CHROMIUM MEDICAL SURVEILLANCE PROJECT

SUMMARY OF FINAL TECHNICAL REPORT

Environmental Health Services
Division of Epidemiology, Environmental and Occupational Health Services

New Jersey Department of Health

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This document is a summary of the final technical report of the New Jersey Department of Health's Chromium Medical Surveillance Project. A copy of the full report and a companion volume containing appendices to the report are available from:

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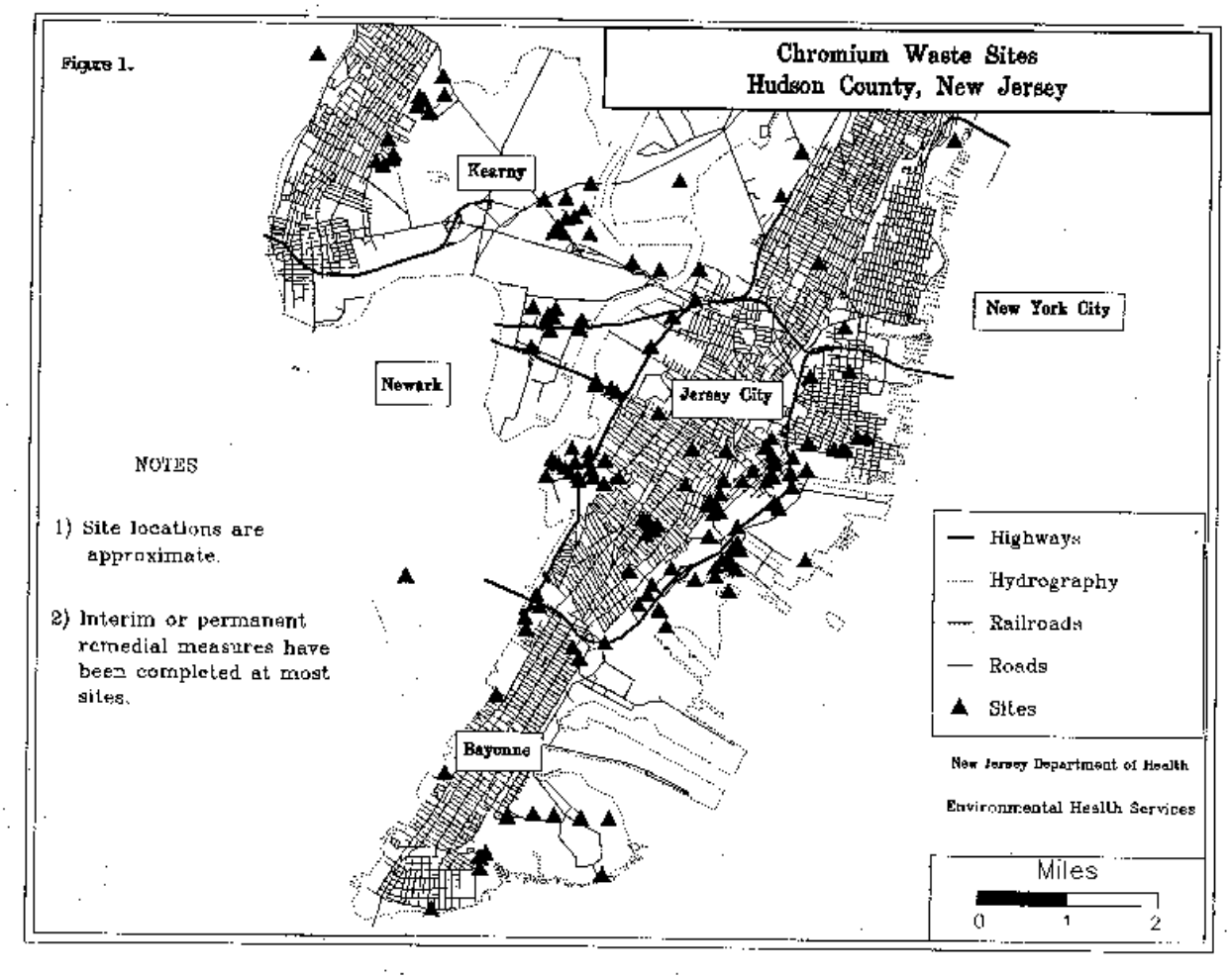


Background

One of the most important hazardous waste problems in New Jersey has been the potential for human exposure to chromium contaminated soils and dust, in parts of Hudson County, New Jersey. Waste material (called "slag") was created by three chromite ore smelting facilities that operated in Hudson County from around 1900 to the 1970s. Approximately 2 to 3 million tons of this slag, which still contained potentially hazardous levels of chromium, was used as fill material in residential, recreational, public, commercial and industrial areas. To date, more than 160 separate waste sites containing chromium smelting slag have been identified in and around Hudson County (see Figure 1). Many of the chromium waste sites have undergone or are undergoing remediation to decrease human exposure to and environmental contamination with chromium.

The New Jersey Department of Health (NJDOH) designed and conducted a screening project to find out if exposure to chromium was occurring and to provide medical evaluations to people who live and/or work on or near chromium waste sites. This project was named the Chromium Medical Surveillance Project (CMSP).

Human Exposure Potential The use of the chromium slag in the 1950s and 1960s, as fill in a wide variety of locations, created many means and pathways by which people could be exposed to chromium in the slag. Persons living or working in the vicinity of chromium waste sites may have been exposed through inhalation, accidental ingestion, or direct skin contact with contaminated dusts and/or soils. The ability of some forms of chromium to concentrate in surface soils and on the inside surface of walls greatly increased the potential for people to come in contact with chromium.

The magnitude of past exposures is not known. Remediation during the past several years has reduced the potential for exposure to contaminated soils.

Public Health Concerns Chromium can exist in several chemical states, and can form many different chemical compounds. Exposure to some forms of chromium have been shown to cause more serious adverse health effects than others. Chromium in its most common and natural state, trivalent chromium, is found in small quantities in a person's diet. However, hexavalent chromium is a poison. *The most serious health effect of exposure to hexavalent chromium is an increase in the risk of lung cancer*. Chromium exposure also may result in asthma, skin rashes, skin irritation or ulcers, nasal irritation or ulcers, nasal septum perforations, or damage to the kidneys.

Screening for Chromium Exposure and Health Effects An appropriate public health response to a cancer-causing substance in the environment is to screen for and minimize exposure to that substance. Although lung cancer is the most serious health effect of exposure to chromium, a practical medical screening method for lung cancer does not exist. Medical screening methods can be used to detect irritative or corrosive effects (such as nasal septum perforations) and allergic effects (such as skin rashes).

Because chromium is removed relatively rapidly from the human body following excess exposure, screening for exposure to chromium is limited to relatively recent exposure. A review of available indicators of chromium exposure revealed that analyzing urine for chromium was the

best available means of finding out if a person had been exposed to chromium. The urine chromium test, which was used in the CMSP, reflects exposure in the previous one or two days.

Goals of the Project

The purposes of the Chromium Medical Surveillance Project were:

1) To provide clinical and laboratory services to resident and worker populations identified by the New Jersey Department of Environmental Protection (NJDEP) and NJDOH as potentially exposed to chromium from waste sites in and around Hudson County. This involved:

* identifying individuals and groups that may be experiencing current exposure to chromium so that interventions to reduce exposure can be undertaken,

* identifying those individuals in need of follow-up evaluation based on observations of potential chromium-related health effect, and

* providing follow-up medical evaluations for those individuals with possible exposure to and health effects from chromium.

2) To provide a public health basis for judgments regarding the population impact of chromium waste exposure in Hudson County, and to assist in decision-making regarding necessary actions for exposure reduction.

Project Design

Before starting to screen potentially exposed persons, NJDOH had to complete certain groundwork. The NJDOH had to develop the capacity to analyze large numbers of samples for chromium at low levels of detection (0.2 micrograms per liter, or µg/l), since analytical methods capable of detecting low level exposure are non-routine and not available commercially. NJDOH also conducted a "baseline survey" of 317 persons from many parts of New Jersey before the screening in Hudson County, since the range of normal urine chromium concentrations were not well known for persons of all ages.

Participant Selection NJDOH identified 14 residential areas and 78 workplaces to be targeted for screening services under this project. Clinical and laboratory services were offered to all persons determined by NJDOH to live or work on or near the chromium waste sites. The CMSP included intensive outreach to notify people of their eligibility to participate. Residential populations were notified of their eligibility by door-to-door outreach, and through their churches,

civic leaders, and schools. Newspaper advertisements and press releases were also used. Worker populations were notified of their eligibility for screening services through their employers.

Screenings were conducted at the Jersey City Medical Center, a mobile medical van, or in local facilities. All urine chromium analyses were conducted by the NJDOH Environmental and Chemical Laboratory Service.

Screening and Follow-up Evaluations People who participated in the medical screening were (1) given a *screening physical examination* of the skin and nasal passages (2) asked to supply a *urine sample*, and (3) asked to complete a *questionnaire*.

During the screening operations, decisions were made about who to refer for high urine chromium levels. These decisions were made on the basis of the "excess" urine chromium. "Excess" urine chromium is defined as the amount that the observed concentration exceeded a predicted or expected individual concentration. Expected concentrations were (1) based on the person's age, sex, weight, chromium supplement intake, and activities, and the diluteness of the person's urine sample, and (2) calculated from a statistical model using information from the baseline survey. If a person's observed level was more than 0.5 µg/l higher than the expected, then the person was referred for follow-up medical evaluation. This cutoff level was chosen such that 98% of the baseline survey population had an "excess" value less than 0.5 µg/l.

Participants who showed signs of potential chromium-related physical effects at the screening physical examination were also referred for follow-up medical evaluation. These decisions were based on criteria specified in a screening examination protocol, including history of allergies, asthma or chronic skin rashes, or an observation by the physician of skin or nasal problems potentially related to chromium exposure.

The *follow-up medical evaluations* were conducted by physicians from the Environmental and Occupational Health Clinical Center (EOHCC) of the Environmental and Occupational Health Sciences Institute (EOHSI). During the follow-up medical evaluations, participants received a review of their medical history, physical examination, laboratory tests of urine and blood, repeat urine chromium tests, tests of lung function, and if needed, examination by a dermatologist.

Many participants, including those who were referred for follow-up medical evaluation, were also offered testing of their household dust for chromium content. These tests were conducted by scientists from EOHSI under a research contract with NJDEP, and results of these

tests are not included in this project report.

Participants in the screening project were informed of all of their screening and follow-up medical evaluation results. Individual data collected in the screening program has been and will continue to be kept completely confidential.

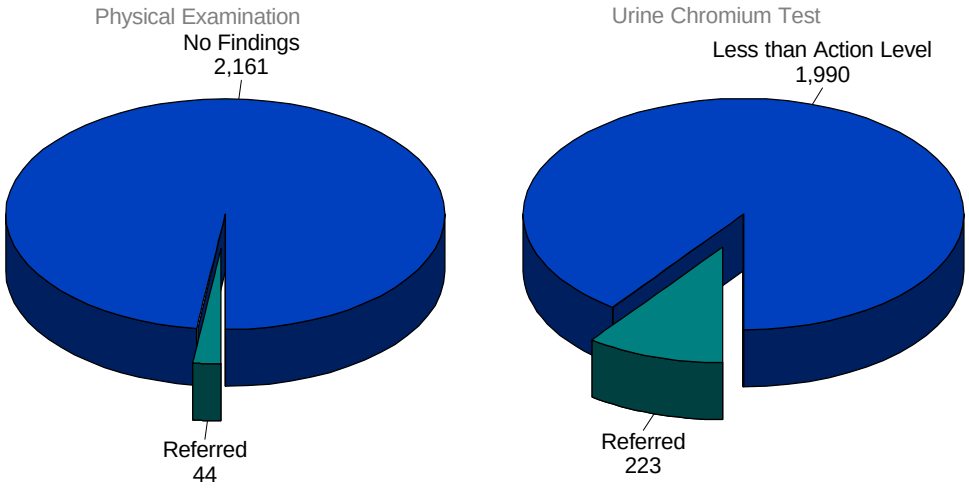
Results of the screening and follow-up medical evaluations were analyzed in a number of ways. These included examining differences in the proportions of persons referred for follow-up evaluation among different screened groups, and comparing the distribution of urine chromium concentrations among groups. The group comparisons of urine chromium distribution were done after using statistical methods to adjust for differences among groups in factors unrelated to waste site exposure that might affect urine chromium levels. These potential confounding factors include urine diluteness, age, sex, race, household smoking, intake of chromium supplements or beer, self-reported medical conditions, and activities possibly related to chromium exposure (such as a hobby or job involving welding).

Results of the Chromium Medical Surveillance Project

* A total of 2,224 individuals participated in the screening project which began in January 1992. Screening evaluations were completed by June 1993, and follow-up evaluations were completed by the end of September 1993. The screened population consisted of 939 workers at targeted workplaces, 811 persons living within targeted residential areas, 224 persons who lived close to a targeted residential area or whose workplace was within a targeted residential area ("associates"), 101 persons from a school in a targeted residential area, and 178 persons not assignable to any of the above groups ("non-targeted"). (Twenty-nine people both lived in a targeted residential area and worked at a targeted workplace.)

* Of the 2,224 participants, 2,205 were examined by a physician. Of this 2,205, 44 (2%) were referred for follow-up medical evaluation on the basis of a potential chromium-related finding, most often related to a skin problem. Of the 2,224 participants, 11 provided a sample that was too small in volume to analyze for chromium. Of the remaining 2,213, 223 (10%) were referred for follow-up medical evaluation on the basis of the urine chromium test (see Figure 2).

Figure 2. Results of Screening Evaluations

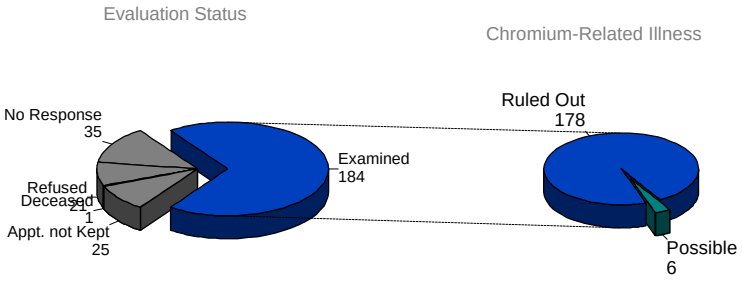


The proportions of persons referred differed according to workplace and residential area (see discussion below).

* A total of 266 participants were referred for follow-up medical evaluations. (One person was referred on the basis of both the physical examination and the urine chromium concentration.) Of these, 184 (69%) received the follow-up medical evaluation.

* Most of the persons undergoing the follow-up medical examinations revealed no apparent clinical effects attributable to chromium exposure. However, for six persons, chromium was suspected to be a possible cause or contributing factor in their clinical conditions (see Figure 3). Five of the six were employed at screened workplaces, while one was from a targeted residential area. Four of the six were found to have skin conditions possibly related to chromium, while three had persistent nasal allergies.

Figure 3. Results of Follow-up Medical Evaluations



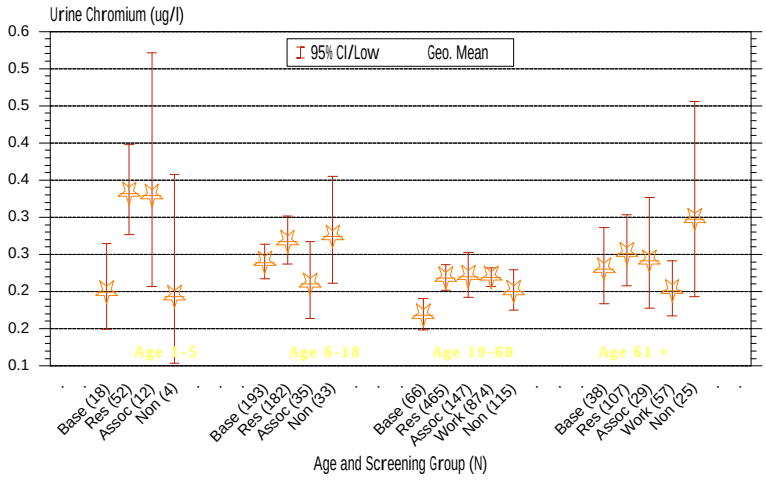
* The average urine chromium levels of all screened groups (residents, persons associated with residential areas, workers, non-targeted persons) were higher than those from the baseline survey, after adjusting for potential confounding factors. However, *most* persons in *most* targeted residential areas and workplaces did not appear to be currently exposed to unusual amounts of chromium from the waste sites or any other source. Analysis of adjusted urine chromium levels in specific age groups shows that the reasons for overall increases among screening groups differ according to age group.

* Children age five and under living near chromium sites showed increased urine chromium concentrations (see Figure 4). In comparison to the baseline survey children, the average adjusted urine chromium concentration was higher in resident children by 0.13 µg/l (0.33 vs. 0.20 µg/l), a difference that is not likely to be due to chance. Elevations were also observed in children associated with these residential areas (primarily living just outside the defined targeted area).

* Older children (age six to 18) within targeted residential areas also showed evidence of exposure to chromium, but the increase was less than that observed in smaller children. Among adults age 19 to 60, adjusted urine chromium in residents, those associated with residential areas, and workers showed small but statistically significant increases relative to adults from the baseline survey. No evidence of exposure was observed among older adults (over age 60) in any screened

group (see Figure 4).

ure 4. Adjusted Urine Chromium Concentrations by Age a
Screening Group



"Base"=Baseline; "Res"=Residents; "Assoc"=Associates; "Work"=Workers; "Non"=Non-targe

* Detailed examination of urine chromium levels revealed seven specific workplaces and two sections of residential areas where further environmental evaluation is necessary to identify possible on-going sources of exposure. The two residential sections are close to the sites of the original chromium smelters in Jersey City. Two of the seven workplaces have been identified as priorities for further environmental investigation. Further remediation steps may be necessary to reduce or eliminate identified exposure sources.

Interpretation

The CMSP has found little evidence of clinically observable chromium-induced health effects, but found evidence of low levels of exposure to chromium among some participants living or working in the vicinity of chromium waste sites. The findings generally reflect exposure levels in the vicinity of chromium waste sites *after* some degree of remediation has occurred. In residential areas, most waste sites had been excavated and replaced with clean fill material; in most workplaces, interim remedial measures had been performed. Because the amount of urine chromium data prior to remediation is limited, it is not possible to assess chromium exposure as it

may have occurred in the past, although exposures are likely to have been higher before remediation.

The biological and public health significance of low level exposure is uncertain, and is dependent on the chemical form of the chromium and on the route of exposure (inhalation, ingestion, or skin contact). The potential for harm is by far the greatest for inhalation of hexavalent chromium compounds, since it is this chemical form and exposure route that is associated with long-term risk of lung cancer. The chemical form and route of exposure may vary or have varied from place to place, making it difficult to generalize about site risks.

It is important to distinguish between statistical distinctions in exposure levels and biologically or clinically important distinctions. Although group differences in urine chromium concentration may indicate increases in exposure, these differences may or may not be indicative of the potential for observable health problems. In addition, average group differences may not reflect exposure in all members of the group. Current exposure, where it exists, appears to be limited to a few individuals at any given time.

The future risk of lung cancer in this population, due to past or current levels of exposure, is not known and, because of population mobility and the long latency period of the disease, will be difficult to measure. The risk cannot be assessed accurately from the limited knowledge of exposure patterns before remediation. Evidence of exposure in small children and, to a lesser degree, in adults, in some areas, indicates that vigilance in investigation and remediation of chromium waste sites and associated contamination must be a priority to prevent additional risk from accruing in the population.

Recommendations

1) The NJDEP should conduct environmental evaluations of some specific residential area locations. The NJDEP and NJDOH should consider carefully the results of the interior dust chromium tests already conducted in many households by scientists from EOHSI, with particular attention to households with small children, and households in the two residential sections with high urine referral proportions. In the two residential sections, the NJDEP should conduct exterior inspections and other environmental sampling for chromium to identify potential sources of chromium exposure. If a chromium waste site-related exposure source is found, the NJDEP

should take steps to reduce the potential for exposure.

2) The NJDEP should sponsor thorough industrial hygiene investigations at the seven identified workplaces, including exterior and interior inspections and sampling for chromium. Such evaluations have already occurred at some of these workplaces. While each workplace needs to be evaluated, two workplaces should receive the highest priority.

3) At all workplaces on or near chromium waste sites, the NJDEP and employers should continue to monitor the effectiveness of interim remedial measures until permanent remedial measures at the sites have been implemented.

4) The screening methods utilized in this project were successfully applied. However, there is a need for research to find and validate the application of biological markers of long-term exposure to chromium, and sensitive markers of adverse health effects from such exposure. To the extent possible, NJDOH and NJDEP should cooperate with research projects designed to find sensitive markers of exposure to and effects of chromium.

5) The screening project provided a one-time evaluation of the potentially exposed population. In conjunction with the residential communities and workplaces, the NJDOH should encourage the appropriate federal agencies to examine the feasibility of studying long-term health risks, including lung cancer, among populations with a history of potential exposure to chromium.