mortality rate for acute myeloid leukemia has been plotted for the recent period 1988-89.

This temporal pattern of sharp rise in acute myeloid leukemia most clearly established as being related to radiation exposure, fallout and strontium-90 in the diet strongly suggests that these unprecedented increases are likely to be related to the releases from nuclear plants.

No other cause for such a sharp, sudden increase is as likely as rises in the dietary levels of radioactivity in the diet, especially the milk and dairy products widely consumed in Switzerland. There has been no sudden increase in the use of medical X-rays or the dose per film. Indeed, the growing use of fast film and electronic means of fluoroscopic imaging have greatly reduced the dose per examination during the last decades. Ultrasound has increasingly replaced X-ray examinations during pregnancy, and magnetic resonance imaging has become more widely used. Neither of these diagnostic techniques has suddenly increased so as to explain the recent rise, and of course no steadily growing use of any medical techniques is likely to explain the rapid rises and declines following known atmospheric bomb-tests.

The case for a fission product related cause of the recent rise in leukemia in Switzerland is further strengthened by the data for all other malignant tumors, that is carcinomas, mainly involving the bronchi and lung for men, and breast cancer for women, both of which can be induced by radiation.

Fig. 9 shows the data for the same period 1945-85 as for the other types of malignancies in Fig. 7. It is seen that the mortality rate of carcinomas was nearly constant between 1943 and 1958, declining somewhat somewhat during the period 1958 to 1964 in Switzerland, probably due to the combined effects of improved early diagnosis, improved therapy, reduction in smoking among men, improvements in air-pollution controls and the fact that the short-lived activity in the low altitude tropospheric fallout clouds passed over Ireland, England and Norway, so that the most intense short-lived activity did not reach Switzerland until it had decayed while circling the globe one or more times. Some small peaks can however be seen in the 1950's when the fallout from atomic and hydrogen bomb detonations from Siberia and the Pacific rained out in the mountains of Switzerland, but the decline from 1958 persisted until 1963.

However, beginning in the latter half of the 60's, the general downward trend ended, and a sharply rising trend took over, despite all further advances in medical care and environmental clean-up. From the low point in 1964 all the way to 1985, there occurred a complete reversal of the previous downward trend. Instead of a decline, there was a completely unprecedented steady rise of 1.3% per year, persisting over a period of 21 years with only minor interruptions, despite great advances in diagnosis, treatment and reduction in smoking among men.

It is seen that the upward upward trend began slowly in 1967-69, some six to seven years after the large U.S.S.R. H test of 1961, again strongly suggesting a causal link to radioactivity in the diet. A clear peak appeared in 1973, some to 12 years later, in reasonable agreement with the longer latency periods for the different solid malignant tumors compared with the 5-6 year delay of a peak for leukemia observed in the case of the Hiroshima and Nagasaki survivors (2).

Because of the longer latency and the combination of many different solid tumors such as breast cancer and lung cancerin this category, there are no such clearly identifiable peaks during the period when the reactors had a series of small and large releases. It is therefore of interest to look at two types of carcinoma that are known to be radiation related and which are not strongly associated with cigarette smoking for the period of rapid rise after 1980.

The first is breast cancer in women, shown in Fig. 10. It is seen that there was a sharp rise of 16% in only three years from 1980 to 1983, or at the enormous rate of 5.5% per year. This was followed by a slower rise to a broad peak between 1985 and1988, some 10-11 years after the very large 1975-76 releases from the Beznau and Muhleberg reactors. The statistical significance of this rise is extremely great (P 0.001) since the number of deaths were 1308 in 1980 and had climbed to 1645 in 1987.

The recent signs of a possible decline are consistent with improvements in the waste-treatment and radioactive gas hold-up systems instituted by the reactor manufacturers world-wide in the late 1970's after public hearings caused the U.S. Nuclear Regulatory Commision to lower the permissible releases.

Fig. 11 shows the mortality rate for another type of carcinoma, namely malignant melanoma, a form of skin cancer that has recently been found to rise extremely rapidly in the U.S. It is seen that just like breast cancer it rose sharply between 1980 and 1983, namely by 26% in only 3 years or at a rate of 8.7% per year.

A small peak occureed in 1983 some 6-7 years after the large releases from the Muehleberg and Beznau reactors in 1975-76, and a second peak appeared in1988, 6-7 years after the large releases of 1981 and 1982, consistent with the known relatively short latency period for this type of highly malignant skin cancer.

No other explanation for the very sudden, extremely great increase and peaking of this type of carcinoma is as likely as radioactive fission products in the air and diet. Skin cancers are of course also produced by exposure to ultra-violet radiation, which is known to be a promoting factor, just as repeated exposures to ionizing radiation (2). But a sudden sharp rise followed by a levelling-off and subsequent decline cannot be solely attributed to a steadily growing exposure to the sun. Neither could a reduction in the ozone in the upper atmosphere be the explanation since studies have found no increase in U.V. radiation on the ground in recent years (47).

The evidence that large releases from nuclear reactors followed by upward changes of strontium-90 in the diet are associated with myeloid leukemia peaks similar to those seen by Archer during the time of atmospheric tests strongly suggests that there exists a causal relationship between nuclear reactor releases and the incidence of leukemia and cancer. The evidence is further strengthened by the fact that known radiosensitive carcinomas such as malignant melanoma and breast cancer also rose sharply after the known large nuclear tests and the reactor releases that produced clearly detectable rises of radioactivity in the diet and human bone.

(VI) Total Mortality

Since total mortality from all causes combined has also been linked to chronic, low-level radiation exposure (10) and extended internal exposure to fission products (11) (15)(16)(48), it is of interest to determine whether the Swiss data also support such an association.

Fig.12 shows the total mortality rate for Switzerland between 1940 and 1988 taken from the publications of the Swiss Federal Office of Statistics (42)(43). As in the case of the dominant type of malignancies, there is an overall decline since 1945 which slowed in the mid-1950's when large hydrogen bomb tests began, slowed once more following the second large series of atmospheric tests in the early 60's, and finally began to rise in the mid-70's.

Again, there is a clear indication of peaks in mortality in 1945 when the first atomic bomb fallout began to circulate the world, and a second peak between 1952 and 1957 when the first H-tests took place and long-lived high altitude stratospheric fallout began to reach Switzerland. After a brief dip during the period of minimal fallout due to the test moratorioum of 1959-61, there was another even sharper rise, divided into two clearly separated peaks in 1960 and again in 1962-63. The first coincides with the first French bomb test in the Sahara desert in 1960, while the second corresponds to the sharp rise in fallout after the large U.S.S.R. and U.S. tests that ende the moratorium, followed by minor peaks when the Chinese A-tests began in 1964.

A minimum of the mortality rate in Switzerland was reached in 1975 followed by a small peak in 1976, the year when large releases and associated whoke-body and thyroid doses were reported were reported for the Muhleberg and Beznau reactors (33). The abnormal rise continued until 1983, after which the mortality rate declined slightly but remained higher than in 1975 for every year until 1988, the last year in the plot.

Since diseases of the circulatory system that include heart disease and strokes are the single most important cause of death, it is of interest to separate them from malignancies. The results are shown in Fig. 13.

It is seen that deaths due to all circulatory system diseases combined showed a rise from 1943 that continued into the mid-50's, with relatively large, sharp peaks some one to three years after each major fallout episode. A clear minimum was reached in 1973-75, 19% lower than the peak rate recorded during the period of low-altitude nuclear atmosperic detonations in the mid-50's, or just about equal to the low rate that existed in 1943 when the air was filled with smoke and people were not yet watching their diet for cholesterol, but when the large-scale releases of radioactive fission products into the environment had not yet begun.

Following this minimum, there occurred a totally unprecedented rise of 17% in only 4 years, followed by a broad peak in 1979 to 1983, and a decline to a value still above the 1973-74 minimum. Again, as during the period of large-scale atmospheric tests, the sharp rise in 1976 to 1979 follows by one to three years the known large releases from the two nuclear plants at Muhleberg and Beznau, located in the most densely populated dairy farming region of Switzerland. And once again, the pattern of the rises and declines is similar to that for leukemias and cancers, but with a much shorter time-lag.

In contrast to the case of ciculatory system disease mortality, the death-rate for all respiratory diseases shown in Fig. 14, which is dominated by pneumonia, shows a rapid drop immediately after the peak in 1943 to 1945, probably due to the sudden availability of sulfa-drugs and antibiotics after the end of World-War II. A minimum was reached during the moratorium of 1959, with a small peak in 1960, the year of the first French atomic test in Africa, after which a sharp peak occurred when the massive 1961-62 fallout reached Switzerland. Following this period, the respiratory mortality climbed steadily despite all the advances in antibiotics, the decline in smoking among men, and the reduction in automobile and other chemical emissions into the atmosphere.

A clear peak occurred in 1969, the year of the Lucens reactor accident with its large airborne releases of tritium and other radioactive substances. This was also the year of the start-up of the Beznau reactor, which suddenly added still more radioactive gases into the atmosphere, followed by still further anomalous rises and declines after known episodes of large releases indicated by the hollow arrows.

Thus, all the evidence points to invisible radioactive gases and particulate released from both atmospheric and the continuing underground tests with their leaks as well as nuclear reactor and reprocessing plants into the into the atmosphere as an important and previously neglected contributary factor to respiratory disease. The action of radioactive chemicals is undoubtedly enhanced by cigarette smoke, dust and smoke from coal and oil-burning plants, and the large automobile emissions, but the observed pattern of close connection to known radioactive releases makes it impossible to blame the recent rise in respiratory deaths solely on fossil fuels, cigarettes, or automobile emissions.

Since infectious diseases dominate the respiratory mortality rate, it is of interest to examine in deaths due to infections separately, and this is shown in Fig. 15 for the case of one specific disease, namely, meningitis.

Just as would be expected, there is indeed a large decline immediately after 1945 associated with the improvements of medical treatment after the end of World-War II. A sharp minimum occurred during the time of the 1958 moratorium, but immediately thereafter, beginning with the onset of releases from the French plutonium production plant at Marcoule, there was a sharp rise, followed by an enormous 8-fold greater peak in 1962-64 when the massive fallout from the 50 Megaton Soviet test and the subsequent U.S. tests reached Switzerland. This was followed by an almost equally large peak 1969-70 after the Lucens accident and the start-up of the Beznau ractor, which were also years when large Chinese H-tests occurred in

Sinkiang province whose stratospheric fallout rained out in the mountains.

The peaks are seen to occur either within the same or the following year of these known events, faster than the peaks of circulatory diseases or leukemias and cancers, in agreement with recent findings of large increases in deaths due to infections in the United States during the summer of 1986, within a matter of weeks or months after the arrival of the Chernobyl fallout (15)(16).

Apparently, the immune system is rapidly damaged by the internal irradiation of such key organs as the bone-marrow, the thyroid and the nearby thymus of infants (49), as well as other organs of the hormonal, reproductive and immune systems that tend to concentrate certain of the many different short and long-lived radioactive chemicals produced in the fission process.

Such reductions in the immune system capability in the form of white-cell decline were first reported in large human populations following the arrival of distant fallout in Europe by Mehring (50). However, these findings were ignored at the time, even though depression of the immune system is a well-known effect of radiation. It would seem that the lack of a biological mechanism to explain the very low dose effects involved prevented the scientific and medical community from believing such a serious effect at the small doses of distant fallout, especially when nuclear weapons production and testing was seen as absolutely vital to national security by all the nuclear nations.

Now, however, with the discovery of a much more efficient mechanism due to free-radical production at extremely low doses and dose-rates (18)(19)(20), this objection can be answered and the mounting epidemiological results accepted, especially in view of recent independent confirmation of a sharp decline of white-cell counts in Germany in May of 1986 after 51the arrival of fallout from Chernobyl discussed by Jensen (51).

But perhaps the strongest indication that fallout can severely impair the function of the immune system comes from an examination of the changes in infectious disease mortality rates for those born during the height of nuclear testing as compared with those born before and after, when the immune system was once again attacked by the intense fallout from Chernobyl in the spring of1986.

The results are shown in Table 1 and Figure 15 forthe period 1980-89, before and after the Chernobyl fallout arrived for the number of deaths due to all infectious diseases combined. As can be seen in Table I, the age-group 0-14 born after 1965 showed no increase in annual deaths between 1985 and 1986, while those in the age-group 25-34 born in the period of the most intensive atmospheric testing between 1946 and 1964 showed a 260% rise from 8 to 29 deaths in a single year, followed by a rise to 148 or by 1750% by 1989, while those born after 1964 actually showed a small decline.

By contrast, deaths in the age-group 45-54, none of whom were born after 1944 and who were thus only exposed in childhood or later years, rose by only 58% from 19 to 30 between 1985 and 1986, and rose only to 55, an increase of 189%. At the same time, those in the age-group 35-44 showed an intermediate rise by 1989 of 788%.

For all ages combined ,not shown in Table I, the deaths due to infectious diseases rose from 472 to 693, an increase of 46.8%. Of these, AIDS was listed as a cause of death for 279 in 1989, leaving the number of non-AIDS deaths due to infections at 414 that year, when the declining trend from1980 to 1985 would have led to an expectation between 250 and 300. Thus, although AIDS accounted for 40% of all infectious disease deaths by 1989, this was by no means the only form of infectious disease mortality to rise after the the Chernobyl fallout arrived in Switzerland. But it accounted for the overwhelming majority of all deaths in the age group 29 to 44 years, all of whom were heavily exposed to Strontium-90, Strontium-89 and Barium-140 irradiating their bone marrow during early development or childhood.

This sudden and abnormally large increase in infectious disease deaths of all types was also seen in the U.S. after the much weaker activity from the Chernobyl accident arrived, again with a much greater effect on those born during the height of atmospheric testing, and again much greater for AIDS deaths than for other infections (15)(16).

These highly statistically significant results are perhaps the most serious of all, since they indicate that nuclear fallout both from weapons detonation and reactor accidents can lead to epidemics of new or previously less virulent infectious diseases, just as Sakharov (1) was so deeply concerned about as early as 1958. And since some of these epidemics can occur for viruses that mutate rapidly like the AIDS virus against which we have as yet no vaccines or cure, and since it is it furthermore at least conceivable that the means of transmission may not be as restricted as in the case of AIDS, it means that the very existence of the human species could be threatened by nuclear war or further large accidents of nuclear reactors or waste-processing facilities.

Since the very small doses produced by the Chernobyl faalout in the U.S. that led to a highly significant increase of some 30,000 excess deaths mainly due to infections during the summer of 1986 were comparable to those from the normal reeases of large nuclear plants, it also means that the continuation of releases from nuclear reactors decreases the length of life of all those whose immune system is already deficient such as the carriers of the AIDS virus, as well as those not yet infected. This includes not only those born during the peak of atmospheric testing but also older people whose natural immune defenses decline as a result of the aging process, further increasing total mortality as nuclear reactors continue to operate and release radioactivity into the environment.

(VII) Infant Mortality

Part of the total mortality rate is of course due to that of the newborn infant 0-1 year old. Since earlier studies have reported upward changes in the normally declining infant and neonatal mortality rates following nuclear tests in the U.S. (12)(30) and other nations (6) correlated with the levels of Strontium-90 in the milk, as well as similar upward changes after the Chernobyl accident in the U.S.(15) (16), the German Federal Republic (52), and Finland (53), it is of interest to examine the data for Switzerland since bomb-tests began.

Fig.17 shows the infant mortality rate for Switzerland from 1932 to 1989 for both Switzerland and the U.S. It is seen that although it started much higher in the U.S. during the years of the deprssion, it had declined to the Swiss level by 1943, despite the existence of large poor Black, Indian and other minority groups in the U.S. In fact, the U.S. infant mortality continued to decline more rapidly than that of Switzerland from 1932 to 1946 and remained lower until 1954, the year of the massive"Bravo" test in the Pacific, when it began to slow down drastically, so that it once again became higher than the Swiis rate.

After 1954, the U.S. rate failed to decline further and actually rose slightly in 1957, the year of the heaviest fallout from the Pacific and Nevada tests as documentesd by Archer (5). During the late 50's, while the U.S. rate refused to come down further, the Swiss infant mortality declined rapidly since the short-lived activity from Nevada largely missed Switzerland, halting only briefly in 1961-62 when the massive fallout of the last U.S.-U.S.S.R. tests arrived. Once again, this pattern is consistent with the fact that the Nevada fallout moved across the northern Atlantic to Ireland, England and Norway on its first pass around the world, thereby allowing the most intense short-lived activity to decay before it finally spread to Switzerland and other central European countries such as France

(6) and Germany .

The U.S. rate began to decline slowly once againafter the peak of strontium-90 occurred in 1964-65, but a more rapid decline took place only after 1970, when near-surface underground and peaceful "Plowshare" explosions were halted following the "Baneberry" accident in Nevada (6). However, the gap between the higher U.S. rate and the lower Swiss rate did not close after the end of the Plowshare test. Instead it remained nearly constant until the end of the 70's, when the Swiss infant mortality was 30 % below that of the U.S.

In 1980, the Swiss infant mortality showed a sharp and unprecedented rise of 7% instead of declining at close to the 10% per year in some of the previous years.This peak occurred some 4 years after the large releases from the Beznau reactor near Zurich and the Muhleberg reactor near Bern, exactly the kind of 4 year delay that was found for the peak of Strontium-90 in bone after the arrival of fallout and the peak activity in milk and milk-teeth discussed above. After another sharp decline of 18% between 1980 and 1981,another increase occurred in 1982, when record-high Iodine-131 releases and large infant and fetal thyroid doses occurred from the Beznau plant located near the major population centers of Zurich and Basel.

By 1985-86, 4 years after these record releases, infant mortality in Switzerland failed to decline any further, just as was the case for the U.S.during the massive releases of short-lived radioactivity into the U.S.milk,food and drinking water of the cities downwind from Nevada.

By 1989,with a rise of 17% to 7.6 per thousand live births relative to 1988, The Swiss infant death-rate showed the beginning of another peak expected to occur in 1990-91, 4 years after the Chernobyl fallout arrived and the stack filter failure accident occurred at the Muhleberg plant a few months later(39).

Thus, both the U.S. and Switzerland are now showing the same unexpected failure of infant mortality to decline, as both countries are experiencing an increasing number of accidents and releases from nuclear plants (16), designed and built before the true magnitude of the very low internal doses from beta emitters in key organs producing free-radical damage had been recognized. And this similarity is occurring despite the fact that prenatal and medical care is far more widely and uniformly available in Switzerland than in the urban ghettos of U.S. cities.

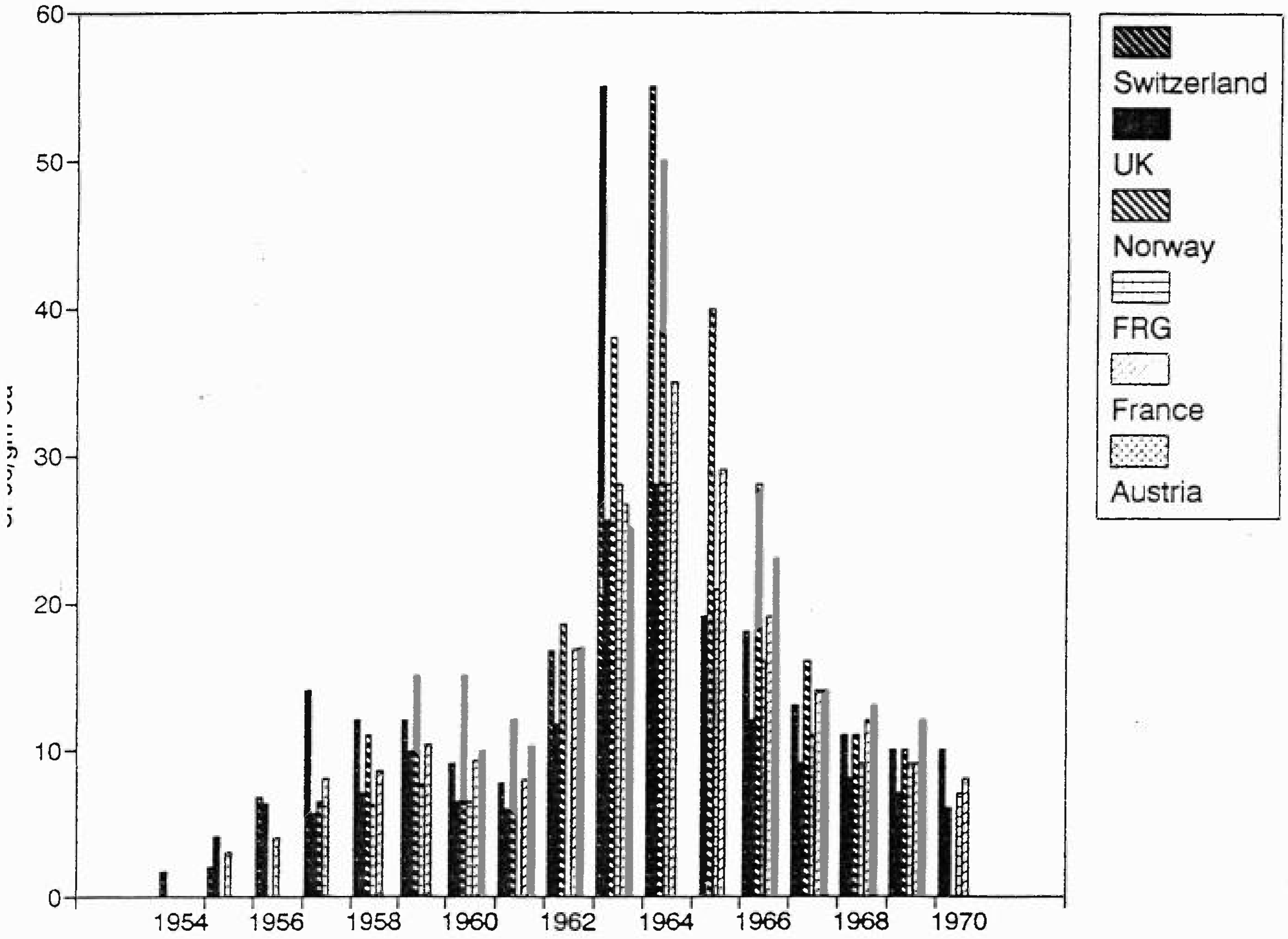
Clearly, prenatal care or the supplementation of the diet of the poor by dairy products cannot by themselvs hope to reduce infant mortality further as long as the diet is contaminated by radioactive fission products that result in premature births and a high percentage of infants born below normal birth weight(6)(16).

This conclusion is in accordance with the recent finding by the U.S.National Center for Health Statistics that very poor Mexican-American women now have very low infant mortality rates, almost half of those of the less impoverished Black population, and actually below that for the average white population in the United States (54). The conclusion by Dr. Joel C. Kleiman of the Center for Health Statistics that there may be a dietary factor that has so far not been recognized is consistent with all the above results: now that above-ground nuclear testing in Nevada has ended and only occasional leaks take place from deep underground tests, the Mexican-American population concentrated largely in the dry Southwest has a lower intake of strontium-90 than the Black population in the cities of the Northeast, most of whose milk comes from areas near large nuclear plants (16).

In order to see whether an analogous phenomenon is taking place in Switzerland for the rural population in the remote mountain regions as compared with the population living in the cities near the reactors, we compared the decline of infant mortality for five Cantons in the areas of Zurich, Basel and Bern with that for five Cantons in the central, rural mountainous region before and after the start of reactor emissions. The results are shown in Figure 18. They indicate that before 1974, when fallout from bomb testing was dominant and greatest at high altitudes, the mountain regions had a 30% higher infant mortality than the urban region. But in the late 1980's after the reactors had been releasing radioactive materials into the local environment for some 10-15 years and Strontium-90 levels were once more rising in the surrounding area, the mountain regions had declined to a lower infant mortality rate than the urban areas to the north. Moreover, during the last 5 years, some rural areas such as the Canton of Obwald achieved infant mortality rates as low as 4.2 per thousand live births, or one-half the lowest rates ever achieved in the urban areas near the reactors, just as remote rural mountain states in the U.S. like Wyoming are now reporting rates as low as 2-6 compared with a U.S. average of about 9.8.

These finding therefore add still further support to the hypothesis that radioactivity in the diet is the principal factor affecting low birthweight and premature births today, both in the U.S. and Switzerland. They strongly suggest that no matter what efforts are made to improve medical care of the newborn, and prenatal care of the mother, they cannot by themselves reduce infant mortality and the tragic problem of the associated increased risk of brain damage, and cognitive impairment for the surviving infants, even in areas with the best medical facilities and social services, until all forms of release of fission products into the environment are ended.

Strontium 90 in Milk for Six Countries 1954-1970



Strontium 90 in Milk
United States of America 1954-1971

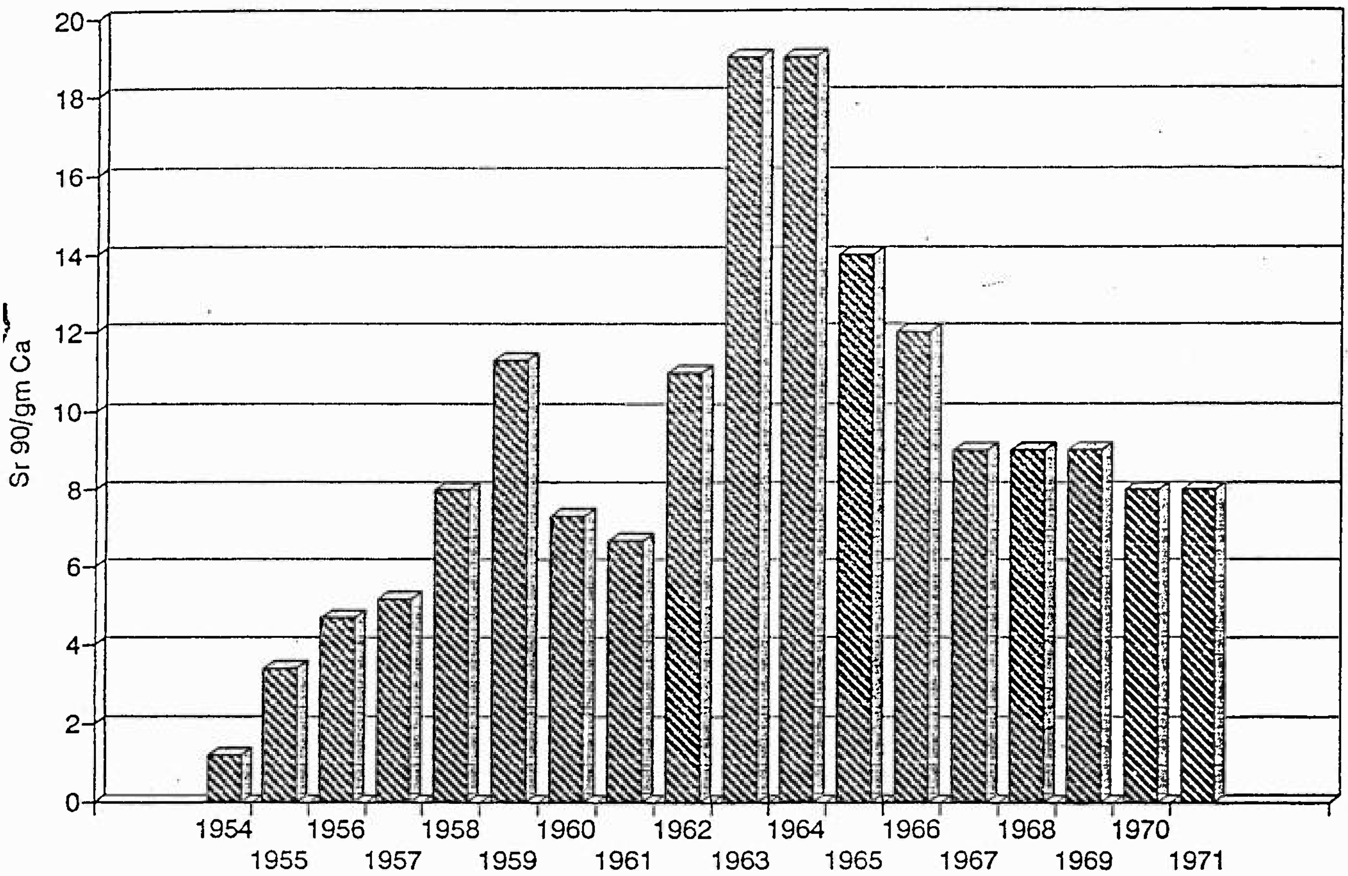


Fig. 2

Strontium 90 in Milk
Switzerland 1954-1970

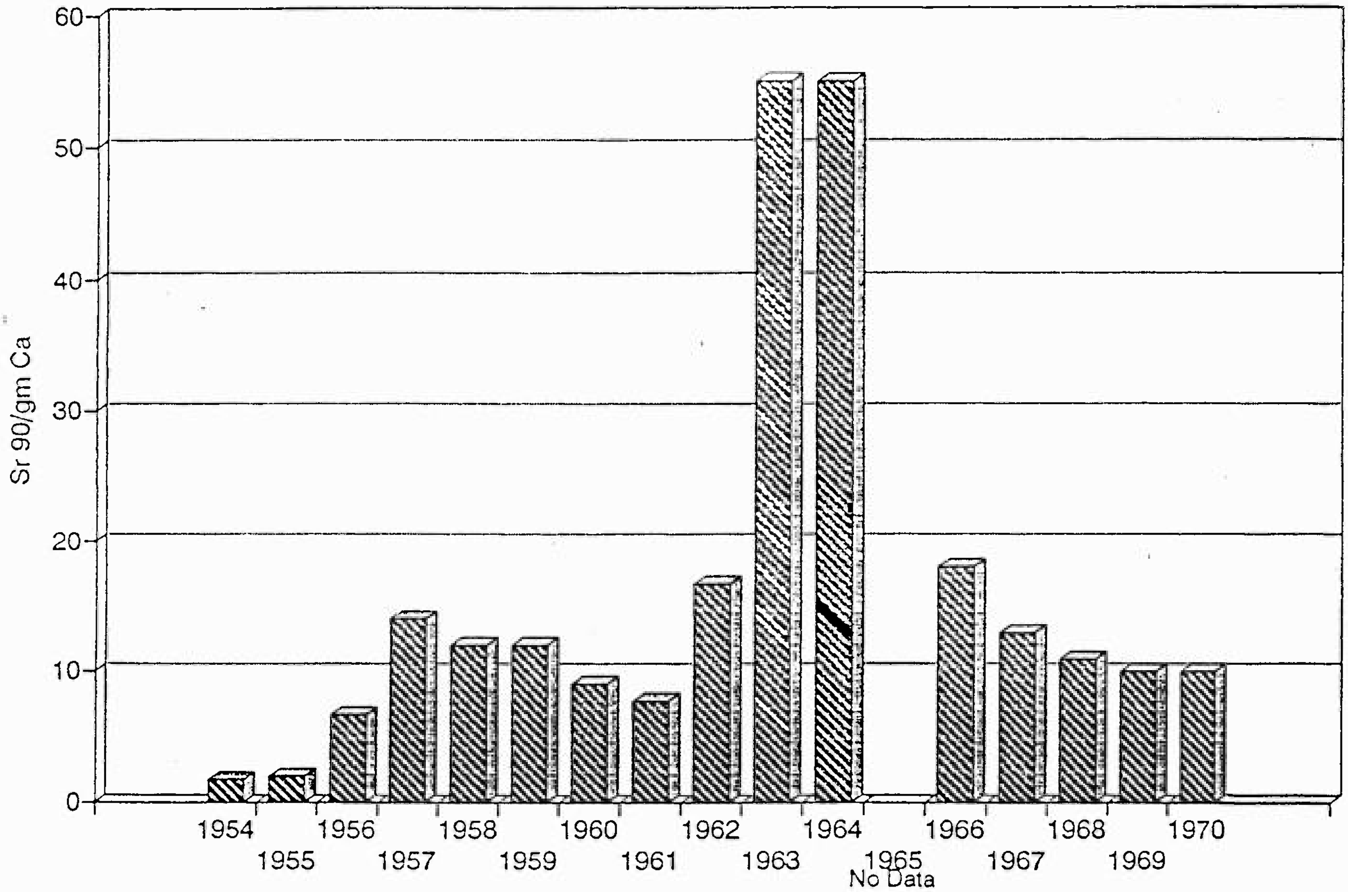
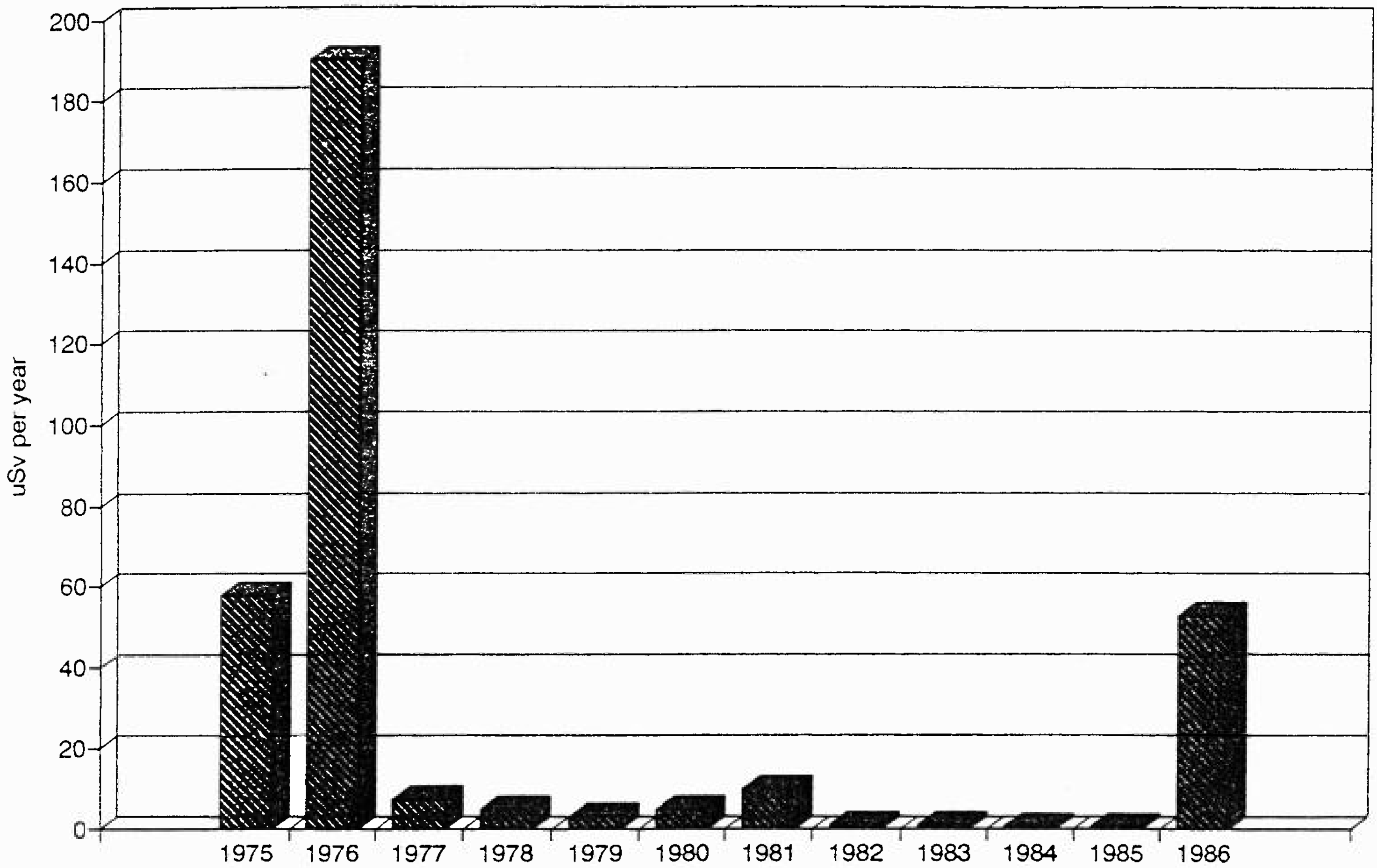


FIG. 3

Swiss Muhleberg Reactor

Yearly I-131 Doses Since Start of Reported Dose Calculations

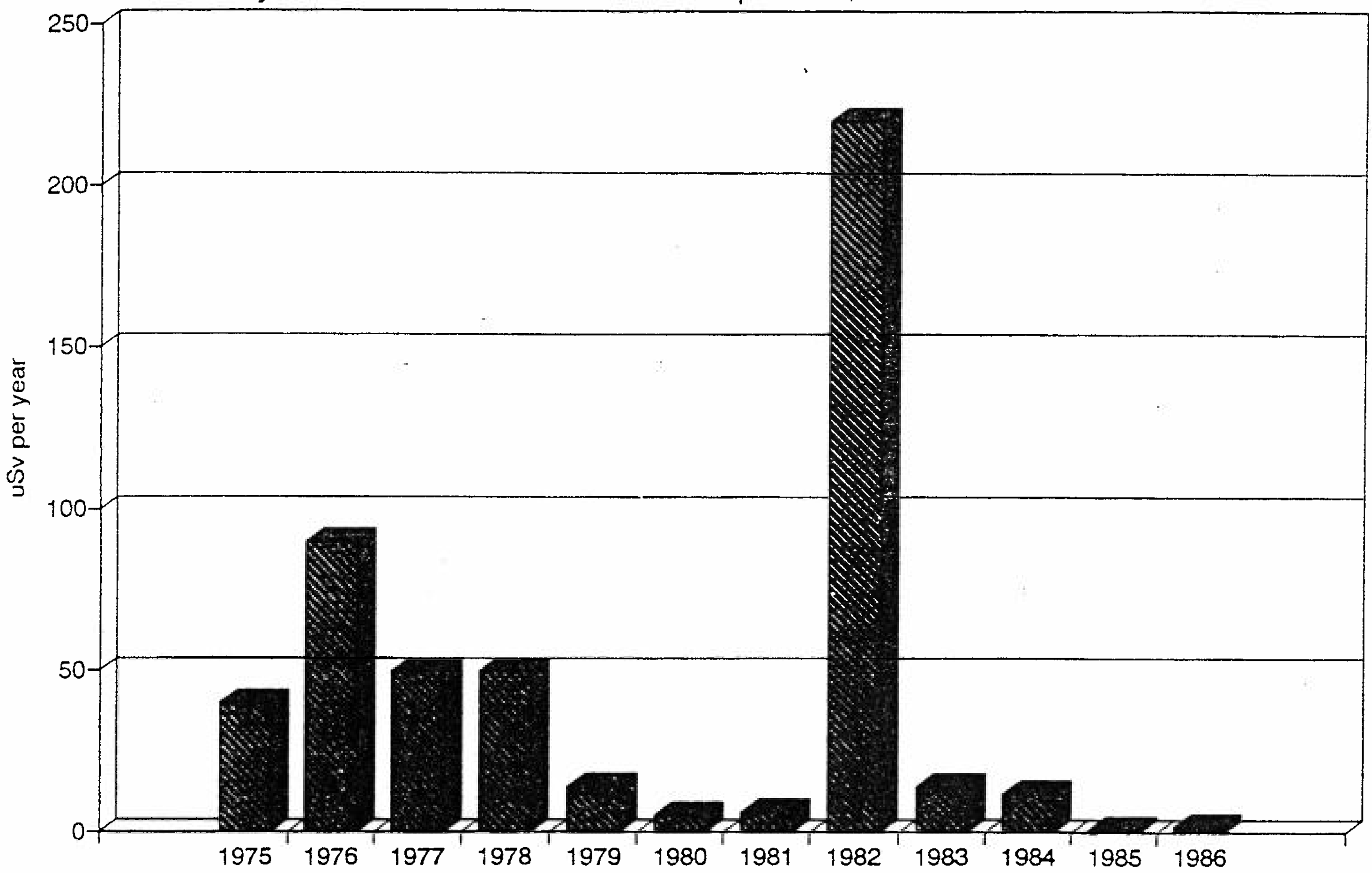


Source: Volkle et al: Fallout From Atmospheric Bomb Tests and Releases From Nuclear Installations, Radiation Phys. Chem. Vol 34, No. 2, pp 261-277, 1989

Fig 4a

Swiss Beznau Reactor

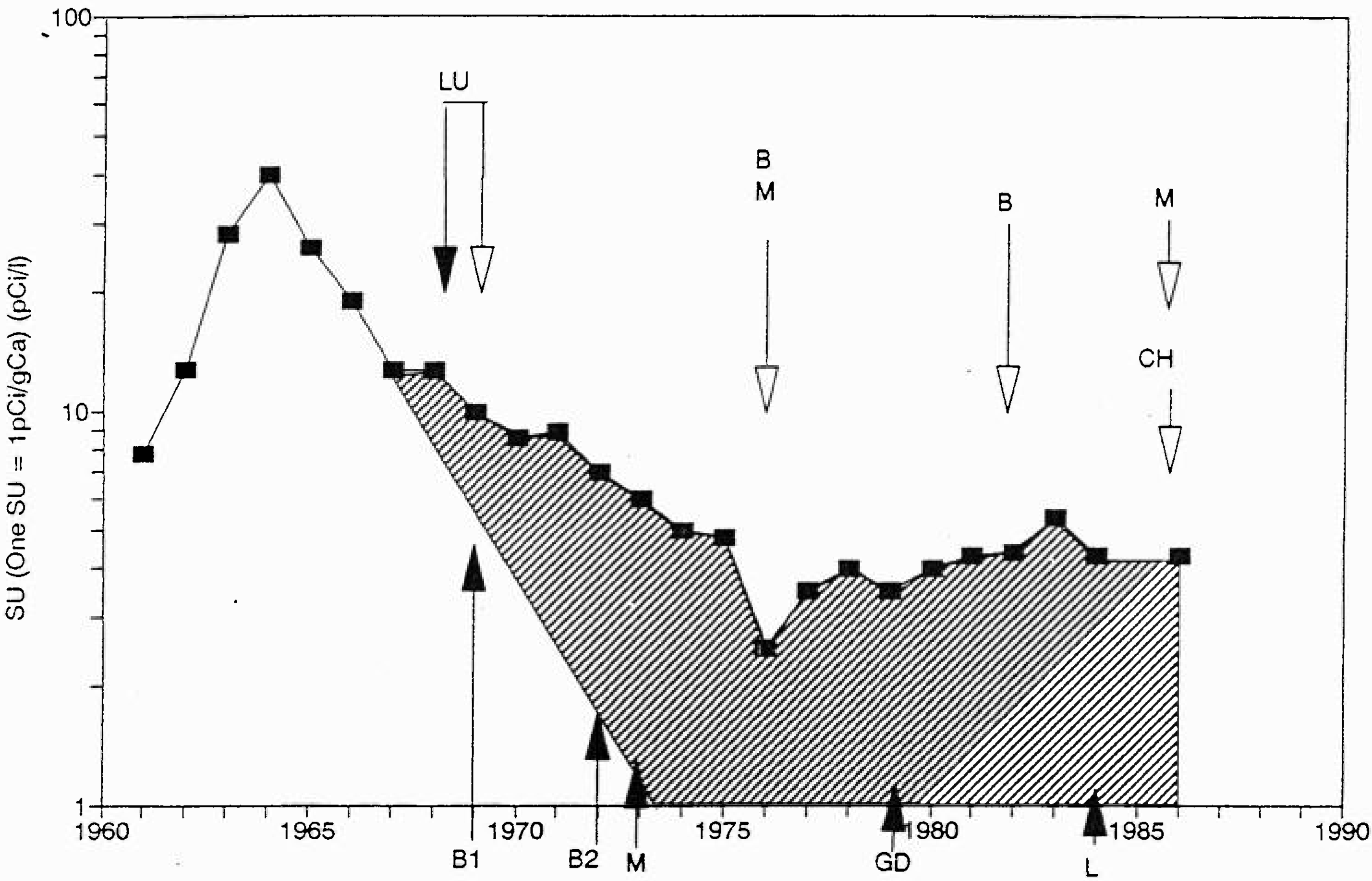
Yearly I-131 Doses Since Start of Reported Dose Calculations



Source: Volkle et al: Fallout From Atmospheric Bomb Tests and Releases From Nuclear Installations, Radiation Phys. Chem. Vol 34, No. 2, pp 261-277, 1989

FIG 4 b

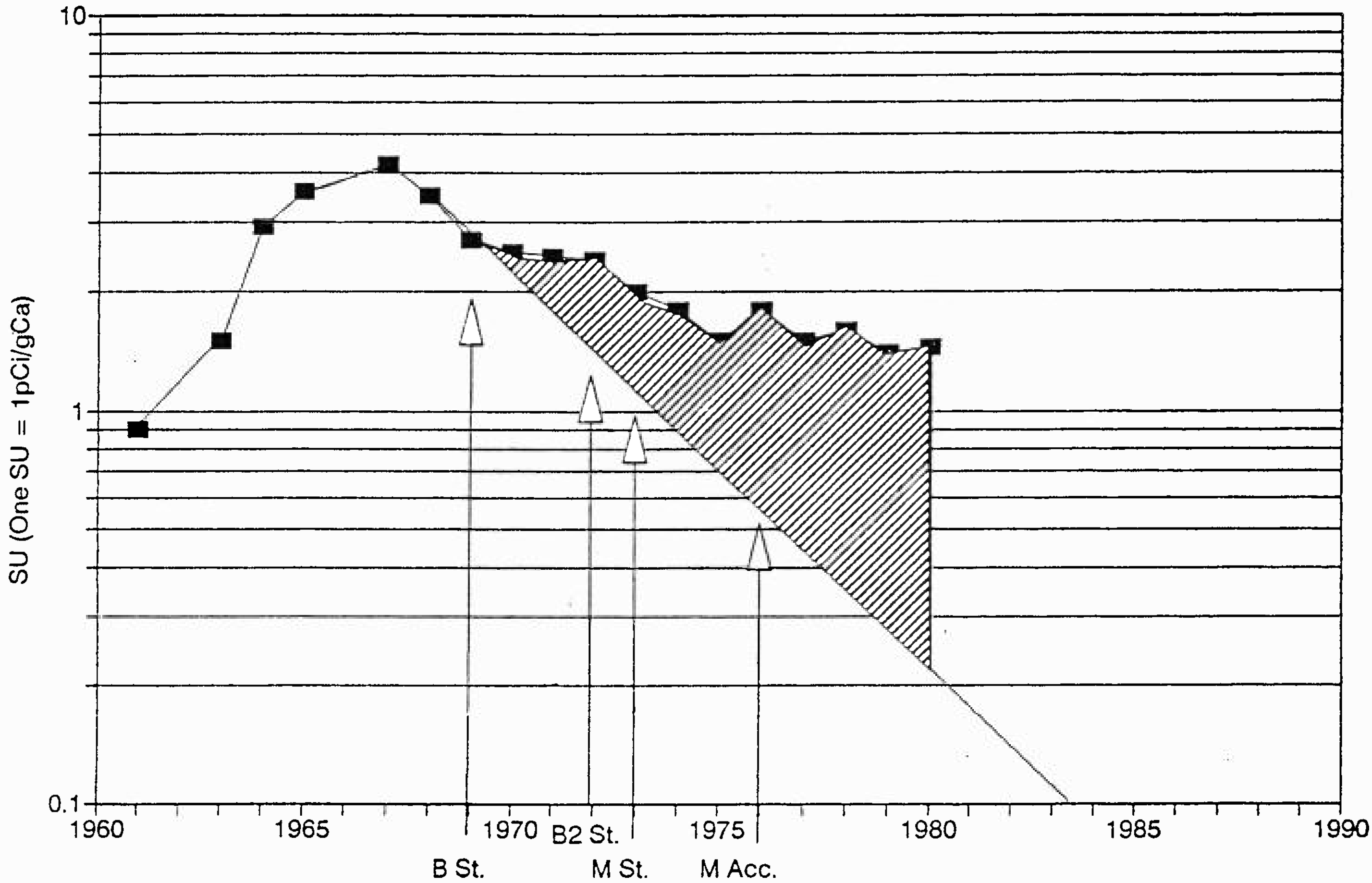
Strontium 90 In Milk



Source: Volkle et al: Fallout From Atmospheric Bomb Tests and Releases From Nuclear Installations, Radiation Phys. Chem. Vol 34, No. 2, pp 261-277, 1989. Data from 1980-86 from the annual reports of the Swiss Federal Commission for Surveillance of Radioactivity.

FIG 5

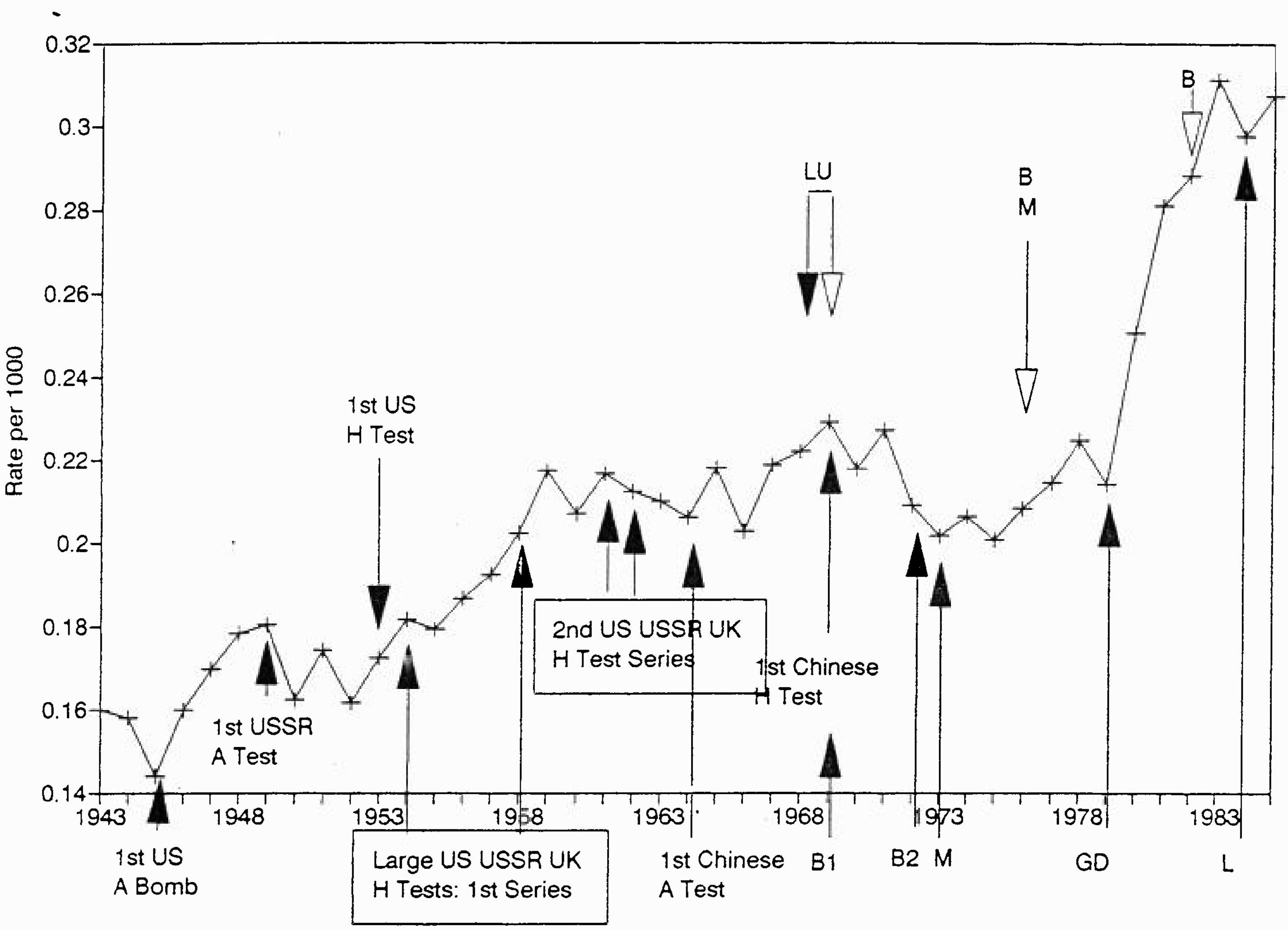
Strontium 90 In Human Bone



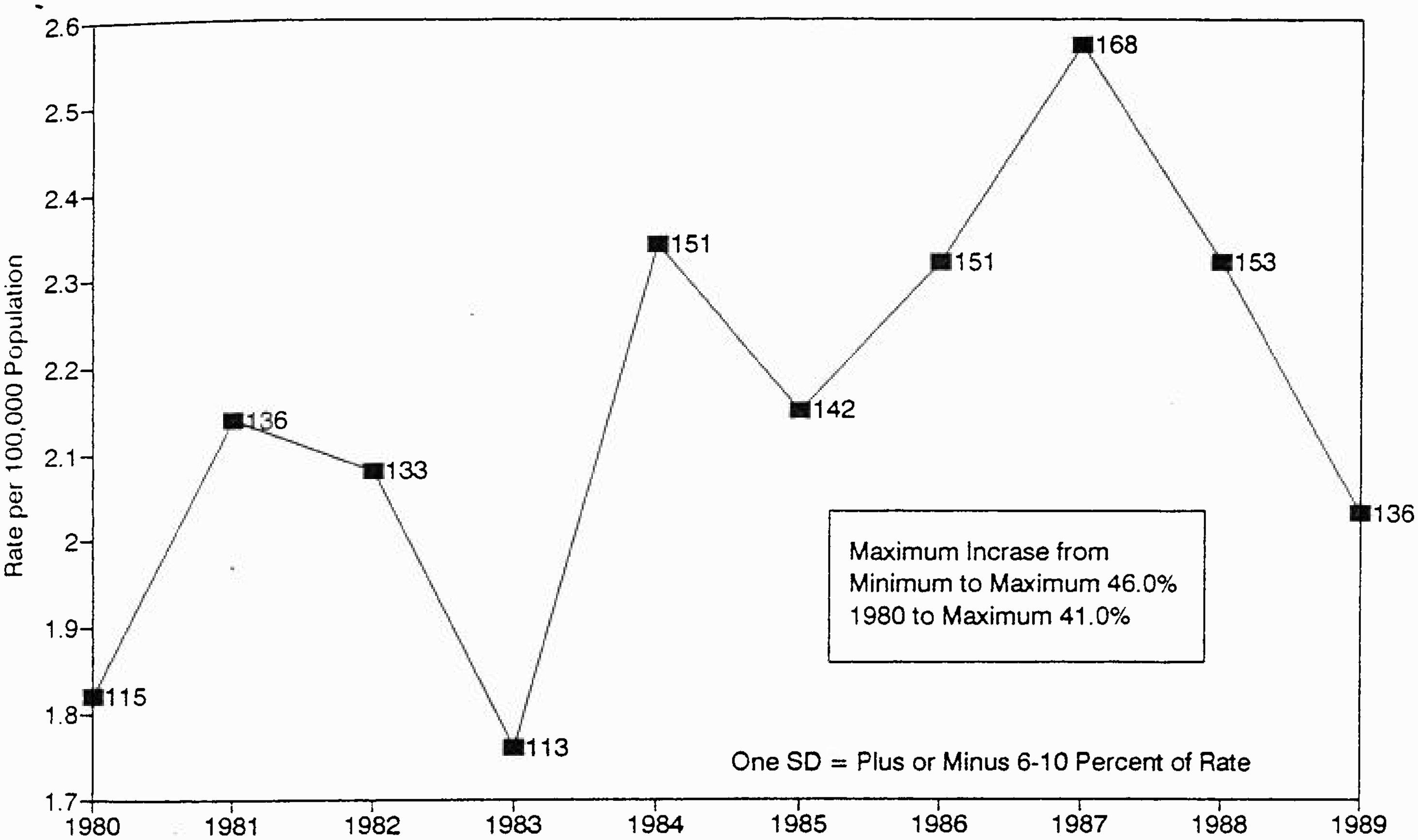
Source: Volkle et al: Fallout From Atmospheric Bomb Tests and Releases From Nuclear Installations, Radiation Phys. Chem. Vol 34, No. 2, pp 261-277, 1989

Swiss Mortality Rate: Other Tumors

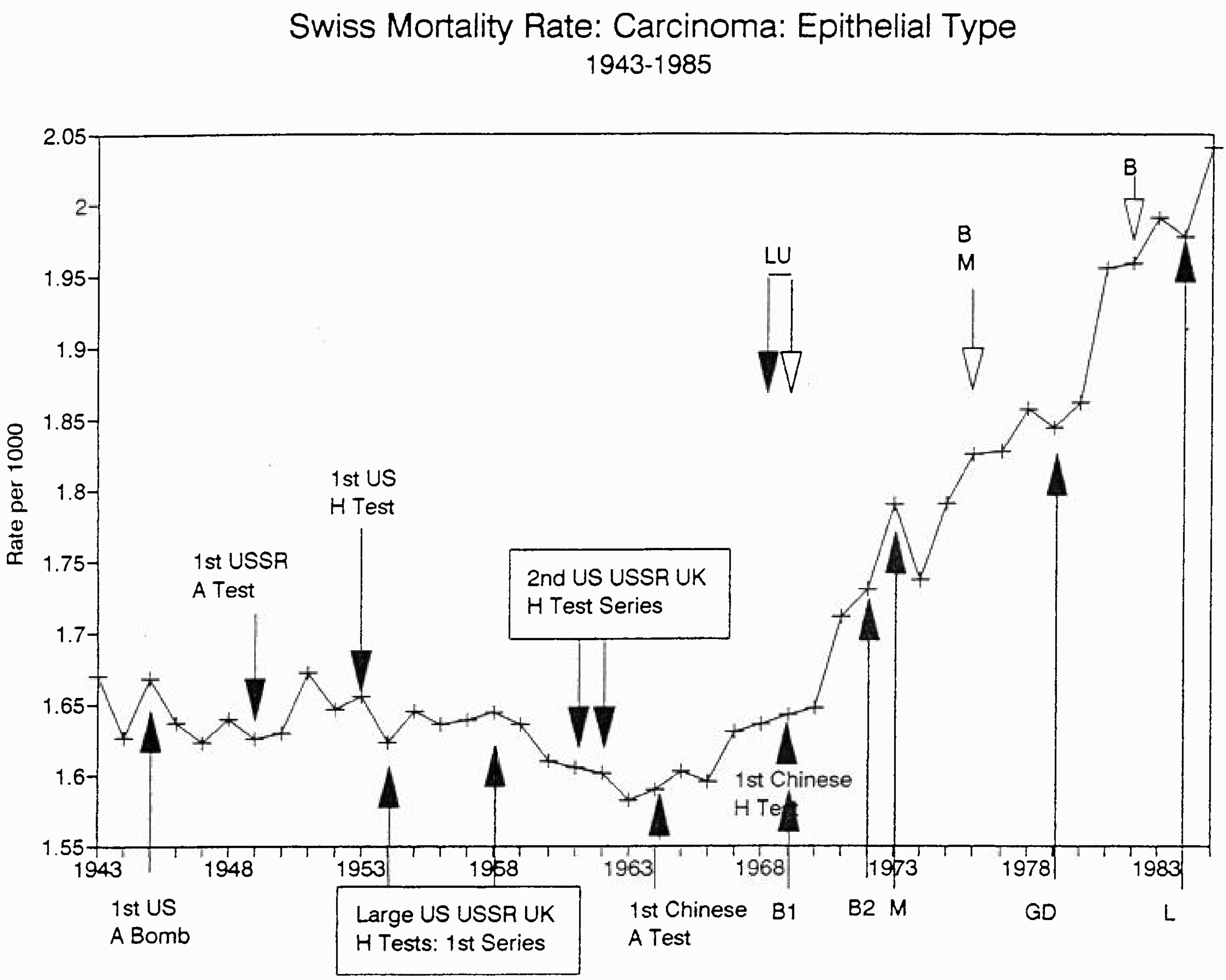
1943-1985



1980-1989 Swiss Mortality Rate for Acute Myeloid Leukemia



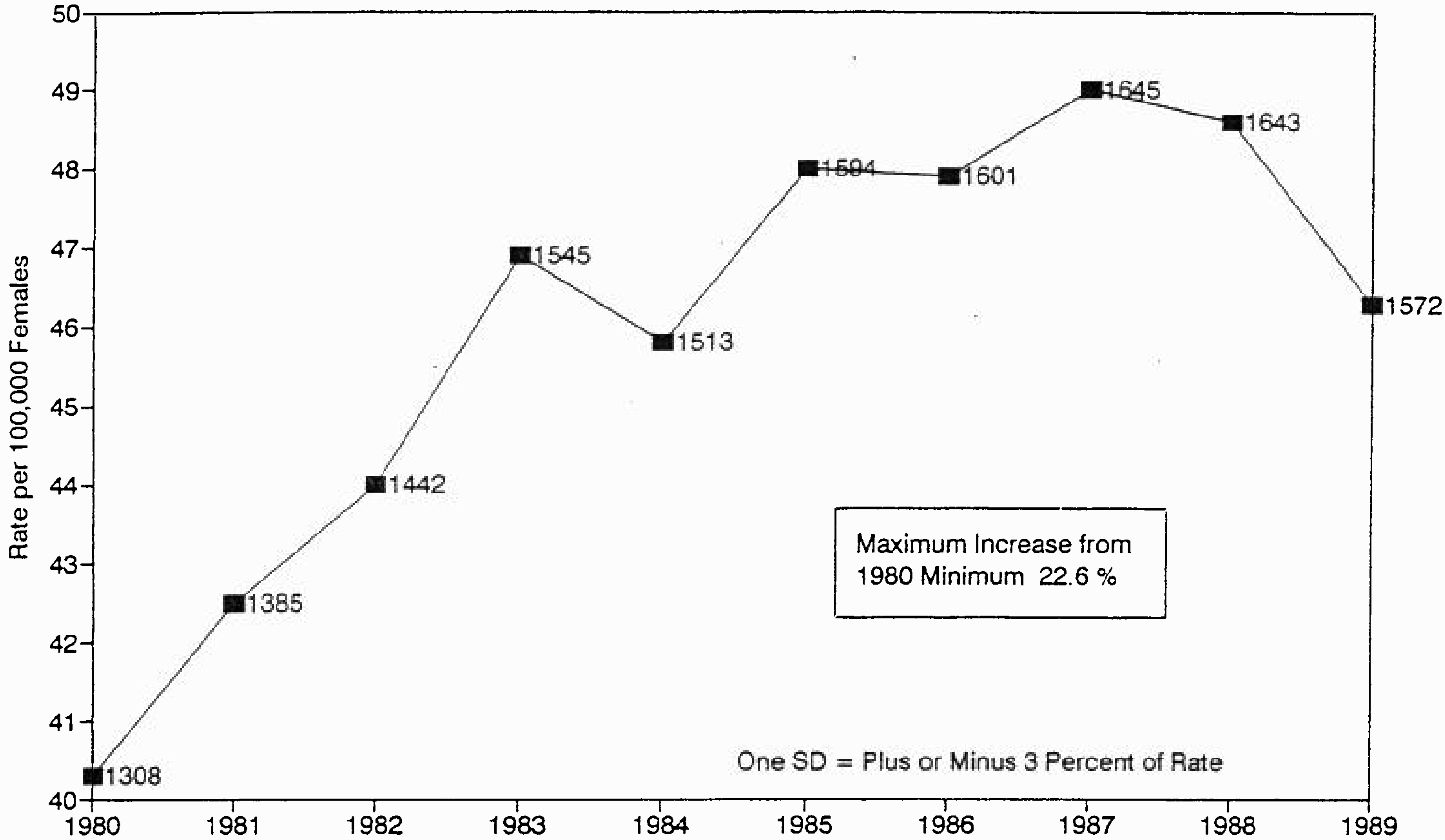
Source: Swiss Federal Office for Statistics, CH 033 Bern



Swiss Mortality Rate: Carcinoma: Epithelial Type
1943-1985
Rate per 1000
2.05
2
1.95
1.9
1.85
1.8
1.75
1.7
1.65
1.6
1.55
1943
1948
1953
1958
1963
1968
1973
1978
1983
1st US
A Bomb
1st USSR
A Test
1st US
H Test
Large US USSR UK
H Tests: 1st Series
2nd US USSR UK
H Test Series
1st Chinese
A Test
1st Chinese
LU
B1
B2
M
B
M
GD
B
L

9

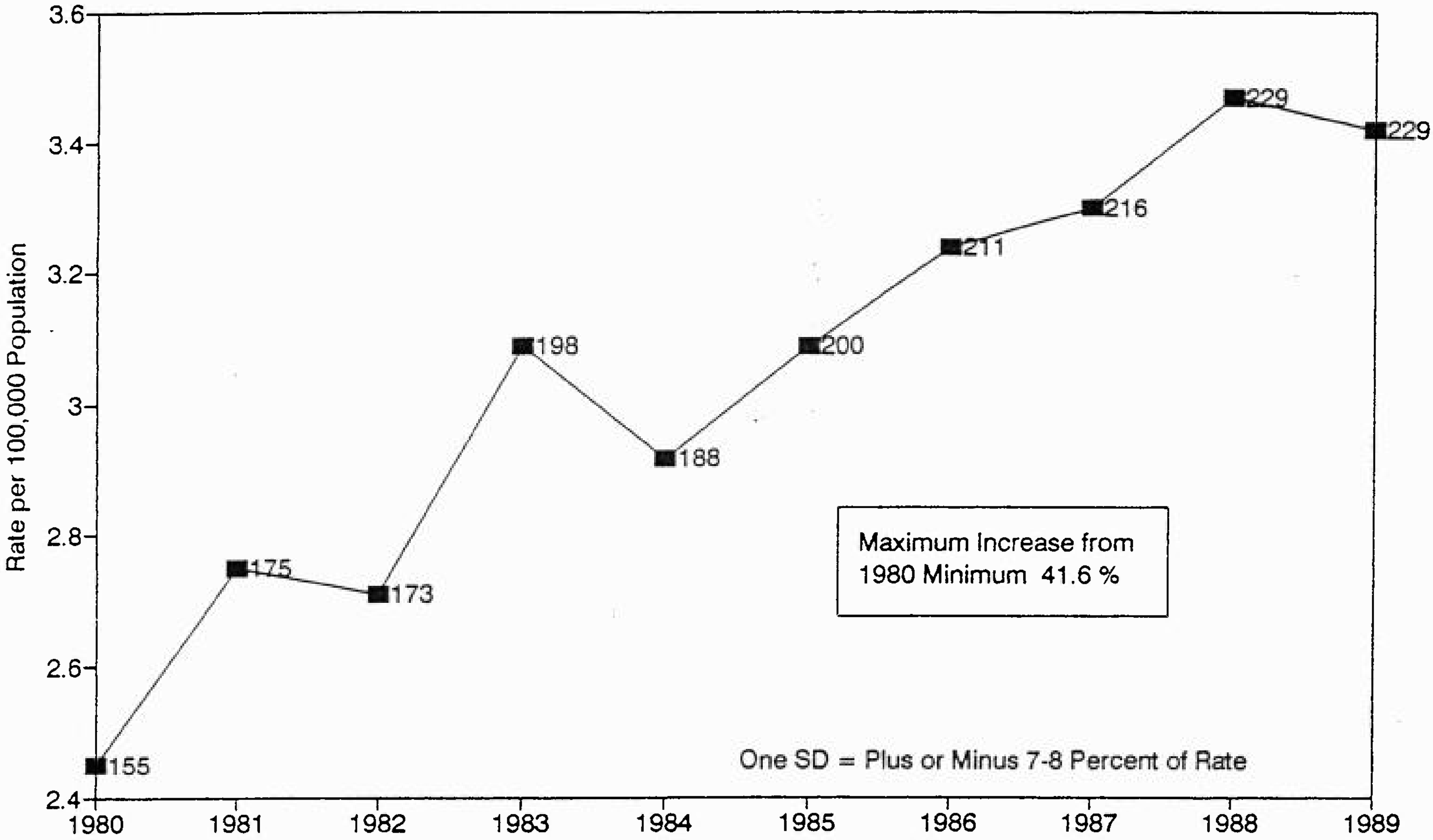
1980-1989 Swiss Mortality Rate for Breast Cancer per 100,000 Females



Source: Swiss Federal Office for Statistics, CH 033 Bern

FIG. 10

1980-1989 Swiss Mortality Rate for Malignant Melanoma

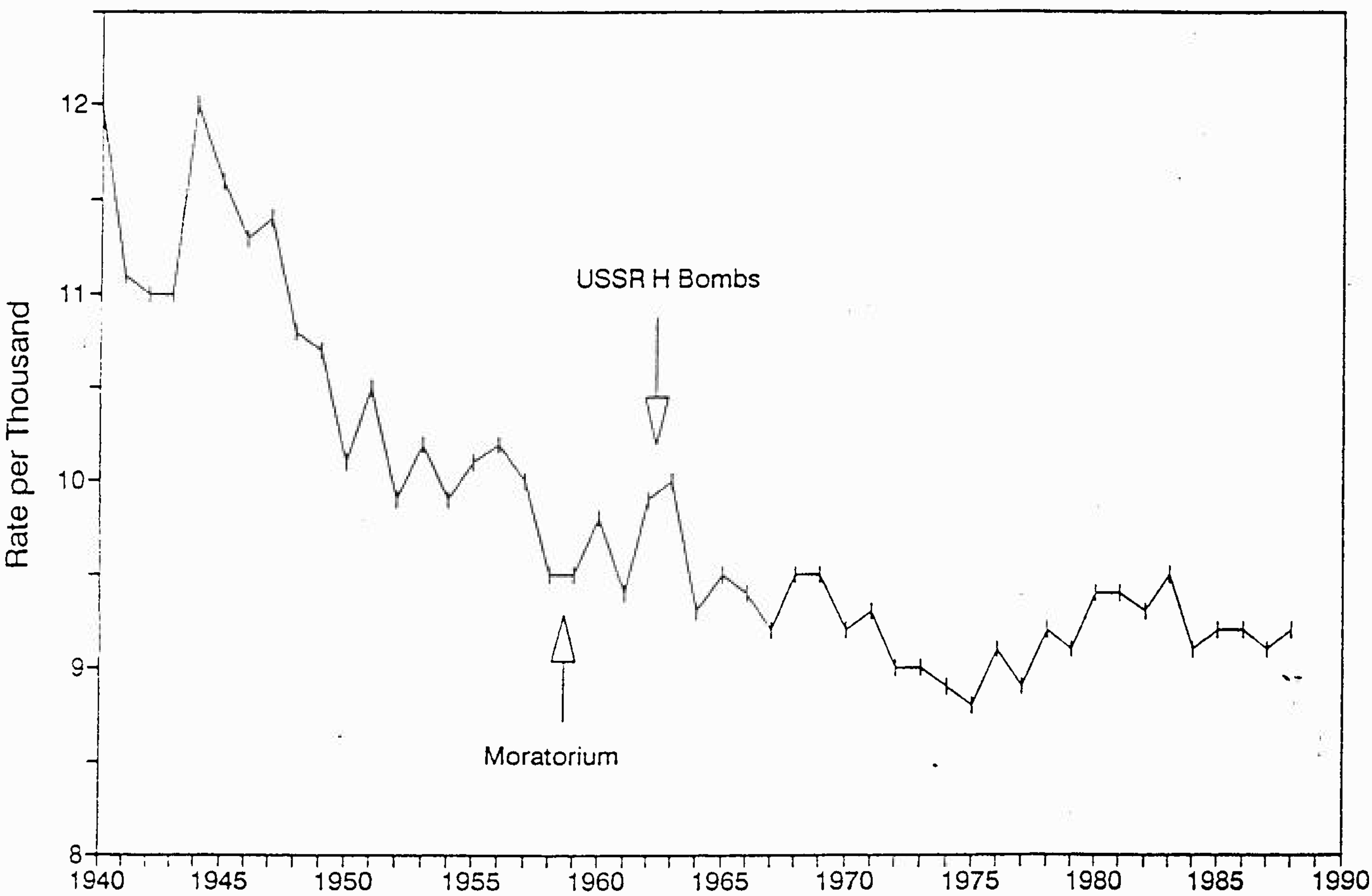


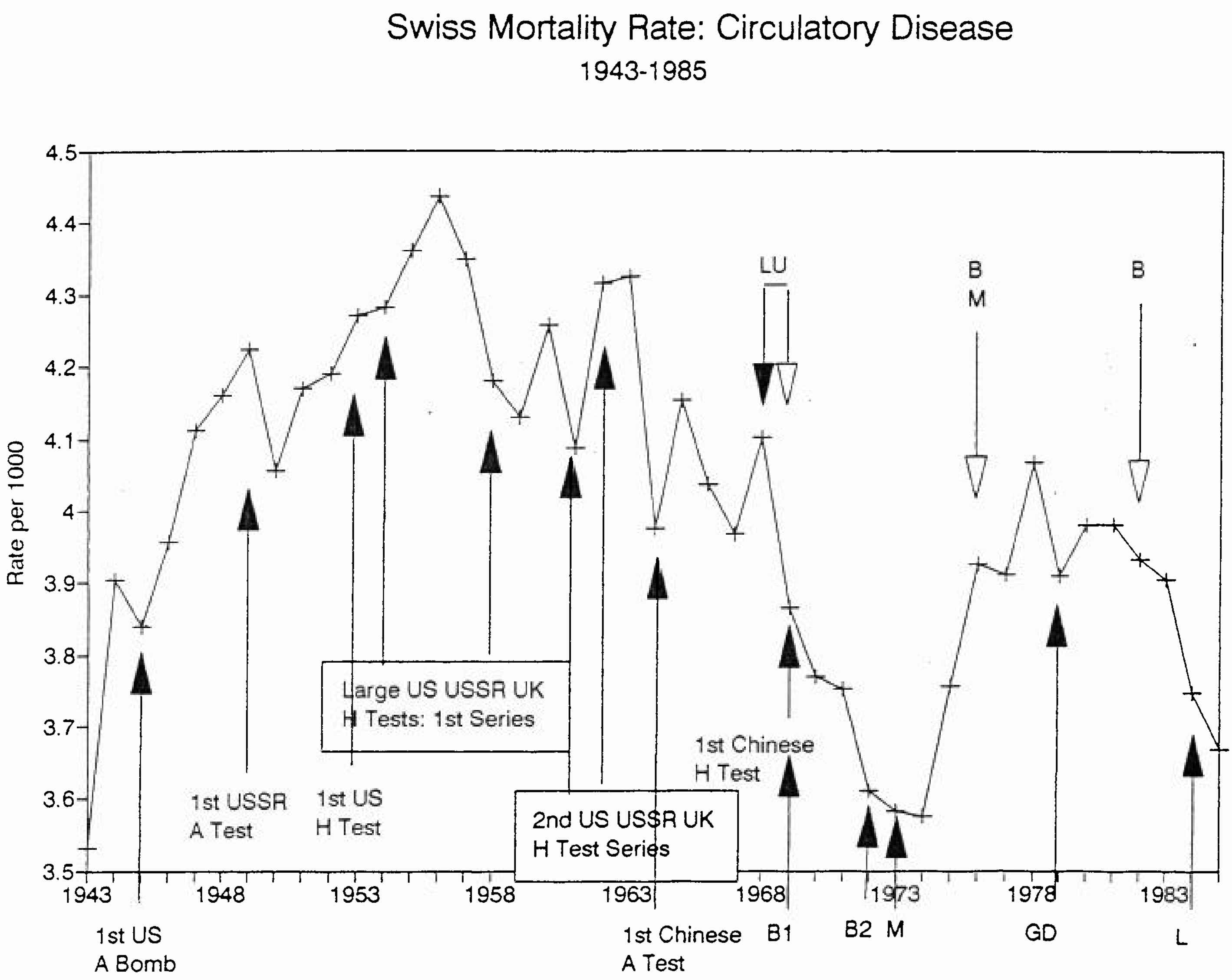
Source: Swiss Federal Office for Statistics, CH 033 Bern

FIG. 11

Figure 21

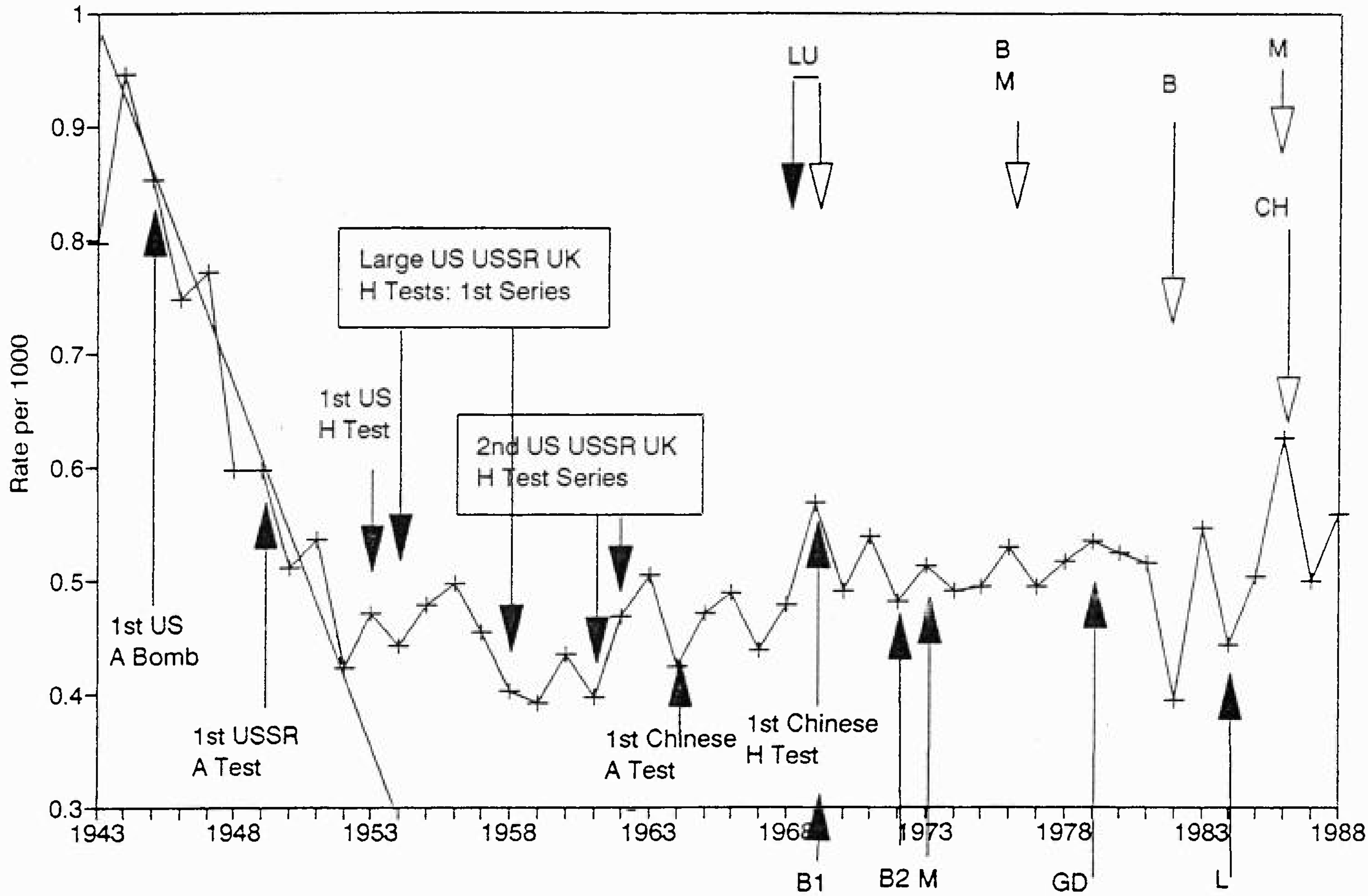
Swiss Mortality Rate Per Thousand
1940-1988





Swiss Mortality Rate: Circulatory Disease
1943-1985
Rate per 1000
4.5
4.4
4.3
4.2
4.1
4
3.9
3.8
3.7
3.6
3.5
1943
1948
1953
1958
1963
1968
1973
1978
1983
1st US
A Bomb
1st USSR
A Test
1st US
H Test
Large US USSR UK
H Tests: 1st Series
2nd US USSR UK
H Test Series
1st Chinese
A Test
1st Chinese
H Test
LU
B
M
B
B1
B2
M
GD
L

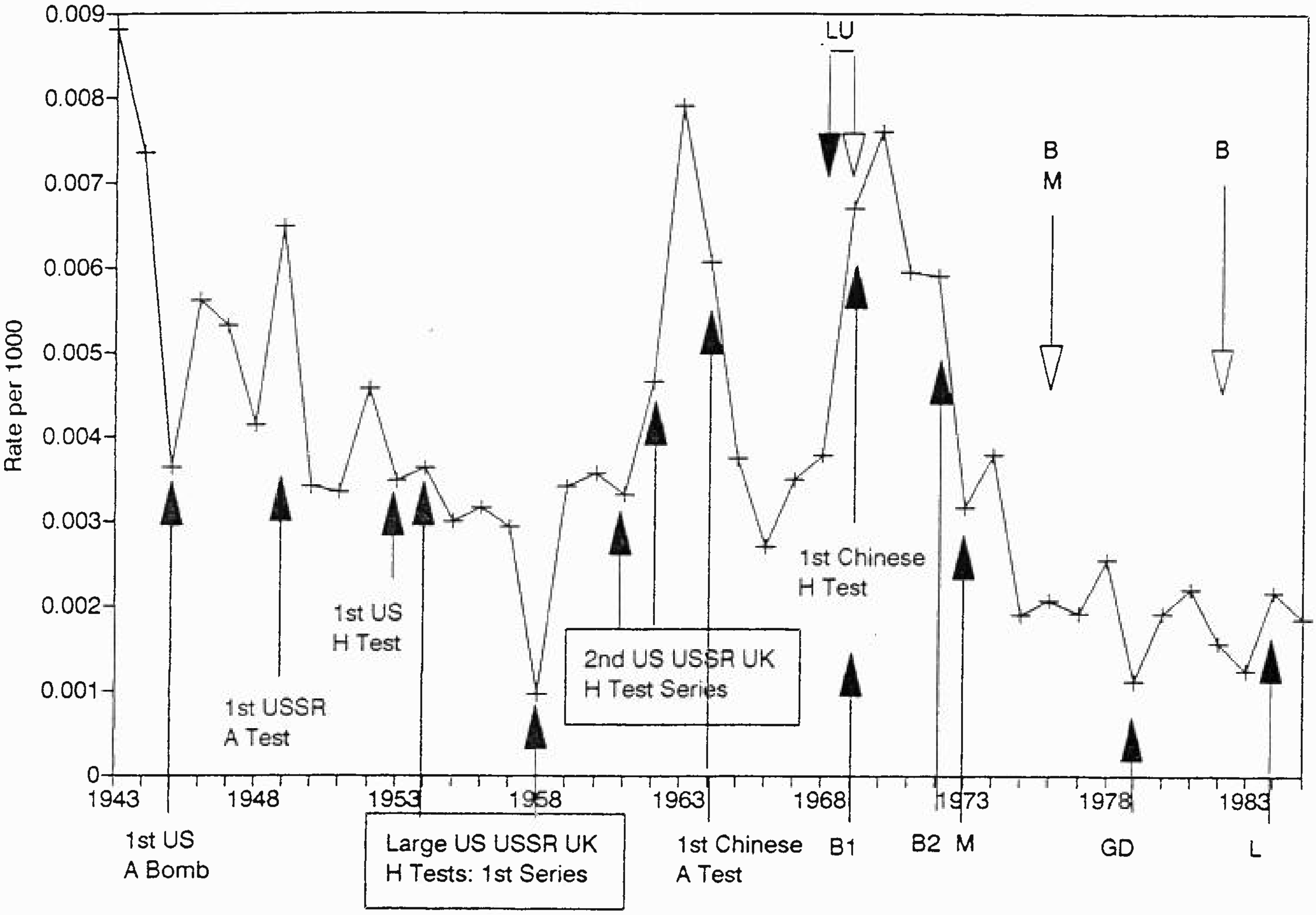
Swiss Mortality Rate: Total Respiratory
1943-1988



1943-1979 Data : Old Classification System; 1980-1988: New Classification System

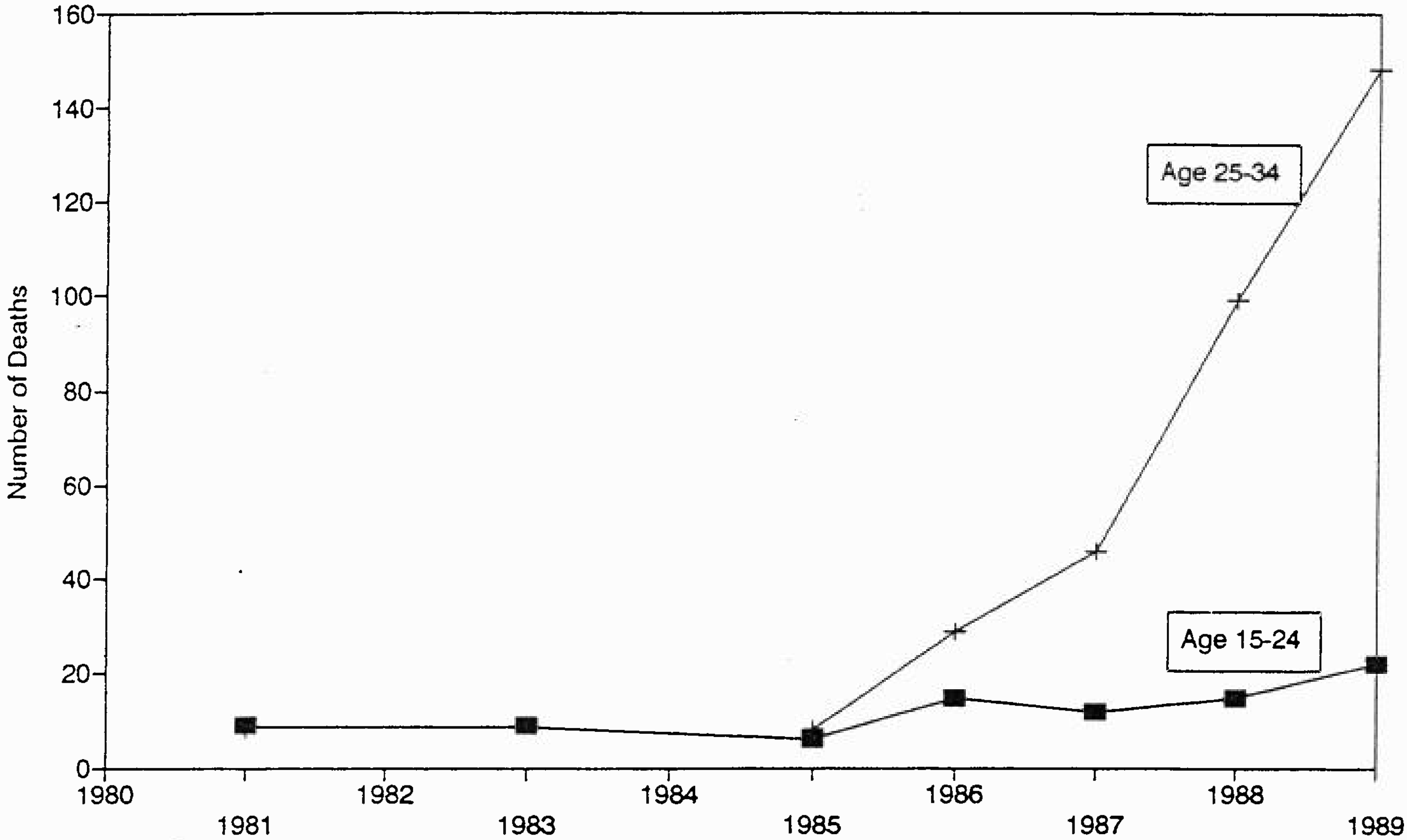
Swiss Mortality Rate: Meningitis

1943-1985

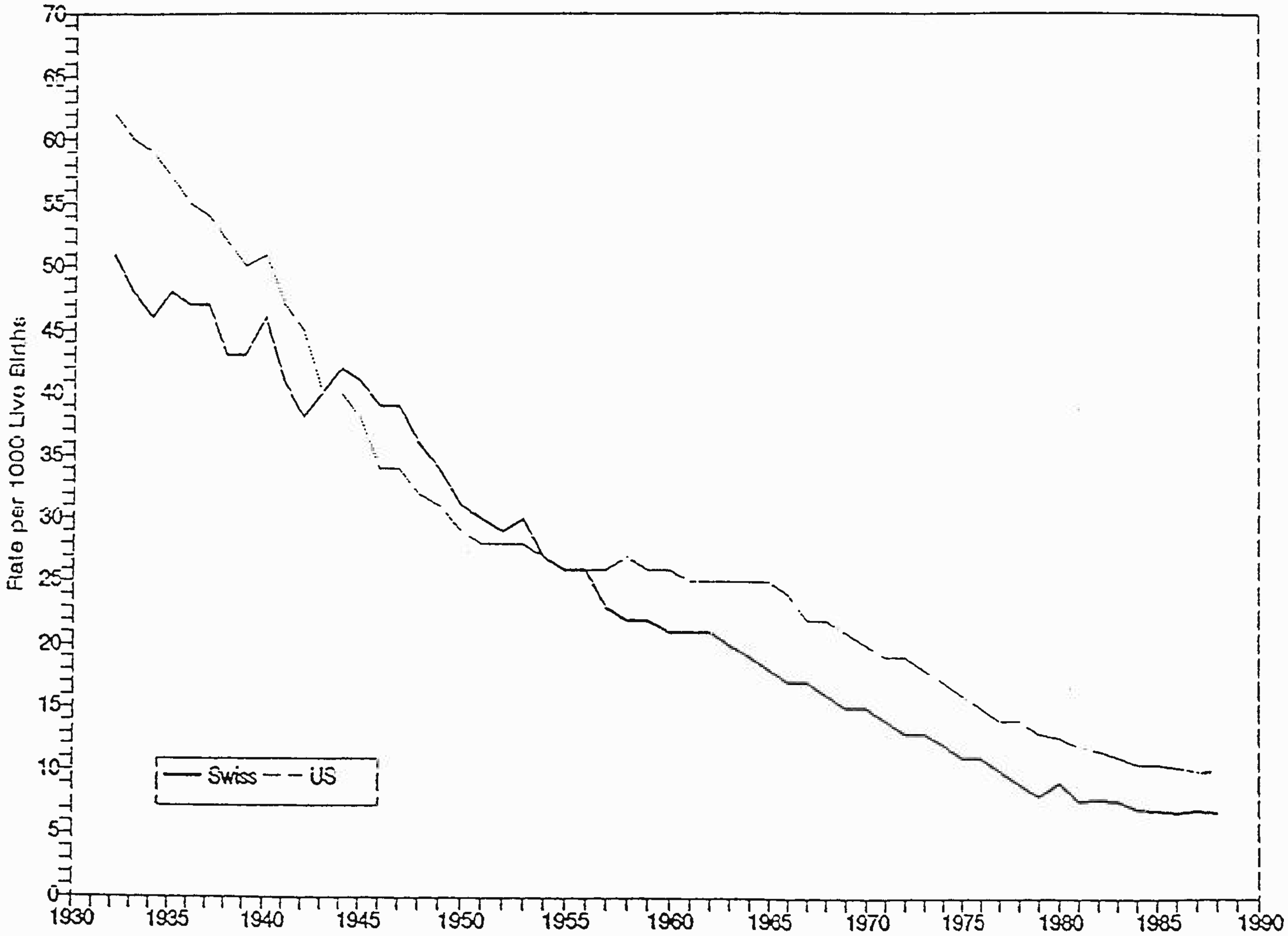


Swiss Mortality 1981-1989

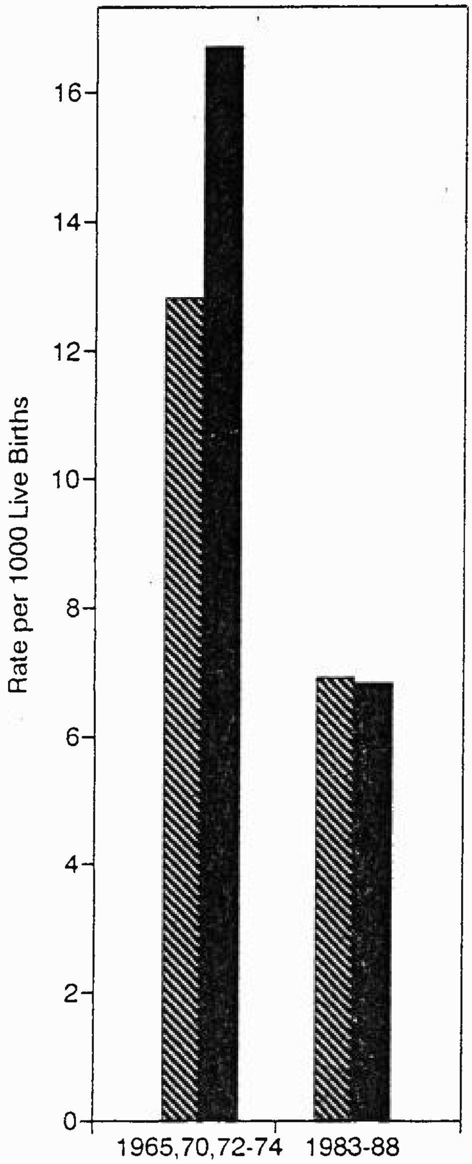
Infections and Parasitic Diseases: Age 15-24 and Age 25-34



Swiss and US Infant Mortality, 1930-1988



FIG



Swiss Infant Mortality for Five Nuclear and Five Non-nuclear Cantons: Comparison of Two Periods

Prior to 1974 the rural cantons of Uri, Obwalden, Nidwalden, Glarus, and Zug had for a select five year period an average infant mortality rate of 16.7 deaths per 1000 live births--30 percent higher than the average infant mortality rate of 12.8 for the five cantons of Zuerich, Basel, Bern, Aargau and Solothurn. The latter, unlike the five rural cantons, were close to the Swiss nuclear reactors, which began operation in the 1970s, and which for the period 1983-1988 had an average infant mortality rate somewhat greater than that of the rural cantons who had been spared the brunt of reactor releases. The different trends are statistically significant.

5 Nuclear Cantons

5 Non-nuc Cantons

FIG 15