Short-Term Adverse Health Effects in a Community Exposed to a Large Polyvinylchloride Plastics Fire

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ABSTRACT. The purpose of this study was the documentation of the short-term morbidity and mortality experiences of an urban community exposed to the airborne byproducts of a large polyvinylchloride plastics fire. The authors administered a survey to representatives of each household who had lived in an area evacuated during the fire. A time-series analysis was performed on emergency room visits and admissions for all hospitals in the city. Chloracne surveillance was instituted. Sixty-two percent of the individuals surveyed from the evacuation area reported no health concerns or symptoms related to the fire. Thirty-eight percent of the residents reported symptoms, and less than 2% of those surveyed reported that they sought medical attention for their health concerns. There was no evidence of increased hospital admissions or emergency room use during and immediately following the fire. No cases of chloracne were reported, and no deaths or serious injuries occurred during the fire. Polyvinylchloride plastics recycling plants pose potential health hazards to civilian populations. Public health authorities should be prepared to assess population health status rapidly and to disseminate relevant health information in a timely way during a crisis.

<Key words: chloracne, hospital admissions, plastics, polyvinylchloride>

POLYVINYLCHLORIDE (PVC) plastic is ubiquitous in the modern world. PVC plastic is inexpensive to manufacture and has numerous industrial and domestic applications. In its stable form, PVC is relatively nontoxic; however, during combustion it can release several toxic compounds. PVC plastics fires have reportedly caused morbidity and mortality in firefighters, electricians, and persons trapped indoors. Recycling of plastic products is a prominent strategy for sustainable economies; therefore, plastics recycling plants are often in possession of large amounts of PVC-containing products. Many of these plants are located
near residential areas. Fires in PVC recycling plants that abut residential areas pose potential health risks to surrounding communities.

Large PVC plastics fires have been reported. The health effects of PVC plastics fires have been well documented among firefighters. However, there have been few reports of measured morbidity and mortality in the communities affected by PVC plastics fires. In this article, we report the measured short-term morbidity and mortality from a large PVC plastics fire in an urban area of Canada.

Background

On July 9, 1997, a fire broke out at a large plastics recycling plant in the industrial section of Hamilton, Ontario. Hamilton is a city with a population of 410,000, and is located at the Western end of Lake Ontario. The 7,400-m² building contained several thousand tons of off-quality auto parts composed mainly of PVC plastics and polyurethane. The plant was located immediately adjacent to a densely populated residential area. In addition, in the immediate vicinity were a tertiary-care hospital, a correctional institute, and several factories and businesses.

The fire was large and difficult to control. It burned for approximately 80 hr before it was extinguished. During the first 2 d of the fire, the plume ascended vertically and dispersed into the atmosphere. On July 11, a thermal inversion occurred. At the same time, the fire lost energy because fire-fighting efforts were successful. As a result of these two events, levels of potentially hazardous chemicals increased in the immediate vicinity of the fire. Evacuation was ordered for the civilian population in an area that immediately surrounded the fire zone. The evacuation was rescinded within 12 hr.

Detailed measurements of exposures were conducted by the Ontario Ministry of Energy and Environmental Two Trace Atmospheric Gas Analyzer (TAGA) mobile vans arrived at the scene. The TAGA van permitted measurements of hydrogen chloride, volatile organic compounds, and carbon monoxide. Many of these readings are instantaneous. Investigators established fixed-site monitors to measure polychlorinated biphenyls (PCBs), dioxins, furans, and particulate matter. Colorimetric tubes, which were exposed downwind, measured cyanide, vinyl acetate, and acid gases. Carbon monoxide and nitrogen oxides were measured. Runoff water from the fire was sequestered and measured for metals. Soil and vegetation were also sampled for dioxin levels. Of all the exposures related specifically to PVC plastics, hydrogen chloride predominated in terms of abundance, and dioxin predominated in terms of media attention and community concern.

Method

Two studies and a surveillance program were established in the aftermath of the fire: (1) a health survey of the residents in the evacuation area, (2) a time-series analysis of emergency room use and admissions through the emergency room, and (3) a surveillance program for chloracne.

Health survey. A health survey was conducted by staff of the Hamilton-Wentworth Public Health Department. The preliminary survey questionnaire was drafted on July 13, 1997. Following a brief orientation session by a Health Department supervisor, 8 public health nurses administered the survey to all households in the evacuation area. The interviews were conducted from July 13 to July 15, 1997.

Information was collected from a household representative, and data were provided for each member of the household. Respondents were asked open-ended questions about whether they or any other household members had either general concerns or health concerns. Data were collected about the onset, nature, and duration of health symptoms, and whether medical attention had been sought. Investigators used specific probes to elicit symptoms of breathing difficulties, throat irritation, dizziness, lightheadedness, or nausea/abdominal pain on any of the 6 d following the fire.

Emergency room visits and hospital admissions. Emergency room logs were obtained from the following 5 major hospitals that served the Hamilton-Wentworth region affected by the fire: Hamilton General, Henderson General, McMaster University Medical Centre, Chedoke Hospital, and St. Joseph's Hospital. Data were requested on the basis of an epidemiological month (i.e., 14 d preceding and 12 d following the fire for the years 1996 and 1997). A time series of at least 30 points is recommended if regression models are to be fit. Framing the period in terms of days before and after the fire permits the fire days to be central in any time-plot graphs and aids in the perceptual interpretation of the graph. This approach also permits an appreciation of day-to-day variability and any trends evident in the data. The data from the previous year serves as a "control" in that it is an identical time period in the same location without the disturbing influence of the fire.

Chloracne surveillance. Chloracne is a sign of severe dioxin exposure. An information package that described the morphological features of chloracne was distributed to family physicians in the fire area. A dermatologist from an academic tertiary care medical center agreed to serve as an expert consultant. The Public Health Department agreed to keep a register of recorded cases.

Analysis. Descriptive statistics were tabulated for survey responses. Open-ended answers were coded and aggregated. Independent time series were created for overall emergency room visits and admissions to the hospital through the emergency room for both 1996 and 1997. Time plots of daily visits and admissions were created for each hospital for both years. Simple descriptive statistics were calculated for each time series for each year.

Results

Health survey. Questionnaires were completed in 86% (163/190) of the households. The average age of
the respondents was 44 y, and 44% (71/163) of the respondents were males.

The numbers of persons (residents or visitors) in each of the 163 households were as follows: 28 single-person households, 45 2-person households, 31 3-person households, and 59 households with 4 or more persons. Therefore, information was gathered from 163 respondents who reported on an additional 325 persons. Health information was obtained for a total of 488 residents, 51% of whom were female and 49% of whom were male.

The reported general concerns are shown in Figure 1. A total of 222 general concerns were reported by 61% (99/163) of the respondents. The 10 most frequently reported concerns were eating garden produce, ash/dust fallout, air quality, response time of public officials, city responsibilities, possible effects on overall health, responsibilities of the plant owner, potential effects on children, long-term health consequences, and water contamination.

The symptoms reported most frequently by respondents over a 6-d period are shown in Figure 2; 62% of the 488 residents in 163 households reported no symptoms during the days of the fire, and 17% (84/488) of the residents reportedly had throat irritation. Other symptoms reported, in order of descending frequency, were as follows: headache, breathing difficulty, nausea, abdominal pain, vomiting, diarrhea, eye irritation, dizziness/lightheadedness, mouth irritation, and nose irritation.

Symptoms, by day, are shown in Figure 3. Symptoms were most prevalent on July 11—the day of the evacuation. The prevalence of symptomatology declined daily subsequent to the fire. Of the residents who reported symptoms, 2% (11/488) reported that they sought medical attention, 8 contacted their family physician, and 2 reported visiting the emergency room (1 of whom reported a 3-d hospital stay). One person reported seeking health-care information from the public-health nurse at the fire evacuation field office. It is interesting to note that when asked about their whereabouts during the evacuation period, 70% (112/163) of respondents reported that they left the neighborhood for some or all of the evacuation period.

Emergency room visits and hospital admissions. Figures 4 and 5 demonstrate the time plots for emergency room visits and hospital admissions, aggregated for all 5 hospitals. The time plots were comparable for both
years; the overall average numbers of admissions were slightly higher in 1996 than in 1997. There was no conspicuous increase in either visits or admissions in the time during or immediately following the fire. The depressions in the graph around June 30 are the result of missing data from two hospitals for both years. The missing data did not include the days of the fire; therefore, they did not affect the interpretation adversely. The mean daily emergency visit and admission counts for 1996 and 1997 are summarized in Table 1.

Chloracne surveillance and additional measures. No cases of chloracne were reported. No fatalities resulted from the fire in the firefighters, emergency service providers, or the community.

Discussion

The literature on the immediate health effects of PVC plastics fires on communities is sparse. A comprehensive search of the MEDLINE database revealed only one report that contained reference to health impacts in communities affected by PVC plastics fires. The report is largely a narrative account of what transpired. The table of data relates to a descriptive summary of complaints reported by emergency personnel who attended the fire and who sought medical attention in the casualty department. Large plastics fires can emit a wide range of toxins into the atmosphere. More than 70 toxic substances have been measured in PVC plastics fires.1,2 Exposures from this fire were predominantly airborne, although dermal exposure to mists of hydrogen chloride also occurred. Elevations of toxins above acceptable levels occurred briefly and likely did not pose significant long-term risks.

The survey and hospital data analysis indicated that morbidity related to the fire studied herein was moderate and was likely short in duration. The survey data indicated that mucous membrane irritation (e.g., eyes, ears, throat) and breathing difficulties were prominent in those who reported symptoms. There were no concurrent control data with which to compare the frequencies of reported symptomatology. However, comparable data originate from a randomly conducted
Fig. 3. The most frequent health concerns/symptoms reported by the residents in the survey (N = 488), by day: July 1997 survey of residents in Plastimet fire evacuation area. Note: The survey questionnaire was administered to 163 respondents who reported on themselves and the other 325 residents in the households, giving a total of 480 residents. (Source: Hamilton-Wentworth Regional Public Health Department: a teaching health unit affiliated with McMaster University and the University of Guelph, August 1997.)

**Total ER Visits**

All Hospitals

![Graph representing the overall series for total emergency room visits for all the hospitals. The rectangular markers represent 1996 and the inverted pyramids represent 1997. The missing values from McMaster University Medical Center and Chedoke Hospital for the days between June 30 and July 8 in both years markedly influenced the perception of the graph.](image)

health survey of the 500 residents in 1995. In this study, investigators determined the prevalence of cough/shortness of breath (12.4% [n = 62]). This percentage is comparable with the 10% who reported breathing difficulties immediately following the fire. There are no area-specific data for the usual incidence of headache and abdominal symptoms. The throat and eye irritation is plausibly related to exposure to hydrochloric acid, which is formed when water comes into contact with hydrogen chloride. Therefore, the process of extinguishing the fire creates its own hazard.

The survey provided residents an opportunity to report health and general concerns in the immediate aftermath of the fire. In the subsequent months, con-
Total ER Admissions
All Hospitals

Fig. 5. Graph representing the overall series of hospital admissions from the emergency room from four hospitals that had admissions. The square markers represent 1996 and the inverted pyramids represent 1997. There were no hospital admissions from the emergency room for Chedoke Hospital. Note that the McMaster University Medical Centre series had 0 values from June 30 to July 8 in both 1996 and 1997.

Table 1.—Mean Admissions and Emergency Room Visits for the Time Period between July 2, 1996, and July 25, 1997

<table>
<thead>
<tr>
<th>Year</th>
<th>Admissions/visits</th>
<th>1996</th>
<th>SD</th>
<th>1997</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admissions</td>
<td></td>
<td>52.5</td>
<td>10.3</td>
<td>39.3</td>
<td>10.3</td>
</tr>
<tr>
<td>Emergency room visits</td>
<td></td>
<td>409.0</td>
<td>56.3</td>
<td>388.0</td>
<td>64.3</td>
</tr>
</tbody>
</table>

Notes: $\bar{x}$ = mean, and $SD$ = standard deviation.

cerns over long-term health effects from the fire predominated in the community and media. This was particularly the case after an activist group announced that the immediate area was very contaminated with dioxins. Subsequent testing from the Ontario Ministry of the Environment and Energy (OMOEE), and independent laboratories confirmed that soil and vegetation dioxin levels were similar to levels found in other Canadian urban areas. Two independent models estimated that airborne exposure to dioxin may have exceeded Canadian lifetime acceptable daily intake standards by a magnitude of 2 on the day of evacuation. The weekly averaged intake, however, was below the established levels. (Note: A complete report of the environmental measurements and risk assessment associated with the exposures can be found in the OMOEE technical report. The report includes a detailed discussion of the dioxin levels found during the fire. It is available for downloading at the following Uniform Resource Locator: http://www.ene.gov.on.ca/envison/techdocs/index.htm #fire.)

The time-series plots indicate that, in general, the daily counts were lower in 1997 than in 1996. There appeared to be a small, but visible peak of admissions and visits around the 14th of July for Hamilton General, St Josephs, and Henderson General hospitals (data not shown). The peaking of visits and admissions was very modest and did not rise above the highest daily levels recorded in the previous year or previous to the fire in the same year. The aggregated overall series indicates comparability between years and no dramatic increase in the time period immediately around the fire. Published studies on hydrogen chloride exposure indicate that severe symptoms develop within 24–48 hr of exposure. The failure of admissions and visits to rise substantially in the period immediately after the fire indicates that exposure levels were not sufficiently high to cause respiratory distress in a large proportion of the exposed community. Sensitive individuals may have been adversely affected, but this study design did not specifically identify and sample these individuals.

One of the limitations of our investigation was that no standardized questionnaire existed for conducting surveys in the aftermath of PVC plastics fires. Given that the survey was developed rapidly for the purposes of documenting symptoms and concerns as expeditiously as possible, face validity was assumed. Pretesting of the survey instrument, detailed training of the nurses administering the survey, and verification of standard administration by staff could not be guaranteed; therefore, one must exercise some caution in interpreting the survey results. Extensive media coverage, which addressed potential health effects of the fire, may have exerted a framing bias. No baseline data on overall health status and concerns exist.

Inasmuch as the hospital records analysis relates to hospital utilization, by definition it will miss morbidity
cases that do not come to the hospital. Bates described a hierarchy of adverse health effects associated with short-term exposures to ambient air pollution. At the top of the hierarchy is increased mortality, which is followed by increased hospital admissions and increased emergency room visits. The survey indicated that only 2% of respondents sought medical care during the time of or immediately after the fire. However, these results accounted only for those in the evacuation area. Given that the plume was extensive in movement, others in the community may have been exposed. Our hospital study covered all the hospitals in the region; therefore, the study results should be reliable indicators of morbidity in the community at large. However, our study could not capture morbidity associated with visits to physicians' offices.

In addition, the survey and hospital records study did not capture intermediate term morbidity. Health concerns in the community increased after the survey was administered. Exposure to hydrogen chloride from PVC plastics fires can also cause prolonged respiratory problems. Whereas this result has been documented for firefighters, it is not implausible for a similar phenomenon to occur in civilian populations.

In our study, we focused on visits and admissions without regard to diagnosis. This decision was made at the outset for the following reasons. The time-plotting exercise was seen as a screening process. If there was an evident peak in the time plots around the time of the fire, then quite plausibly it would be related to the fire, and further examination would be required to determine the nature of the morbidity. Further characterization of morbidity would require creation of a standard data extraction and recording sheet, inasmuch as the reliability and validity of emergency room diagnosis codes are questionable.

The results of this report must be interpreted in light of the nature of the exposure. The population was exposed to a substantial, preventable, and involuntary risk. They were, therefore, harmed without consent. The owner of the recycling plant was in violation of the municipal fire code when the fire occurred. The land on which the recycling plant was located was also the site of a previous environmental emergency in Hamilton.

Conclusions

Combusted PVC plastic can pose a potential health threat to civilian populations. Policymakers, public health officials, and environmental officials should be cognizant of the threats posed to civilian populations by plastics recycling plants located close to residential areas. Information about the potential adverse health effects of combusted PVC plastics should be available to public health officials for rapid dissemination to health-care providers, community members, and emergency service personnel. The existence of a standardized symptom record would aid in the rapid assessment of community health status in the aftermath of similar disasters.

The authors wish to acknowledge the efforts of the community members, public health nurses, and health inspectors in completing the health survey, and the assistance of Kate Freiheit in her search for comparable control data.

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References