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Public Health Investigations of Hazardous Organic Chemical Waste Disposal in the United States

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Despite marked national concern, the number of published public health investigations of organic chemical hazardous wastes is small. Moreover, the extant literature provides little or no convincing evidence, either positive or negative, as to the question whether waste sites are harmful to human health. In this review, available literature is characterized as to time, place, and person. The majority of studies began 2 years or more after the end of exposure and 10 years after the start of exposure. Vast geographic areas of exposure have never been investigated. The number of study subjects evaluated has generally been too small to detect rare but important effects. The most common determinant of sites chosen for investigation has been the concern of local citizen groups. Several hypotheses are advanced to explain this pattern: (1) methodologic and logistic difficulties; (2) extensive litigation surrounding many waste sites; (3) governmental reorganization which transferred environmental health from public health authority in the 1970s; and (4) the presence of forces which have worked to block active community diagnosis.

Investigations

While concern over the potential hazards of chemical waste disposal has reached a high level over the past two decades, the number of waste disposal areas subjected to epidemiologic scrutiny has been small. Moreover, there has yet to be established either a substantial link between organic chemical hazardous waste sites and serious chronic disease or convincing evidence that the sites are benign. In part, both the small number of investigations and the paucity of meaningful results may be related to logistic and methodologic problems which need to be overcome (*1*).

At the same time, there is a need to describe the social and professional milieu in which most of the current investigations have taken place, that of public health. George Rosen, writing in the preface to his history of this discipline pointed out the origins of public health developed from, "A recognition of the signal importance of community action in the promotion of health and treatment of disease" (*2*). Moreover, public health has traditionally been regarded as a medical discipline, with a charge to diagnose and treat community health problems (*3*). In order to address the dichotomy between the traditional role of public health investigations and the apparent failure to fill this role with respect to hazardous wastes, this review will endeavor to describe currently available public health studies in the United States, in terms of time, place, and person. This description will be used to generate hypotheses concerning the present public health milieu.†

Time Course of Public Health Studies

Table 1 shows the period of active waste disposal and the year public health investigation started. In 9 of 16 cases, studies began or are proposed to start more than two years after the end of active waste disposal. This is true for five of ten investigations begun in the 1970s and for four of six started or proposed in the 1980s. Additionally, among these 16 studies, 13 started or are proposed to start 10 or more years after the onset of active waste disposal. This is true for seven of the ten investigations which began in the 1970s and for all six of the studies with actual or proposed start dates in the 1980s.

Place of Public Health Investigations

While hazardous waste sites have been found throughout the United States, (*4*) many areas have been

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†Several unpublished studies were not available for review at the time of this workshop. Those studies which have been identified since the workshop have not substantially altered the authors' conclusions.

Table 1. Public health investigations of hazardous waste sites containing organic chemicals.

Disposal site[a]	Start of study, impetus, exposure criteria.	Agency involved	Chemical exposure	Health determinants
1853–1970; Woburn, MA	1979: Citizen reaction to Love Canal reports; exposure measured by surrogate means (e.g., distance from site)	CDC	Multiple organic chemicals; heavy metals, arsenic	Leukemia; cancer of kidney, liver, and urinary bladder
		Harvard University; concerned citizens		Leukemia, low birth weight, spontaneous abortions, birth defects, and perinatal deaths
1920s–1953; Love Canal. Niagara Falls, NY	1978: EPA; surrogate measures of exposure	NY Dept. of Health	Multiple organic chemicals	Cancer incidence rates
		CDC 1984		Cytogenetic analysis
		NY Dept. of Health		Spontaneous abortions, low birth weight, birth defects
		Piagen		Birth weight, growth, medical complaints
1940s: Fullerton Hills, Los Angeles, CA (McColl site)	1981: Citizen complaints about odor; quantitative odor zones.	California Dept. of Health	Acid petroleum sludge	Odor complaint, medical symptoms; medical care use; social, intellectual skills of children; cancer, prematurity, birth defects, miscarriages, stillbirths, life quality; pet health
1940–1977: New Bedford, MA	1983: EPA monitoring data; circulating PCB	CDC; MA Dept. of Health	PCB	Not applicable (pilot studies only)
1940s–1964: Hollywood Dump, Memphis, TN	1983: EPA monitoring data	Health Depts. of Memphis, Shelby County, TN; CDC	DDT	
1947–971: Triana, AL	1979: EPA monitoring data: circulating levels of DDT and PCB	CDC	Residues of pesticides in food chain.	Medical questionnaire, physical exam, ancillary laboratory tests
1953–1975: Hyde Park, NY	1979: Citizen complaints about odors, skin irritation and corrosion of metal; exposure measured by surrogate criteria	NIOSH, CDC, NY State Dept. of Health	Chlorinated hydrocarbons	Medical questionnaire, physical examination, multiphasic laboratory screen (180 variables)
1964–1972: Hardeman County, TN	1978: Citizen complaints about unpleasant odors in well water: exposure assessed by air and water monitoring and urinalyses	EPA	Carbon tetrachloride, hexachlorocyclopentadiene, hexachlorobicyclohep tadiene	Medical questionnaire, physical examination, clinical laboratory tests

Study design	Subjects	Possible effects	Litigation (yes/no)	References
Case comparison	Cancer cases: 12 Leukemia, 30 Kidney, 7 Liver, 20 Bladder	None	No	(*5–7*)
All cases/non-random controls	All cases, persons at 3234 of 6219 listed phones (52%) served as controls	Childhood leukemia, Multiple, adverse reproductive outcomes		
Retrospective cohort of Cancer Registry	State of NY Cancer Registry Data 1955–1977	None	Yes	(*8–11*)
Case comparison	29 of 42 samples from 12 highest exposure homes	None		
Interviews	Area residents since 1940	Low birth weight (< 5 lb 8 oz.) questionably more frequent		
Case comparison	220 births in Love Canal; 697 control births, 15 yr observation	Low birth weight, slow physical growth, more medical complaints.		
Cross-sectional mail survey of McColl and 2 comparison neighborhoods	1024 Adults (82% of McColl and 69% of Comparisons); 448 children (73% McColl, 64% comparison); pets (70% of McColl and 60% comparison)	Odor complaints; Medical symptoms not requiring medical attention (respiratory, eyes, nausea); mentstrual problems; decreased quality of life; pets not affected	No	(*12*)
Volunteers, no comparison groups	Two pilot studies: 21 volunteers, and 51 volunteers; Special effort to include seafood eaters.	Excess number of subjects having circulating levels of PCB among proposed study population	No	(*13*)
			No	(*14*)
Cross-sectional community studies	499 of 518 participants gave blood; population 600	Positive association with serum cholesterol and glutamyl transpeptidase; hypertension, and systolic and diastolic blood pressure	Yes	(*15,16*)
Cross-sectional community study	290 of 490 current employees (59%)	9 of 180 tested variables reported more frequently by tested group (5%) than the 1971–1973 HANES populationd; none attributable to landfill	No	(*17*)
Short-term prospective cohort	61 exposed 59 took part once; 31 took part twice); 33 intermediate and 57 unexposed also checked	Transitory liver injury	Yes	(*18*)

(Continued)

Table 1 (continued)

Disposal site[a]	Start of study, impetus, exposure criteria.	Agency involved	Chemical exposure	Health determinants
1965(?)–1977: Bloomington, IN	1977: Citizen concern about a possible contamination of sludge; circulating PCB levels	Indiana Board of Health, CDC	PCBs	Medical questionnaire, physical examination, clinical laboratory tests
1970–1980: GEMS landfill, Camden County, NJ	1982: Citizen complaints about odor and adverse health effects; surrogate measures of exposure	Health Departments of Camden County and State of NJ		
1971: Southwestern Missouri	1983: Concern by citizens about deaths of small animals in horse arenas; surrogate measures of exposure	Missouri Division of Health, CDC	2,3,7,8-TCDD contamination of living or working areas; participation in activities involving soil contact	Medical questionnaire, physical examination, immune response tests, other clinical laboratory tests
1973: Michigan	1974: (pilot) Federal monitoring data; Circultating PBB levels used to assess exposure	Michigan Dept. of Public Health; National Institutes of Health; FDA; EPA; CDC	Persons living on PBB-quarantined farms; persons who had received *food directly from* those farms; workers and their families engaged in PBB manufacture; circulating PBB	Medical questionnaire, toxicologic, clinical laboratory studies including immune *function*
1972–1980: Price Landfill, Atlantic County, NJ	1982: EPA monitoring data; Surrogate measures of exposure	1982: Health Departments of Atlantic County, NJ; State of NJ; CDC	Heavy metals, multiple organic chemicals	Medical questionnaire
1975(?)–1977: Chester, PA	1979: Resident concern about fire and explosion at dump site; EPA monitoring data; Surrogate measures of exposure	CDC	Multiple inorganic and organic toxic wastes, including benzene, copper, lead	Medical questionnaire
1978: Highways in NC	1978: Investigation of illegal dumping; circulating PCB	NIEHS	PCB of spilled PCB	Medical history and physical examination; chromatography PCB in breast milk
Unspecified: Southern NJ	1977: Resident concern about dump site fire explosion; Surrogate means of exposure	NJ State Dept. of Health, CDC	Multiple chemicals	Medical questionnaire
1980: Jackson Township, NJ	Unavailable for review			
1981: Barco-Ferro, MI	Unavailable for review			
1983: Drake chemical site, Clinton County, PA	Proposal unavailable for review			

[a] Period of active disposal and place.

Table 1 (Continued)

Study design	Subjects	Possible effects	Litigation (yes/no)	References
Cross-sectional survey	89 Exposed residents, 18 workers, 19 family members of workers; 22 persons with no known exposure (total: 148)	Positive correlation between PCB and circulating serum triglycerides	No	(*19*)
			No	(*20*)
Cross-sectional survey of high-risk and low-risk exposure groups	80 high-risk persons, 40 low-risk persons	None (pilot study	No	(*21,22*)
Prospective cohort	4,545 persons selected; 3,639 gave venous blood for PBB analysis	None	Yes	(*23*)
Cross-sectional survey of exposed and comparison populations	123 Exposed, 123 comparison persons from 68% of exposed homes and 76% of control homes	Increased number of reports among females of rash, skin irritation, joint pain, nausea or abdominal pain; no increased frequency of disease	Yes	(*24*)
Nonrandom door-to-door survey; Interviews of local physicians; voluntary questionnaire completed by fire fighters	86 persons residing immediately around dump site; 35 of 45 fire fighters	No obvious problems found; study results uninterpretable	No	(*25*)
Prospective birth cohort	900 children	None	No	(*26*)
Prospective cohort of persons exposed at dump site fire	440 persons	Transient respiratory symptoms	No	(*27*)
				(*28*)

excluded from public health investigation. Only twelve states, for example, are listed in Table 1. Ongoing review of litigation concerning hazardous waste sites, however, suggests that many more investigations are taking place (*4*).

Persons and Agencies Initiating Public Health Investigations

Table 1 also shows the origins of public health investigations as described in the reports or proposals associated with each organic chemical waste site. At nine of 16 sites, concerned residents were cited as the initiators of the investigation. Four of these nine cases of citizen concern related to unpleasant smells or tastes associated with the waste site; two were related to a fire and/or explosion at the dump site; one occurred as a result of queries to public health agencies about local cancer rates in the wake of early Love Canal reports; one followed local gardener's suspicions about free sludge supplied by a local chemical company, and one was precipitated by the observation of small animal deaths in a rodeo arena following the spraying for dust control. Among the seven sites for which residents' complaints were not cited, four were attributed to EPA monitoring data, two were associated with the discovery of chemicals in the food chain, and one with the serendipitous occurrence of an illegal dumping episode and an ongoing research study. Almost without exception, the health agencies responsible for the ultimate investigation were not cited as originators of the community action. Finally, while it is not possible to reconstruct the role of litigants in the initiation of these investigations with the documents at hand, at least five of these sites are associated with major legal action (*4*).

Methods and Results of Public Health Investigations

Table 1 also summarizes the public health investigation of organic chemical waste sites as to the chemicals involved, exposure criteria, health endpoints, study design, subjects and possible effects attributed to hazardous waste exposure.

Among these investigations, polyhalogenated biphenyls are listed six times; in one of these six studies DDT was also a factor. Of the remaining nine studies, eight were concerned with multiple chemical exposures, while one dealt mainly with 2,3,7,8-TCDD.

Six of these studies attempted or proposed to use direct measures of human body burden as indices of exposure. Specifically, five of the six employed or proposed to use either levels of PCB in breast milk or circulating levels of PCB and/or DDT. One study, involving several chlorinated organic compounds, did urine screening but failed to detect any of these agents. When the waste site contained chemicals which were more transient in nature, various alternatives to direct measurement were employed, including distance of residence from the waste disposal area, occurrence of work and/or recreational activities associated with waste exposure, measurement of waste chemicals in the air, food or water, and, in one case, quantitative determinations as to the strength of odors traceable to a waste site.

By far the most common health effects indicator has been the general medical questionnaire often accompanied by physical examination and/or ancillary clinical testing. Less frequently, occurrence rates of specific illnesses, particularly cancer and poor reproductive outcome, were sought. In one case, cytogenetic studies were done and in another study medical care utilization, quality of life, parentally reported social and intellectual skills of children, and owner reported pet health were assessed.

The most common methodology among these studies has been the cross-sectional survey (seven sites). Prospective methods have been used in five cases, while case-comparison studies were used at two sites. At one site, a nonrandom, door-to-door survey and in one other case, a pilot investigation using volunteers was done.

The number of subjects involved has been, with few exceptions, quite small. This problem has been noted in several reports as a caveat for negative results. Specifically, five investigations have involved fewer than 100 exposed participants. Among the remaining sites, seven involved between 100 and 500 exposed, one included 1472 townspeople, and one included 3639 persons. One Love Canal study which endeavored to interview as many residents of the area as possible was not available for this review, so the exact number of subjects is unknown (*11*). Of those Love Canal reports which are available, fewer than 50 exposed persons were involved in the recently reported cytogenetic analyses (*8*), while 220 births were analyzed in a second study (*10*).

To date, none of these public health investigations has produced a convincing link between hazardous waste exposure and serious adverse health effects. On the other hand, they have also failed to establish the benign nature of these disposed chemical wastes. In fact, several positive associations have been suggested. Specifically, one Love Canal study noted decreased birth weight among children of exposed parents and another has raised the question of association with spontaneous abortions; slower physical growth of children has also been mentioned (*11*). Among those investigations with measurements of circulating PCB and/or DDT, statistically significant positive correlations have been found between PCB and circulating triglycerides, (*15*) PCB and cholesterol, (*15*) DDT and cholesterol, (16) and both DDT and PCB with gamma-glutamyl transpeptidase (*15*). PCB has also been positively correlated with both systolic and diastolic blood pressure as well as hypertension (*16*). In contrast, PCB in breast milk was not found to produce a measurable adverse effect on exposed infants (*26*). Another study of chlorinated organic compounds found transitory liver damage associated with exposure to a site containing carbon tetrachloride, hexacyclopentadiene, and hexachlorobicycloheptadiene (*18*).

Finally, several reports have noted an increased frequency of complaints related to eye, respiratory, skin, and/or joint irritation as well as menstrual symptoms, and one investigation has stressed the impact of such symptoms, as well as the offensive odor associated with the waste site, on the residents' quality of life. On an anecdotal basis, individuals' sense of well being seemed to improve when they left the area (*12*).

Comment

There has been no shortage of published scientific literature relating to hazardous chemicals during the past two decades. The Chemical Substances Information Network, (Washington, DC), for example, has access to 400 data bases with thousands of articles concerning this subject. And yet, public health investigation of hazardous waste disposal has yielded a vanishingly small crop of peer reviewed work. Moreover, the investigations available for discussion are uniformly unconvincing about whether or not organic chemical hazardous waste sites are harmful to people. This dearth of information defines an epidemic of silence, one which is consistent with the interpretation that public health agencies have been able to offer little substantive advice pertinent to the public health in a area which is clearly of great community concern.

At least four hypotheses can be considered regarding possible explanations for the silence of public health investigators. One, the inherent difficulties in conducting such studies, was alluded to at the beginning of this review (*1*). A second reason may relate to the difficulty of obtaining information due to extensive litigation surrounding the issue of hazardous wastes (*4*). Third, legislative action by many states following the establishment of the federal Environmental Protection Agency in 1970 resulted in a shift of environmental health responsibilities away from the public health agencies. In 1981, for example, only 14 state health authorities had primary responsibility for the environment (*28*). It is quite apparent, however, that wherever responsibility has been held, scientific silence has been the rule. A fourth hypothesis is suggested by the time, place and person aspects of the public health studies reviewed herein.

With respect to time, the above data suggest large gaps between population exposure and the onset of public health study. One extreme example is the proposed investigation of the Hollywood dump site in Memphis, Tennessee. This repository of DDT and other pesticides was closed as a possible hazard in 1964 and was nominated for extensive investigation of health effects in 1983, nearly 20 years after the closing and more than 10 years after the ban of commercial DDT in the United States.

Concerning place, it is clear that vast areas of potential exposure have been excluded from investigation. In Florida, for example, where more than 400 hazardous waste sites have been identified, including more than 20 which are designated as eligible for Superfund Cleanup aid, there has yet to be a single public health investigation which sheds light on the issue of whether or not these sites have actually harmed human health. There is no scientific justification for the overall time or place distribution of these investigations.

Finally, with respect to the persons encompassed by public health investigations to date, it is apparent that the numbers of people investigated are almost always far too small to detect an association with potentially important but relatively rare diseases. Moreover, even if the small sample sizes were overcome, it is abundantly clear (in most case to the investigators themselves) that the design strategies employed (e.g., self-reported symptoms, nonrandom controls) are inadequate relative to the questions being asked.

Central to the dichotomy between community concern and pallid public health response may be the striking imbalance apparent in the origination of public health investigations. In most cases, agencies have responded to requests for investigation, but have not performed in an active investigative manner. What is, in most other instances, a traditional medical role, has been all but eliminated from this aspect of public health. Specifically, neither public health nor environmental agencies have taken a primary, active role in choosing diagnostic targets (that is, the sites which are selected for study). As such, it is hardly surprising that many of the selected populations have not been particularly suited to epidemiologic purposes. The inefficient use of public funds inherent in the investigation of sites selected may be necessary, but that this type of investigation should comprise the bulk of scientific output for over 20 years is disturbing.

None of the three previously mentioned hypotheses (difficulties of methodology and logistics, extensive litigation or the lack of public health authority) is sufficient to explain completely the nearly exclusively reactive response of public/environmental agencies to community concern about hazardous waste sites. The methodologic approaches discussed elsewhere at this workshop, for example, have not arisen *de novo* in 1984. Also, litigation, while it may make some studies more difficult, should not prohibit an aggressive pursuit of public health investigations. Finally, it has not seemed to matter which agencies have primary authority ("environment" or "public health"). The passive mode has been all-pervasive.

It is therefore necessary to hypothesize that other forces may be working to block active community diagnosis. One possible source has been suggested by Adeline Levine in her work concerning the Love Canal. She argues that public scientists may be, "Reluctant to generate findings that have social or economic consequences with which they are not prepared to deal" (*29*). Under the conditions of such an hypothesis, even the most ingenious methodologic solutions would be difficult to implement. Other hypotheses could be offered. For example, public agencies may have been given the responsibility for active inquiry, but neither the investigative authority nor the resources to adequately perform

such a function; human study may have been given a low priority relative to toxicologic study by public agencies. Whatever the reason, however, it seems clear that two decades of operation in a predominantly passive mode have failed to make satisfactory progress towards answering a question of major community interest and public health consequence. A more balanced approach, allowing for both reaction to specific community complaints and active identification and pursuit of important community diagnostic targets, would be more in keeping with the traditional charge of public health and would enhance the likelihood of achieving more meaningful results.

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