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A respiratory health survey of a subsurface smoldering landfill

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ABSTRACT

In late 2010, a subsurface smoldering event was detected in the Bridgeton Sanitary Landfill in St. Louis County, Missouri. This was followed by complaints from nearby residents of foul odors emanating from the landfill. In 2016 a health survey was conducted of residents near the landfill and, as a comparison, other regions of St. Louis County. The survey was a two-stage cluster sample, where the first stage was census blocks, and the second stage was households within the census blocks. The health survey, which was conducted by face-to-face interviews of residents both near the landfill and away from the landfill, focused mainly on respiratory symptoms and diseases such as asthma and chronic obstructive pulmonary disease. The differences in the prevalence of asthma (26.7%, 95% CI 19.8–34.1 landfill vs 24.7%, 95% CI 15.7–33.6 comparison) and COPD (13.7%, 95% CI 7.2–20.3 landfill vs 12.5%, 95% CI 6.4–18.7 comparison) between the two groups were not statistically significant. Landfill households reported significantly more "other respiratory conditions," (17.6%, 95% CI 11.1–24.1 landfill vs 9.5%, 95% CI 4.8–14.3 comparison) and attacks of shortness of breath (33.9%, 95% CI 25.1–42.8 landfill vs 17.9%, 95% CI 12.3–23.5). Frequency of odor perceptions and level of worry about neighborhood environmental issues was higher among landfill households ($p < 0.001$). We conclude that the results do not support the hypothesis that people living near the Bridgeton Landfill have elevated respiratory or related illness compared to those people who live beyond the vicinity of the landfill.

1. Introduction

On December 23, 2010, the Bridgeton Sanitary Landfill in Bridgeton, Missouri—approximately 32 km west of downtown St. Louis—reported the landfill was experiencing elevated temperatures in some gas extraction wells (MDNR, 2015). High levels of hydrogen and carbon monoxide and low levels of methane were found in the landfill gas, indicators of a subsurface smoldering event (SSE). SSEs are heat-producing reactions that cause waste to decompose at a faster rate and occur without visible flame or smoke. In early spring of 2012, residents and businesses in Bridgeton started lodging complaints about foul odors and numerous health effects, especially respiratory problems. The SSE and community worries about potential adverse public health effects attracted attention from local, state, and national stakeholders from environmental and public health agencies. The Bridgeton SSE remains ongoing.

There appears to be little or no data on potential health effects due to exposures that specifically occur near landfills that have SSEs, and few reports of air quality measurements in the context of spontaneous landfill fires (Vrijheid, 2000). One recent study suggested that volatile organics, dioxin/furans along with PM2.5 are increased during burning as compared to the period of time after extinguishing the fire (Weichenthal et al., 2015). Although the previously mentioned study examined air pollutant emissions, health-related data are lacking. The respiratory system is considered one of the most vulnerable parts of the human body to effects from environmental pollutants (Silveira Correa et al., 2011). In general, previous studies have found some association between residence near landfills and adverse health outcomes such as increased incidence of respiratory diseases and even lung cancer mortality (Pukkala and Pönkä, 2001; Fielder et al., 2001; Mataloni et al., 2016). While long-term exposure to landfill emissions has been linked to chronic respiratory ailments, short-term exposure is also associated with adverse respiratory reactions such as asthma attacks (Macklin et al., 2011; Vrijheid, 2000). One retrospective cohort study in the U.S. found an increased rate of hospitalization for asthma and respiratory diseases in children when the exposure was to a waste site containing persistent organic pollutants (Ma et al., 2007).

The Bridgeton landfill operators, with oversight from the Missouri

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Department of Natural Resources (MDNR) and the U.S. Environmental Protection Agency (EPA), designed and implemented corrective actions to address the elevated temperatures and mitigate odors from the time the SSE was first discovered. In February of 2013, they began submitting weekly reports of gas well data, maximum temperature spreadsheets, and maps to MDNR (MDNR, 2016). Additionally, they began continuous air monitoring at points around the landfill, including air sampling upwind and downwind of the landfill (MDNR, 2015).

Between July 28–31, 2015, MDNR and their contractors conducted a comprehensive sampling event at the Bridgeton landfill, of acute acting respiratory agents. A total of 83 ambient air samples were collected from 12 sampling locations (Fig. 2). The siting included: 3 upwind, 5 downwind, 3 onsite, and one from a landfill flare. Samples were collected for 173 chemicals and they included aldehydes, amines, ammonia, carboxylic acids, hydrogen cyanide, elemental mercury, dioxins/furans, polyaromatic hydrocarbons, volatile organic compounds, and reduced sulfur compounds. The amines, ammonia, carboxylic acids, hydrogen cyanide, and mercury were not detected. All of the aldehydes were below health based screening levels except for formaldehyde. Formaldehyde was detected in every sample collected. All of the sites recorded formaldehyde on July 28 ranging from 9.4 to 11 parts per billion (ppb) and this exceeded the lowest acute screening level of 7 ppb for repeated 8 h exposures. After July 28, formaldehyde concentrations fell below the screening level. Carboxylic acids, dioxins/furans, polyaromatic hydrocarbons, and volatile organic chemicals were all detected in the landfill flare sample, upwind and downwind of the site but were all below health screening levels. A summary of this report can be found at the Missouri Department of Health and Senior Service (DHSS) website (DHSS, 2015).

The Missouri DHSS reviewed air quality screening data and occasionally issued health advisories for sensitive individuals during periods of objectionable odor. The advisories describe odor detection and indicate whether detected air pollutants were at unsafe concentrations–posing increased risk of respiratory symptoms (DHSS, 2016). For example, over the night of July 29–30, 2013 average concentrations of reduced sulfur compounds exceeded a health-based guideline for acute exposure (i.e., highest concentration detected by the Jerome meter was 5.9 ppb).

In addition, the Saint Louis County Department of Public Health (DPH) Air Pollution Control and Waste Management Programs conducted odor and emission monitoring around the Bridgeton Landfill (DPH, 2016). DPH staff measured detectable odors during July through December of 2015. Although the source of the odors and respiratory complaints also came from a landfill outside of the Bridgeton study, the Bridgeton air sampling data were used to indicate potential odor sources and guide actions to address and remediate air quality concerns.

In response to concerns about the Bridgeton Landfill causing nuisance odors and potential health effects, DPH designed a community-based health survey. This investigation described the respiratory health of St. Louis County residents living near the Bridgeton landfill, with an ongoing SSE, compared to residents living beyond the vicinity of the landfill. Our objectives were to determine 1) the prevalence of respiratory symptoms and diagnosed conditions, 2) prevalence of symptoms related to perceived odors and the frequency that odors were detected, and 3) levels of concern about neighborhood environmental issues.

2. Methods

From February 22, 2016 to March 3, 2016, we conducted a cross-sectional household survey both near and away (comparison) from the Bridgeton Landfill in St. Louis County from 9:00 a.m. to 7:00 p.m. CT on weekdays and 9:00 a.m. to 2:00 p.m. CT on Saturday, February 27. We used the Community Assessment for Public Health Emergency Response (CASPER) methodology (CDC, 2012). These methods are increasingly being used in non-emergency situations for collecting information about a community's health status and needs (Schnall et al., 2017). However, to our knowledge, this is the first time CASPER has been used to study chronic respiratory conditions related to an SSE using simultaneous surveys in an “exposed” and comparison sample.

2.1. Sampling frames

The landfill sampling frame contained 4311 housing units (2010 census) and included all census blocks that overlapped or were completely within a 3.2-kilometer radius from the Bridgeton Landfill perimeter (Fig. 1). The 3.2-kilometer radius allowed for a consistent distance around the landfill without crossing the Missouri River into neighboring St. Charles County.

The comparison sampling frame contained 27,469 housing units (2010 census) and included census blocks that 1) were not included in the landfill sampling frame and 2) matched the middle 50% of the landfill population distributions for two demographic characteristics: percentage of white population (72.9–92.1%) and percentage of adults aged 25 years and older with at least a high school or equivalent education level (90.6–94.6%). Matching was based on Census Block Group, American Community Survey (ACS) 5-year estimates (2010-2014) and performed in SAS, version 9.3 (SAS Institute, Cary, NC). There were 39 block groups[1] with comparable demographics to the landfill population.

A representative sample of households was selected for interviews from each sampling frame using the CASPER, two-stage cluster sampling methodology. In the first stage, 30 census blocks (clusters) were selected within each sampling frame, with their probability proportional to the estimated total number of housing units in each census block. Clusters were selected with replacement. In stage two, trained interview teams systematically selected seven households from each of the 30 clusters—every *n*th household was selected, where *n* is the total number of households divided by 7 (CDC, 2012). The CASPER toolkit recommendation to use a 30 × 7 sampling design, to gain a target of 210 interviews in a sampling frame, was employed.

2.2. Household survey

The two-page standardized paper questionnaire was developed to capture: 1) demographic information; 2) physician-diagnosed asthma and chronic obstructive pulmonary disease (COPD) (CDC, 2014); 3) symptoms related to respiratory illness and allergies (Janson et al., 2001) exposure to landfill odors (Mattiello et al., 2013; New Jersey Department of Health, 1985; Lipscomb et al., 1991); 4) interactions with healthcare providers (CDC, 2014)[2]; 5) occupational and household exposures to known risk factors for respiratory health issues (Janson et al., 2001); 6) odor perceptions (New Jersey Department of Health, 1985; Neutra et al., 1991; Lipscomb et al., 1991); and 7) concern about neighborhood environmental issues (Neutra et al., 1991). There were 38 closed-ended questions (e.g., multiple choice, yes/no) and one open-ended question (i.e., specify “other respiratory conditions”). Most questions were framed as members of households “ever” experiencing respiratory illness or experiencing symptoms “in the last 12 months.” All questions captured household-level data.

Interview teams consisted of 60 DPH personnel and 36 volunteers. The teams were trained during five sessions offered by DPH staff—who received guidance from experts in CASPER implementation—on the overall purpose for the study, CASPER methodology (with an emphasis on household selection), logistics, standard interview protocols, and

[1] 674 block groups did not contain or overlap the landfill block groups. St. Louis County has a total of 692 block groups (Census 2010).

[2] “Do members of your household have anyone they think of as a primary care provider or health care provider?” “Has any member of your household had to go to an emergency room to get help for breathing problems or lung infection in the last 12 months?”.

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