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Health issues in the industrial port zone of Marseille, France: The Fos EPSEAL community-based cross-sectional survey

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Health issues in the industrial port zone of Marseille, France: The Fos EPSEAL community-based cross-sectional survey

Abstract

Aim: Community-based participatory research (CBPR), is an increasingly common approach in the USA, but still relatively rare in Europe. In the industrial zone of Marseille, there is a long history of pollution, but little is known about the health implications. This study documented the prevalence of different health issues in two heavily polluted towns in the industrial zone using a CBPR approach.

Subject and Methods: This study used a CBPR approach and epidemiologic methods to answer community members' questions about the health of residents in Marseille's industrial zone by randomly sampling a cross-section of residents to systematically document health issues in Fos-sur-Mer and Port-Saint-Louis-du-Rhône, two towns in the industrial port area of Marseille, France.

Results: Many chronic illnesses were elevated in these communities, as compared to regional and national prevalences, including chronic skin problems, asthma, cancer, and diabetes. Chronic skin problems and asthma were among the most common chronic illnesses reported. A majority of respondents also reported acute symptoms that affected daily life, including eye irritation or nose and throat problems.

Conclusion: There is likely an environmental explanation for why, even after direct standardization, the prevalences of many diseases were higher in these communities than elsewhere. The combination of CBPR and rigorous epidemiologic methods helps make our findings relevant to both community members and researchers.

Keywords: community-based participatory research; environmental health; environmental justice; epidemiology; France; health disparities

Competing financial interests declaration: The authors have no competing financial interests to declare.

Introduction

Health issues in the Golfe de Fos/Etang de Berre region

Myriad industrial sites exist in the Golfe de Fos/Etang de Berre region, located to the west of Marseille, France (figure 1). Over the last two decades, researchers conducted over a dozen environmental health studies (SPPPI 2012) in the region but revealed very little about residents' health outcomes. Those studies varied in methodology, from descriptive and analytical epidemiology using primary and/or secondary data to technical risk modeling studies. Most studies looked for correlations between air pollutants and health outcomes and concluded there were few, if any, health problems or that further study was needed. However, residents were not included in designing those studies and many felt that their questions were not addressed and thus the findings were not relevant, or believable, to them (Allen et al. 2017). There were also several studies that either never concluded and/or never fully released findings to the public. Distrust and frustration regarding professionally-driven health studies was high in this industrial zone. Some residents had tried and failed to get access to health data from government agencies, including being escorted away by police, highlighting how much residents were interested in better understanding their community's health.

Community-based participatory research

Community-based participatory research (CBPR) is an approach that seeks to address these concerns by engaging laypeople—community residents often without any formal scientific expertise, but who have relevant knowledge from their lived experiences—collaboratively in the research process (Minkler and Wallerstein 2008). In CBPR, community members can work together with academic researchers at all phases of the research process, from identifying study questions to interpreting the data collected (Israel et al. 1998). As compared to traditional

researcher-driven studies, high-quality CBPR can increase the study's scientific rigor and relevance (Balazs and Morello-Frosch 2013) and the likelihood that results are used to inform actions that can improve population health (Jagosh et al. 2012; Salimi et al. 2012). CBPR, also called participatory research or action research (Minkler and Wallerstein 2008), has become a popular methodology in the USA, but is rare in Europe.

CBPR studies often seek to understand and address health disparities (Minkler 2010). CBPR has a particularly extensive history studying environmental health disparities (O'Fallon and Dearry 2002), since environmental health questions often emerge among residents living in polluted communities, where official (e.g., government) knowledge can be contested (Allen 2003; Brown 2007). CBPR environmental health studies have explored topics including health in residential communities adjacent to industrial activity (Cohen et al. 2012; Brown et al. 2012), health implications of mobile sources of pollution (Garcia et al. 2013), food and agricultural health concerns (Hoover et al. 2015), water concerns (McOliver et al. 2015), and climate change (McOliver et al. 2015).

Study objectives

To the best of our knowledge, CBPR has not been used to address environmental health questions in France. In this study, our interdisciplinary team used CBPR to design and conduct an epidemiologically rigorous health survey that would answer residents' questions about the health burden of living in a polluted region (Allen et al. 2016). Our study, entitled Fos EPSEAL (étude participative en santé environnement ancrée localement, or locally-anchored participatory environmental health study), sought to document the burden of disease in these two towns. Through conducting this study, we sought to provide data that could respond to residents' hypotheses of elevated health issues in their community, using a study approach that they trusted.

We hypothesized that many health issues would be prevalent. We also hypothesized that the prevalence of diseases with environmental etiologies would be elevated in comparison to regional and national estimates.

Methods

Research approach

Following CBPR principles, residents, local doctors, and other stakeholders contributed at all stages of the research, from framing research questions, offering hypotheses and perspectives on the data analysis, and reflecting on dissemination goals and possible use.

Study population

From June through December of 2015, we systematically randomly sampled households in Fos-sur-Mer and Port-Saint-Louis-du-Rhône, France, by knocking on the door of every fifth residential unit (i.e., freestanding house or unit within a multiunit building) of systematically randomly generated walking loops designed to cover as much of the towns as possible. (The door at which surveyors began was also systematically randomly generated, and surveyors alternated which side of the street they sampled every block.) Our surveyors sampled individuals during the weekday, in the late afternoon/early evenings, and on Saturdays, to maximize our chances of reaching participants while they were home.

Whoever answered the door was invited to participate in the study (provided they were over 18 years of age) by completing the survey in-person at that time, scheduling a time to complete it over the phone at a later date, or completing it themselves online. If no one was home, a flyer was left behind inviting them to participate in the survey online or contact our staff to complete the survey over the phone. We provided all three methods for completing the survey to increase flexibility and accommodate participants' schedules as much as possible. Since

survey participation was completely anonymous, this also precluded us from recording any identifying data that would enable us to contact people subsequently to attempt to increase our response rate; therefore, we attempted to do as much as possible to encourage participation at that single point of contact. It took respondents 20-60 minutes to complete the survey. Data were entered (both in-person/over the phone and online) through the survey provider Qualtrics.

We surveyed 816 respondents, out of 3,776 households randomly sampled, for a 21.6% response rate. (While this response rate may seem low, this is actually considered decent for field surveys, especially those that are only able to contact each potential participant once (Bodewes and Kunst 2016), and because it counts anyone not home as a non-responder. When we remove households where no one was home from our sample, the response rate is approximately 45%.) These 816 respondents, in addition to providing information about their own health and other measures, also reported on the health of the other members in their household. Therefore, we had information about 2,055 residents of these two towns. Since the combined population of the two towns is 24,438 individuals (INSEE 2012), this means that we surveyed approximately 3% of the population and collected data about approximately 8% of the population. Assuming an average household occupancy of 2.5 (based on the data we collected), this means that we invited households home to approximately 38% of the residential population to participate in our survey.

Research ethics

The [University] Institutional Review Board approved the survey. No identifying data was collected at any point, so the IRB determined that no consent forms were needed. After describing the survey to potential participants, we interpreted consent to participate as the respondents' agreement to be part of the study.

Measures of interest

We created the survey using diverse sources for inspiration, including both local and expert knowledge. We consulted with members and staff of local environment and/or health associations in the region, local residents, activists, and practitioners, and other environment and health experts. We drew heavily on a survey conducted in Richmond, California, that documented health and environment issues in a similar industrial context (Cohen et al. 2012; Cohen et al. 2016).

Analytic approach

Data were downloaded from Qualtrics and prepared for analysis in Stata 14.0. We used Stata 14.1 to conduct all descriptive and analytic statistics. Confidence intervals for prevalences were calculated using http://vassarstats.net/prop1.html.

As a sensitivity analysis, we chose a set of conditions for which to directly standardise the prevalences, in order to make our results more comparable. Age- and gender-stratified estimates of the population of France (which includes its island territories), metropolitan France (which only includes continental France), the region (Provence-Alpes-Côte d'Azur (PACA)), and the department (Bouches-du-Rhône) in which the towns are located were used as reference populations. For each condition, the prevalence within our study sample among each group, which were defined by gender and 10-year age group (5-year groups in children), was weighted by the reference population in that group. We did this separately among respondents, the entire adult sample (respondents and household members), the children, and the entire sample. Finally, we summed the variances in each cell, weighted by the squared weight, to construct approximate confidence intervals (Curtin and Klein 1995). Because approximate confidence intervals can cross 0 when the prevalence is low, we truncated lower bounds at 0.

Results

Population characteristics

Fifty-eight percent of respondents were female, but when we considered all household members for whom we had information, the gender balance was even, which was similar to the gender balance in the two towns (table 1). Our respondents also had a higher proportion of individuals who were unemployed or retired than residents of the two towns on average. These demographic phenomena are relatively common to observe in surveys that sample households in person, as women are more likely to participate in surveys and unemployed and retired individuals are more likely to be home. The median age of respondents was 54, and the median length of time at their current address was 10 years. Respondents' educational attainment was, on average, higher than the general Port-Saint-Louis or Fos-sur-Mer populations.

The proportion of respondents who self-reported smoking (30.1%; 95% CI: 27.1-33.3%) was comparable to and slightly lower than the proportion of smokers in the surrounding PACA region (33%) and in France (34%) (Inpes 2013; Guignard et al. 2015); since smoking can affect many health outcomes, the comparability here suggests that smoking is unlikely to be an explanation for any differences in health status observed. When we standardized our population to the regional (appendix tables 2 and 3) and also the French populations (table 3), the standardized proportion of smokers was equivalent to the prevalences observed in studies of those populations.

We asked about dietary consumption of local products, as this could be a pathway of pollution exposure. Sixty-nine percent of respondents reported consuming fruits, vegetables, or plants picked locally, 50% of respondents reported eating fish caught locally, 50% of respondents reported eating seafood caught locally, and 26% reported eating meat hunted locally. We also asked about perceived occupational exposure to pollution: among those currently

employed (n=182), who had worked for a median of 10 years at their current job (range: 0.33-45 years), 44.0% reported being exposed to pollution in their current job. Given the French health care system, respondents had access to health care: 93% of respondents had seen a health professional in the last 12 months, and only 10% of respondents did not access health care because of financial reasons.

Adult health outcomes: chronic diseases

While most respondents self-reported their health to be excellent or good (72%), they simultaneously reported having many chronic diseases and acute symptoms (table 2). In fact, at least 63% of the population had at least one chronic disease, in comparison to 37% of French people (Brocas 2011).

The most common chronic diseases were chronic skin problems and asthma. Over one-quarter of respondents reported chronic skin problems (26.8%; 95%CI: 23.8-30.0%) (table 2), in comparison to 9.7% (Prost and Rey 2015) to 15-20% (INSERM 2016) of the French population, depending on the data source. When we standardized our study population to the French population (table 3), the standardized prevalence was the same as the raw prevalence and significantly higher than comparison populations' prevalences.

Among all respondents, 15.1% (95%CI: 12.8-17.8%) had ever had asthma; among non-smoking respondents, 12.3% (95%CI: 9.9-15.3%) had ever had asthma (table 2). Both the total population and the non-smoking population of respondents have a higher prevalence of asthma than the region (6% have asthma currently) (INVS 2016) and France (10.2%) (Afrite et al. 2011). When we standardized our study population to make the results more directly comparable, asthma remained elevated: if our study population had the same age and gender distribution as the region, the prevalence of asthma in our population would be 15.6% (95%CI: 13.7%-17.5%),

and if it had the same population as France, it would be 15.8% (95%CI: 13.9%, 17.8%). Interestingly, while asthma often begins in childhood, 48% of respondents with asthma reported that it began at age 18 or later. Having asthma affected respondents' daily lives: 28% of those with asthma had ever missed school or work due to asthma, and 25% had ever been hospitalized due to asthma.

Cancer was also relatively common: 11.8% (95%CI: 9.8-14.2%) of respondents had ever had cancer (table 2), and the standardized prevalence for direct comparison to France was 10.5% (95%CI: 8.9%-12.1%) (table 3). Measuring the prevalence of cancer can be limited since the most severe cancers can act rapidly, but is still informative. Estimates of the prevalence of cancer in France range from 4.1% (Brocas 2011) to 6% (INC 2016). The most common types of cancer among respondents in order of prevalence were breast cancer, uterine cancer, prostate cancer, and thyroid cancer.

Diabetes was also elevated. Among respondents, 12.9% (95%CI: 10.7-15.4%) reported having been diagnosed with diabetes, in comparison to a 5% prevalence of diagnosed diabetes in France (Fagot-Campagna et al. 2010). The standardized prevalence of diabetes if our study population had the same population as France was 11.6% (95%CI: 10.1-13.1%) (table 3). Among respondents with diabetes (n=104), 11.5% had Type I diabetes, 76.9% had Type II diabetes, and 11.5% did not know which type of diabetes they had. In comparison, among French people receiving diabetes medication, 5.6% had Type I, 91.9% had Type II, and 2.5% did not know (Fagot-Campagna et al. 2010).

We also asked if respondents had any endocrine disease not including diabetes; 13.4% (95%CI: 11.2-15.9%) reported that they did (table 2)). The best comparison data we could find was that 5-10% in the French population has an endocrine disease, but those data had included

obesity, which we had to subtract out, and diabetes (Fagot-Campagna et al. 2010; Brocas 2011; Roche 2012). When we standardized to the French population (table 3), the prevalence of any endocrine disease remained elevated (11.3%; 95%CI: 9.5-13.1%). The most common types of endocrine diseases among respondents were nodules, cancers/ablations, and thyroid problems (both hyperthyroid and hypothyroid).

Adult health outcomes: pregnancy events and acute symptoms

In addition to chronic diseases, there were also two other important domains of disease: pregnancy outcomes and acute symptoms. We asked women respondents only about fertility (n=465). One-tenth (10.3%) reported having sought fertility advice from a health professional (table 2); the standardized prevalence (table 3) to all women in France was almost exactly the same (10.9%). Women reported the outcomes for each of their known pregnancies (n=1099). Over three-quarters (76.4%) of these pregnancies led to a live, term, normal weight birth, 6.1% led to premature and/or low-birth weight babies, 15.5% ended in miscarriage, and 2% ended in stillbirth.

Respondents also reported many symptoms that affected their daily life: 63% reported at least one acute symptom (for which we explicitly ruled out any symptoms potentially caused by hay fever), which included eye irritation (43.4%; 95%CI: 40.1-46.9%), nose and throat problems (other than asthma or other respiratory diseases or allergies) (39.0%; 95%CI: 35.6-42.4%), frequent headaches (37.2%; 95%CI: 34.0-40.6%), and frequent nosebleeds (7.5%; 95%CI: 5.9-9.6%)).

Child health outcomes

We also collected data from the respondent about the health of any children in the household. The most common health problems among children were chronic skin problems

(20%), hay fever (20%), chronic nose/throat problems other than asthma or hay fever (18%); the standardized prevalences (table 3) considering all children in France were almost exactly the same (e.g., standardized prevalence of 21% for chronic skin problems and 20% for hay fever).

Discussion

Several health problems, including chronic skin problems, asthma, cancer, and diabetes, are elevated in these two towns in the industrial zone of Marseille. The prevalence of any chronic illness was also quite high. Many of these prevalences are elevated in comparison to the region and the country, including after doing direct standardization. Systematic reviews have documented associations between air pollution and asthma (Anderson et al. 2013), cancer (Chen et al. 2008), and diabetes (Eze et al. 2015), and emerging evidence on environmental pollution and chronic skin conditions (Morgenstern et al. 2008; Kim et al. 2013), endocrine disease (Benvenga et al. 2016), and reproductive health (Nieuwenhuijsen et al. 2014; Mahalingaiah et al. 2016). Therefore, it is plausible that there are local environmental determinants of disease in these towns, perhaps including the many stationary and mobile pollution sources.

Our study had several strengths. Our study sample of over 800 participants is likely one of the largest CBPR primary data collection efforts conducted in Europe to date. We were able to conduct a systematic random sample, which allowed us to make statistical inferences about the population of these towns as a whole. We collected detailed health information that, due to our community-based approach, was of great interest to community residents and filled gaps in expert-generated knowledge.

While a major strength was our random sample, our study's main limitations were also related to this sampling approach. Our IRB approval parameters included recording no identifying information (including address) about our participants to ensure confidentiality.

However, this meant that we could not return multiple times to households where residents were not home when we originally sampled their household to try to encourage their participation. People who are willing to participate upon first contact could be systematically different from people who are not. Nevertheless, because of our CBPR approach and conducting substantial amounts of public outreach, many participants noted that they had heard about our study when we knocked on their doors, and so we may have somewhat mitigated this potential limitation by our first contact being a warm contact for many. An additional limitation is that we surveyed whoever answered the door (unless the person answering the door was under 18, in which case we asked to speak to an adult), rather than randomly sampling someone upon receipt of a full household list. We decided this approach was acceptable since we still collected health information about all household members. Our last limitation is that all of our data were self-reported. We sought to overcome this limitation by asking participants to report whether or not their doctor had diagnosed them with each disease, an approach used by many leading health surveys that rely on self-report (e.g., USA's National Health Interview Survey), but notes from our surveyors suggest that there could nevertheless still be under-reporting of disease (including instances of people mentioning, but not counting, diseases in the process of being officially diagnosed). It is also possible that health prevalences are an underestimate: our surveyors anecdotally noted multiple instances when potential respondents declined the survey due to their illness or that of a household member.

Conclusions

We have several recommendations for future research and practice. In general, we recommend this community-based approach to conducting research. Many studies have been conducted in the region to explore environmental and/or health issues affecting residents, but few

have engaged residents in the process. By engaging residents throughout the research process, from design to dissemination, we were able to ensure that we answered novel questions that were also of interest to community members. More specifically, we also recommend that future researchers empirically assess possible explanations for the elevated prevalence of disease documented in these towns. There are many implications for practice. For example, given the elevated prevalence of so many health issues captured in our study, we recommend that health services, including specialty care, be easily accessible to local residents. Local residents and politicians have also used our findings to advocate for reduced environmental pollution in the area as a precautionary measure.

We documented many health issues of concern, many of which were aligned with residents' perceptions. In a meeting to disseminate preliminary results in Fos-sur-Mer, the mayor stood up in the meeting and announced confidence in our project. He encouraged community members to participate in the focus groups we assembled to help us analyze the data. In the final dissemination meetings, many residents and local doctors expressed their satisfaction and trust in the results as it reflected what they were seeing in their practices and daily lives. We recommend increasing the use of CBPR methods when conducting health studies across Europe, and beyond.

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Tables

Table 1. Demographics of study population, as compared to demographics of each of the two towns sampled.

Demographics	Respondents (n=816)	All household members (n=2055)	Port-Saint-Louis-du-Rhône (n=8579)	Fos-sur-Mer (n=15589)
Towns	66% Fos 34% PSL	69.6% Fos 30.3% PSL	0% Fos 100% PSL	100% Fos 0% PSL
Gender	57.7% female 41.5% male	49.3% female 49.2% male	52% femmes	51% femmes
Age, in years	Median: 54 Mean: 52.7 Range: 18-98	Median: 41 Mean: 40.5 Range: 0.06-104	18.3% : age 0-14 17.0% : age 15-29 18.7% : age 30-44 20.9% : age 45-59 15.3% : age 60-74 9.8% : age 75+	19.9% : age 0-14 18.3% : age 15-29 21.0% : age 30-44 21.0% : age 45-59 14.8% : age 60-74 5.0% : age 75+
Household size	Median: 2	n/a	Mean : 2.24	Mean : 2.55

	Mean: 2.5 Range: 1-9			
How long at current address, in years	Median: 10 Mean: 15.2 Range: 0.008-84	n/a	Mean: 15.5	Mean: 13.7
Current employment status	33.2% full-time 8.0% part-time 57.0% unemployed/retired	n/a		
Employment status among those 18-64	56.9% employed (46.1% full-time, 10.8% part-time) 41.8% unemployed/retired	n/a	55.9% employed, 32.3% unemployed/retired, 11.8% chômeur (unemployed but actively searching)	62.7% employed, 27.5% unemployed/retired, 9.8% chômeur (unemployed but actively searching)
Educational attainment				
Up to 10th grade	11.2%	n/a	27.9%	17.9%
High school degree	19.9%	n/a	15.3%	18.6%
Vocational/trade school degree	35.3%	n/a	27.6%	31.8%
Any higher education	20.8%	n/a	12.2%	18.0%

degree (bachelor, masters, and/or professional)				
Other	12.8%			
Income	<11,500 EUR: 12.8% 11,501-13,800 EUR: 13.3% 13,801-23,000 EUR: 25.6% >23,000 EUR: 32.8%	n/a	20.2% below poverty level (<11,840 EUR)	9.9% below poverty level (<11,840 EUR)

Note: source for data for Fos-sur-Mer and Port-Saint-Louis-du-Rhône is (INSEE 2012).

Table 2. Health issues in our study sample and relevant comparison populations

Health outcome	Respondents (n=818)	Region	France
Self-rated health	Excellent: 15% Good: 57% Poor: 19% Very poor: 7%		Very good: 25% Good: 43% Somewhat good: 23% Bad: 7% Very bad: 1%
Chronic conditions			
At least one chronic disease	63%		37%
Chronic skin problems	26.8%		9.4% 15-20%
Asthma	All: 15.1% Only non-smokers: 12.3%	Marseille: 5.2% Region: 6%	10.2%
Cancer	11.8%		4.1% 6%
Endocrine disease other than diabetes	13.4%		5-10%
Diabetes	12.9% (11.5% Type I, 76.9% Type II, 11.5% unknown)		5% (5.6% Type I, 91.9% Type II, 2.5% unknown)
Sought fertility advice	10.3%		

(women only)			
Acute conditions			
At least one acute symptom non-hay fever related	63%		
Eye irritation	43.4%		
Nose and throat problems	39.0%		
Frequent headaches	37.2%		
Frequent nosebleeds	7.5%		
Health risk factor			
Smoking	30.1%	33%	34%

Note: the citations for all of the comparison prevalences are provided in text in results section. Cells are blank when no comparison data are available. When multiple prevalences are reported, these come from separate studies, except in the instance of the endocrine disease prevalence range, which represents the lower (0%) and upper (100%) bounds depending on what proportion of people who had diabetes in that estimate also had another endocrine disease.

Table 3. Standardized prevalences, using the entire French population as the standard population.

All of France	Respondents	All adults	All kids (< 18)	Everyone
Asthma	15.8 (13.9, 17.8)	11.6 (10.0, 13.2)	11.1 (8.2, 14.0)	11.5 (10.3, 12.8)
Autoimmune diseases	6.8 (5.4, 8.2)	6.1 (4.8, 7.3)	2.0 (0.7, 3.3)	5.2 (4.2, 6.1)
Breast cancer	2.3 (1.4, 3.3)			
Among women	4.5 (2.6, 6.3)			
All cancers	10.5 (8.9, 12.1)	8.2 (6.8, 9.5)		6.4 (5.3, 7.4)
All Diabetes	11.6 (10.1, 13.1)	9.8 (8.3, 11.2)	0.2 (0.0, 0.7)	7.6 (6.5, 8.8)
Type 1 Diabetes	1.1 (0.6, 1.7)	1.6 (1.0, 2.2)	0.2 (0.0, 0.7)	1.3 (0.8, 1.8)
Type 2 Diabetes	9.0 (7.7, 10.3)	7.2 (6.0, 8.5)	0.0	5.6 (4.7, 6.6)
Endocrine disease(s) other than diabetes	11.3 (9.5, 13.1)	10.2 (8.7, 11.7)	0.4 (0.0, 0.9)	8.0 (6.9, 9.2)
Fertility problems	9.6 (8.0, 11.1)			
Among women	10.9 (8.0, 13.8)			
Hay fever	42.3 (39.9, 44.8)	34.9 (32.5, 37.3)	20.0 (16.3, 23.7)	31.6 (29.7, 33.5)
Other respiratory illnesses	13.8 (12.1, 15.4)	10.7 (9.2, 12.2)	6.2 (4.0, 8.4)	9.7 (8.5, 10.9)
Other respiratory allergies	25.9 (23.7, 28.2)	19.0 (17.0, 21.0)	12.3 (9.3, 15.3)	17.5 (16.0, 19.1)
Chronic skin conditions	26.7 (24.5, 29.0)	20.9 (18.8, 23.0)	21.0 (17.2, 24.8)	20.9 (19.3, 22.5)
Smoking	33.7 (31.5, 35.8)	32.3 (30.1, 34.6)	1.9 (0.6, 3.2)	25.6 (23.8, 27.3)

Figure legends

Figure 1. Map of the region, including zones where study occurred and locations of industrial activity.

(See separate file.)