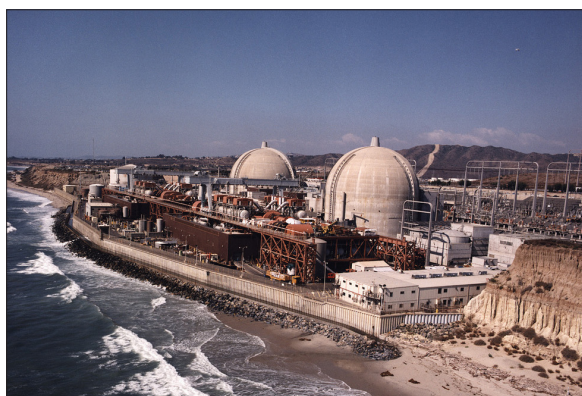


Analysis of Cancer Risks in Populations near Nuclear Facilities: Phase 1

Studies of health effects in populations (epidemiologic studies) could provide clues for a potential association between living near nuclear power plants and other nuclear facilities and risk of cancer. However, such studies are challenging because of incomplete data on occurrences of cancer and cancer deaths in geographic areas of interest (i.e., smaller than the county level), incomplete information on radioactive releases from nuclear facilities during early years of operation, and other factors. Moreover, because radioactive releases are generally low, any risks would be expected to be small and difficult to detect with statistical certainty. This report identifies two health study designs deemed suitable for assessing cancer risks in populations near nuclear facilities, having both scientific merit and the ability to address some public concerns. A pilot study would be needed to determine whether either or both of the two recommended study designs are feasible to implement on a large scale and to assess the required time and resources.

The question of whether there are cancer risks associated with living near a nuclear facility is of great interest to the public, especially those living closest to the facilities. Today, the United States has 104 operating nuclear reactors and 13 fuel cycle facilities that are regulated by the U.S.

Nuclear Regulatory Commission (USNRC). Airborne and waterborne emissions of radioactive materials from the facilities' normal operations (called effluents) can expose nearby populations to ionizing radiation. This radiation could elevate the risk of cancer in the exposed populations. The USNRC has been using the results of a 1990 National Cancer Institute (NCI) survey as its primary resource for communicating with the public about cancer risks near the nuclear facilities it regulates. The NCI study concluded that "if nuclear facilities posed a risk to neighboring populations, the risk was too small to be detected by a survey such as this one." However, that study is now outdated and has recognized limitations.



The San Onofre Nuclear Generating Station near San Clemente, CA

Photo courtesy: SoCal Edison

The USNRC requested that the National Academy of Sciences provide a de novo assessment of methodologies for carrying out cancer risk assessments in populations near USNRC-licensed nuclear facilities. The result of this Phase 1 study will be used to inform the design of

the cancer risk assessment that would be carried out in Phase 2.

The Challenges of Assessing Cancer Risks

The availability and access to quality data is one of the main challenges for carrying out an assessment of cancer risks in populations near nuclear facilities. These challenges include:

- *Uneven availability and quality of data on cancer deaths and incidence at geographic levels smaller than a county.* Cancer death and incidence are tracked by individual states, and the availability and quality of data vary from state to state. In general, cancer mortality data are available electronically since about 1970, but subject address

at time of death is not captured until much later in some states (In the absence of subject address at time of death, mortality data cannot be geo-coded at levels of geographic interest for a population health effects study, such as census tracts.) Cancer incidence data of known quality are generally available from about 1995, although such data are available for earlier times in some states. These data include address at time of diagnosis and have been widely geo-coded.

- *Uneven availability and quality of data on nuclear facility effluent releases.* Effluent release data may not be available and data quality may be poor for some nuclear facilities, especially during early years of facility operations. Effluent releases from many nuclear facilities were much higher in the past and their radionuclide compositions have changed over time. Uncertainties in dose estimates may be much higher in years when effluent releases were highest.
- *Inability to reliably capture information on population mobility, risk factors, and potential confounding factors.* There is no centralized source of information on residential histories or lifestyle characteristics of individuals who live in the United States. The U.S. Census provides decadal snapshots of some population characteristics, including population size and distribution with respect to age, race/ethnicity, gender, educational level, and income. However, data on population lifestyle risk factors, including exposure to cigarette smoking and access to healthcare, are limited to state-level health surveys and are not consistently available from state to state at the same level of resolution.
- *Low expected statistical power.* Radiation doses from monitored and reported radioactive effluent releases from nuclear facilities are expected to be low. As a consequence, studies of health effects in populations living near nuclear facilities may not have adequate statistical power to detect increases in cancer risks arising from these monitored and reported releases, which are presumed to be small.

Study Designs Considered

An assessment of cancer risks in populations living near nuclear facilities could be carried out using several different study designs, each of which has advantages and disadvantages for estimating cancer risks. Study designs include:

- *Risk-projection models* estimate cancer risks by combining estimates of population radiation dose or dose surrogate (e.g., distance and direction

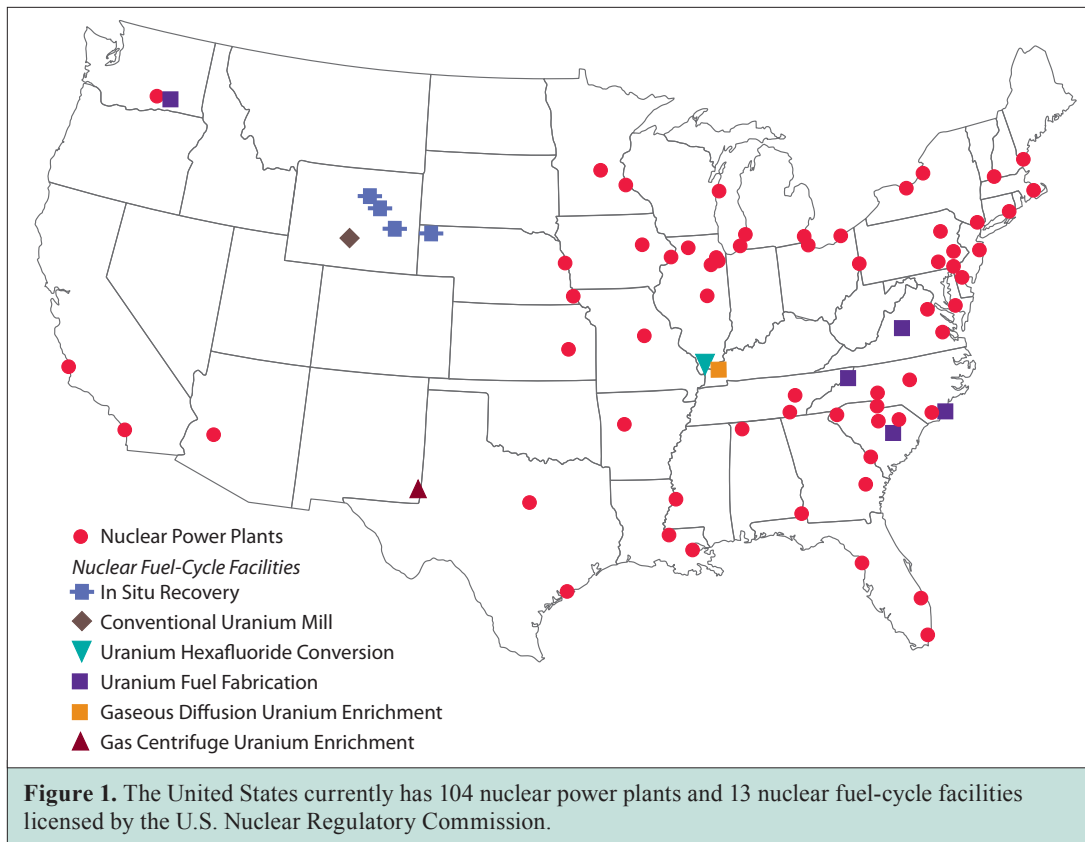
from a nuclear facility) with what is known about radiation and cancer risk from studies of other exposed populations, for example, Japanese atomic bombing survivors.

- *Ecologic studies* estimate cancer risks by comparing observed cancer incidence/mortality rates in populations, considered as a group rather than as individuals, as a function of average radiation doses/dose surrogates for those populations.
- *Cohort studies* estimate cancer risks by following individuals for a specified period of time to determine the rate or risk of cancer as a function of doses/dose surrogates. In a *prospective* cohort study, subjects are followed from the present to a future time; in a *retrospective* cohort study, subjects are followed from a past time to a more recent time, usually via available records.
- *Case-control studies* estimate cancer risks by comparing radiation dose/dose surrogates between individuals selected because they have (cases) or do not have (controls) cancer.

In the absence of information on residential history, most studies make assumptions about relevant exposures based on information about location of residence at one time point in the lifetime of the study cases, such as place of residence at time of birth, or place of residence at time of diagnosis or death, with the equivalent time for controls. This single time point of place of residence may not be the most relevant one regarding radiation exposures from nuclear facilities. Studies that are based on individuals, such as cohort and case-control studies, can potentially provide stronger evidence for or against an association between radiation exposure and cancer compared to an ecologic study. However, such studies are likely to involve fewer cancer cases than an ecologic study due to the effort involved in subject selection and data collection. The required effort could be reduced by partnering with existing multistate cancer studies that have already linked cancer and birth registration data.

Dose Reconstruction in Support of Studies of Population Health Effects

Studies of health effects that make assumptions about exposure based solely on the distance of a person's place of residence from the nuclear facility (the closer one lives to a nuclear facility, the more exposed) can be improved by incorporating actual dose estimates into the risk analyses. Data on radioactive effluent releases, direct exposure, and weather data (e.g., the direction of prevailing winds) collected by nuclear facility



licensees, if available, are likely to be sufficiently accurate to develop rough estimates of annual doses that adequately reflect variations as a function of distance and direction. Existing or newly developed computer models could be used to obtain rough estimates of doses to support an epidemiology study.

Recommended Studies of Health Effects

Should the U.S. Nuclear Regulatory Commission decide to proceed with epidemiologic studies of cancer risks in populations near nuclear facilities, the committee recommended two study designs: (1) an ecologic study of multiple cancer types of populations living near nuclear facilities; (2) a record-linkage based case-control study of pediatric cancers in children born near nuclear facilities.

The **ecologic study** should assess cancer incidence and mortality of relatively common cancer types in populations within approximately 50 kilometers (30 miles) of nuclear facilities for the operational histories of those facilities to the extent allowed by available data. A study zone of this size would incorporate both the most potentially exposed as well as essentially unexposed regions to be used for comparison purposes. A sub-analysis should specifically be carried out for highly radiogenic cancers such as leukemia in children. The study should examine

associations between (i) cancer and distance/direction from the nuclear facility and (ii) cancer and estimated radiation dose, both at the census tract level.

The **record-linkage based case-control study** should assess the association of childhood cancers (diagnosed at younger than 15 years of age) in relation to maternal residential proximity at the time of birth of the child under study, among those whose address at time of delivery was within a 50-kilometer radius of a

nuclear facility. The study period for individual facilities should be based on the quality and availability of cancer incidence information in each state. Controls born within the same 50-kilometer radius as the cases should be selected from birth records to match cases on birth year at a minimum. Absorbed doses/dose surrogates should be based on address of the mother's place of residence at time of delivery, as determined from birth records.

These recommended studies are complementary in that each addresses different aspects of cancer risks and could be carried out individually or together. The ecologic study would provide a broad assessment of population cancer risks over the operational histories of nuclear facilities to the extent allowed by available data. The record-linkage based case-control study would provide an assessment of early life exposure to radiation and cancer risk during more recent operating periods of nuclear facilities, and it would provide more focused analysis than is possible by the ecologic study.

Need for a Pilot Study

In order to assess the feasibility of the recommended epidemiologic studies on a large scale and to estimate the required time and resources, the committee recommended that a pilot study be carried out. The committee recommends that these six nuclear power plants and one

fuel cycle facility become part of the pilot study: Dresden (Illinois), Millstone (Connecticut), Oyster Creek (New Jersey), Haddam Neck (Connecticut), Big Rock Point (Michigan), San Onofre (California), and Nuclear Fuel Services (Tennessee). These facilities are good candidates to evaluate study feasibility because they represent both currently operating and decommissioned facilities that started operation in different time points and with some variation in: a) the population size in close proximity, b) quality and maturity of cancer registration, c) level of complexity for registry's research approval processes and research support. The pilot study would focus on:

- Collecting effluent release and weather data for the 7 nuclear facilities.
- Development of a computer model to obtain dose estimates as a function of distance (0 to 50 kilometers from the plant) and direction for each of these seven facilities.
- Retrieving of cancer incidence and mortality data at the census tract level within 50 kilometers of these seven facilities to assess feasibility of the recommended ecologic study.

- Conferring with investigators who are conducting linkages of cancer and birth registration data to identify eligible cases of pediatric cancers and matched controls to assess feasibility of the recommended record based case-control study. Where such linkages are not already in place, link birth registration and cancer incidence data to identify eligible cases of pediatric cancers and matched controls.

Stakeholder Engagement

Stakeholder engagement is an essential element of any risk assessment process that addresses important public interests and seeks to have maximum acceptance of the results. If a Phase 2 study goes forward, efforts should be made to:

- Identify key stakeholders and stakeholder groups with whom engagement is essential.
- Assess stakeholder concerns, perceptions and knowledge.
- Communicate the questions that the Phase 2 study can address, its strengths and limitations and its results in forms that are useful to different stakeholder groups.

Read or purchase this report and locate information on related reports at
<http://dels.nas.edu/nrsb>

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The National Academies appointed the above committee of experts to address the specific task requested by the U.S. Nuclear Regulatory Commission. The members volunteered their time for this activity; their report is peer-reviewed and the final product approved by both the committee members and the National Academies. This report brief was prepared by the National Research Council based on the committee's report.



For more information, contact the Nuclear and Radiation Studies Board at (202) 334-3066 or visit <http://dels.nas.edu/nrsb>. Copies of *Analysis of Cancer Risks in Populations near Nuclear Facilities: Phase 1* are available from the National Academies Press, 500 Fifth Street, NW, Washington, D.C. 20001; (800) 624-6242; www.nap.edu.

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