

## **Warning Siren Responsiveness: Richmond, CA**

**Sarah Sanchez**

**Abstract** The Community Warning System (CWS) in Contra Costa County, CA is designed to assist communication between chemical plants, emergency response agencies, the public and the media. The purpose of CWS is to alert local citizens of hazards from accidents at nearby chemical plants. If the community is not fully educated about how to respond to CWS, the safety of citizens in the event of an accident will be compromised. My research question addresses whether there are differences in awareness of the CWS that correlate with people's income, education, ethnic background, and home ownership status. In February 2003 2,000 citizens of Richmond, CA were surveyed through the mail, with 281 being returned. Through this research it has been found that there is a relationship between level of knowledge concerning the warning sirens and whether a person rents or owns their home, with owners scoring higher on the knowledge test on average. Unexpectedly, it was also found that people with lower formal education had greater knowledge concerning sirens than those with high levels of education. Not surprisingly, most respondents' self-assessed level of knowledge was closely linked to their tested knowledge level. All of these findings have implications in the future planning for educating the public about the siren system in an effort towards better protection from dangerous chemicals.

## **Introduction**

Community warning systems are responsible for the protection and safety of citizens who live near oil refineries and other chemical plants, and they are becoming increasingly important as the use of hazardous materials increases (Semenza 2002, pers. comm.). A quick and effective warning system can save lives and improve community safety (Semenza 2002, pers. comm.). In 1974 a chemical release in Europe demonstrated the value of a warning system. This release killed people from as far away as 660 feet, but people as close as 260 feet to the incident who heard the warning sirens and sheltered-in place were unharmed (CCCCAER, 2001). Those people who were uninformed about the warning system were left in harm's way. For a community warning system to be most effective, most citizens must understand the system and what to do when it is activated.

An important issue for refineries and municipalities is how to best protect a community in the event of a chemical release. Contra Costa County, California, addresses community safety with the Community Warning System (CWS) (CCCCAER, 2001). CWS uses sirens, specialized telephone systems, national weather service radio stations, and the media to inform the public of potential dangers (CCCCAER, 2002). The sirens are the fastest way of notification, and Contra Costa County used them for the first time in 1998 (Semenza 2002, pers. comm.). Instructional telephone calls follow the sirens, but these are made to a small number of people. Efraim Petel, the President of Hormann America, the company that manufactures the sirens, stated “CWS will not function well if the public is not educated and prepared for the correct action when the CWS activates” (Petel, 2001).

Many studies have found that minorities and low-income people live near chemical plants more than other groups (Semenza 2002, pers. comm.). A recent study focused on accident reports for two counties in New York (Margai, 2001). GIS and statistical analysis of the population was used to determine if the incidents affected disadvantaged neighborhoods disproportionately. “The results suggest that the areas of high-impact from accidental releases of hazardous materials are best characterized by a large proportion of families below the poverty line, Hispanics, and other minorities.” (Margai, 2001)

Minorities and low-income people may have less knowledge about the warning system in Richmond, CA, because of several factors. These include, but are not limited, to an inability to read, language barriers, and lack of time to look through pamphlets and mailings (Semenza 2002,

pers. comm.). Renters are another group of people that are potentially excluded from access to knowledge about the Community Warning System. Informative notices detailing the system and the proper shelter-in-place response are sent out in water bills on an annual basis (Semenza 2002, pers. comm.). A homeowner is likely to pay the water bill, whether they are living in the house or are renting it out, thereby decreasing the information that reaches renters. Renters may also stay in the area for only a short period of time, and therefore may be less familiar with local systems and issues than someone who has owned a home in the community for several years.

The need to look at differences between the knowledge levels of different groups of people is extremely important in Richmond. In a 1999 study the United States Environmental Protection Agency (EPA) determined the Richmond Chevron oil refinery to have the highest leak rates of seventeen U.S. refineries studied (U.S. House of Representatives, 1999). Due to this high leak rate, danger from a chemical release is too great to have uninformed groups of citizens, especially if they comprise the majority of the population around the. The 94801 zip code, where Chevron is located, is one of the poorest in the state of California according to 1990 census data (Sherman, 2000). With the high proportion of impoverished people and minorities near the refinery, it is crucial to know if they also tend to be less educated on how to protect their families.

An Oakland research organization, Evans/McDonough Company Incorporated, has conducted research surveys, on behalf of the Contra Costa County Community Awareness and Emergency Response (CCCAER) program. The survey's 54 questions covered the respondent's ethnicity, language, gender, education level, housing status, and the actions they took during a chemical incident (Evans, 2002). The surveys took place only two days after an incident (Evans, 2002). Knowledge level could then be expected to be higher than at any other time due to recent personal experience and media coverage. The surveys also focused on people who received automated calls (or should have) detailing what to do in an emergency (Evans, 2002). This heightened awareness may skew the level of everyday knowledge about the system, making it seem that people know more than they really do.

Even though the data from the Evans/McDonough survey is skewed by a heightened awareness at the time, there were still some interesting findings. Of the people who had heard of the system, 56% own their home while only 41% rent (Evans, 2002). As far as examining minority groups, 62% of those who had not heard of CWS belonged to an ethnic minority group

(Evans, 2002). A better analysis of these results would be provided by comparing the data with the prevalence of renters and minorities in the study population as a whole. Due to the fact that the Evans/McDonough survey focused on a one-mile radius from the refinery, however, it is not possible to get the specific census data for that particular area. The results of the Evans study were also not analyzed statistically so their significance is questionable.

This study surveyed a wider section of the population than the Evans' survey (2002), examining the entire city of Richmond. By studying the entire city of Richmond I was able to compare my data on minorities and home ownership with census data from the city of Richmond, and thus was able to determine if I had a representative sample. The emphasis of this study was to see if there is a difference in awareness based on whether people rent or own, their income bracket, their highest level of education, and their ethnic background. My hypotheses were that lower income people, less educated people, and renters are under-informed about what to do in the event of an emergency. This study also looked at whether people tend to think they are more informed about the warning system than they actually are. Substantiating my hypotheses will provide an impetus for developing a new approach to inform communities about the CWS that is more inclusive and cost effective.

## **Methods**

In January of 2002 I mailed surveys to 2,000 residents of Richmond, CA. I chose such a large number due to the likelihood of significant non-response. Based on an average response rate of 40% for studies in general (Piazza 2002, pers. comm.), I anticipated that at least 800 surveys would be returned for analysis and hypothesis testing. The addresses surveyed were chosen randomly from an address list of 8,000 registered voters compiled by Evans/McDonough. A random number generator was used to pick a number between one and ten and then starting with the seventh label every fourth label was then used.

The surveys were provided in three languages (Spanish, English, and Laotian) as these have been determined by Evans/McDonough to be the most prevalent languages in the area (Chang 2002, pers. comm.). All three surveys were mailed to each home, with the envelopes being addressed to the head of household, and the survey instructing the head of household to complete the form. The survey was initially created in English and was translated to Spanish and Laotian by volunteers from CCCCAER. Included in the packets that were mailed to each randomly

chosen house was postage paid return-envelopes (addressed to a P.O. Box provided by CCCCAER). Magnets that describe what to do when you hear a siren were provided by CCCCAER and mailed along with the surveys. The fact that some of the answers to the survey were listed on the magnet was considered, however it was worth the risk to the data set to still include the magnets in an effort to educate the public. There also should not have been much bias to my data set from this as everyone surveyed received the same magnet.

The finalized survey and the questions that are included on it can be found in the appendix of this paper. The first eight questions are background questions that cover: gender, age, ethnicity, income level, highest level of education, and rent vs. own. The second set of questions are aimed at determining the confidence level the respondents have as far as what they know about the sirens. Four categories are listed and the respondents are asked to rank their knowledge level with a 4 being fully informed and a 0 being not at all informed. The final group of questions are multiple choice and tests the respondent's actual knowledge level of the community warning system. Five quiz type questions about the system are given and five answer choices are available, with one being correct and the other four false.

Each survey was numbered as it was received, and no personal information, such as name or address, was recorded in an effort to protect the respondents' anonymity. The letters corresponding to the categories that they marked in the background section were entered into a table, along with the numbers for their confidence levels in the second section. Income and education were categorized as low (answer a), medium (answer b or c), or high (answer d or e). For the quiz questions in the final section, right answers will be coded with a one and wrong answers will receive a zero. A total of their quiz scores was tabulated out of a possible 5 points overall. From these point assignments a proportion, representing the people who had the right answers, was obtained.

Several different statistical tests were used in order to examine my three main hypotheses; (1) self-assessment versus actual knowledge, (2) score of renters versus score of owners, and (3) other factors that are associated with a decrease in awareness level. First, in order to look at how much respondents think they know versus how much they actually know, a correlation and four separate Mann-Whitney U tests were run. There are four categories of questions, each one having a self-assessment question and a quiz question. For each category, self-assessment scores were compared between people who got the quiz question wrong and those who got it right.

Second, in order to look at the scores of renters versus owners the total of the quiz question section was used and a Mann-Whitney U test was run between rent and own. Finally, in order to determine if ethnicity, income, or education are additional variables in people's knowledge of the Community Warning System three separate two-way ANOVA tests were run. In each of the two-way ANOVAs homeownership was included in the model because of it's significant effect on knowledge scores. In all of the two-way ANOVAs, interactions were not significant and therefore were not included in the model.

## Results

Of the 2,000 surveys mailed out 385 were returned (19%). Descriptive statistics show that 46% of respondents classified themselves as Caucasian, while 54% placed themselves in categories this survey considered as "Other". Also, of the respondents 26% are renters and 74% are homeowners. In the area of highest level of education, 12% are high school graduates or below, 56% have Bachelor's Degrees, and 22% have their Graduate degree.

The correlation analysis for the first hypothesis yielded no significant information (Figure 1), yet the four Mann Whitney U tests gave statistically significant results showing that people know what they think they know (Table 1).

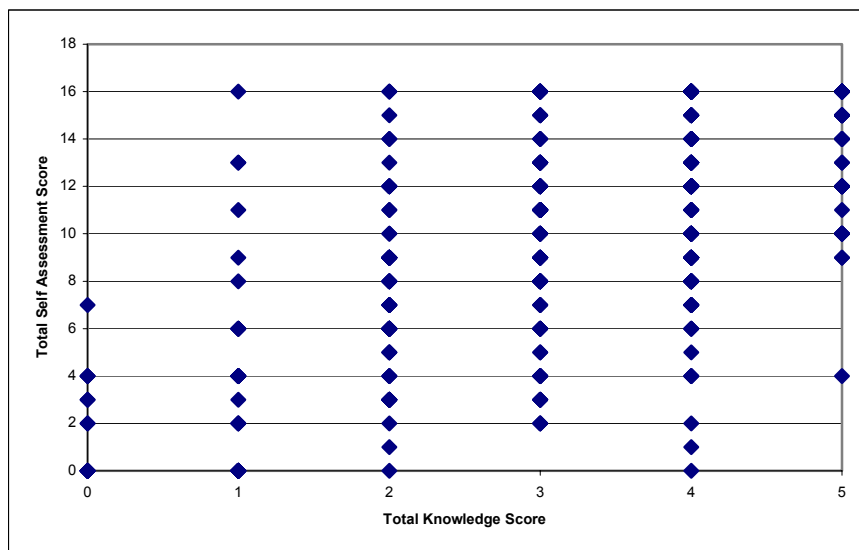


Figure 1: Total Self-Assessment Score Correlated with Total Knowledge Score

Categories	Self Assessment Score ( $\bar{x} \pm sd$ )		Z	P
	Answerd Correctly	Answered Incorrectly		
<b>Community Warning System</b>	3.19 $\pm$ .97	1.75 $\pm$ 1.3	-9.99	< .0001
<b>What the Sirens Signal</b>	2.93 $\pm$ .08	2.41 $\pm$ .11	-3.16	0.0016
<b>Proper Course of Action</b>	2.89 $\pm$ .06	0.75 $\pm$ .16	-8.41	< .0001
<b>Channels with Info.</b>	3.14 $\pm$ .09	1.34 $\pm$ .10	-10.87	< .0001

Table 1: Mann-Whitney U Test Results for Hypothesis 1

Renters had a significantly lower knowledge score ( $2.91 \pm 1.42$ ) than homeowners ( $3.29 \pm 1.29$ );  $Z = -2.23$ ,  $n_R = 97$ ,  $n_O = 275$ ,  $P = .026$ . Education level plays a statistically significant role in knowledge level, with knowledge level going down with higher education, Table 2 and Figure 2. Income level also plays a statistically significant role in knowledge level, with knowledge level going down with higher income level, Table 3 and Figure 3. Finally, ethnicity did not have a statistically significant influence on knowledge level, Table 4 and Figure 4.

	DF	Mean Square	F-Value	P-Value
<b>Rent/Own</b>	1	11.48	6.59	0.011
<b>Educ. Level</b>	2	6.95	3.99	0.019
<b>Residual</b>	360	1.74		

Table 2: Two-way ANOVA for Education Level and Homeownerships based on Total Knowledge Level

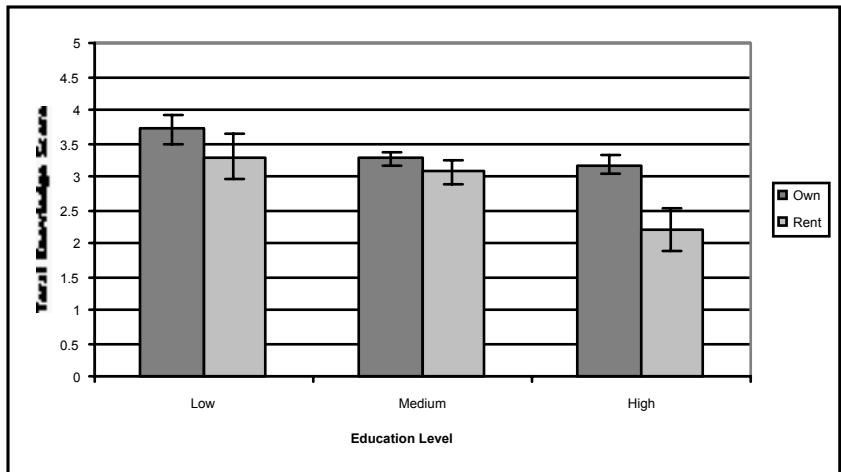


Figure 2: Knowledge Level Based on Housing Status and Education

\*Sample sizes for Rent/Own and Education were: Own/High (OH) = 80, Own/Medium (OM) = 150, Own/Low (OL) = 38, Rent/High (RH) = 20, Rent/Medium (RM) = 66, and Rent/Low (RL) = 10.

	DF	Mean Square	F-Value	P-Value
<b>Rent/Own</b>	1	11.32	6.45	0.012
<b>Income Level</b>	2	5.74	3.27	0.039
<b>Residual</b>	349	1.75		

Table 3: Two-way ANOVA for Income Level and Homeownership based on Total Knowledge Level

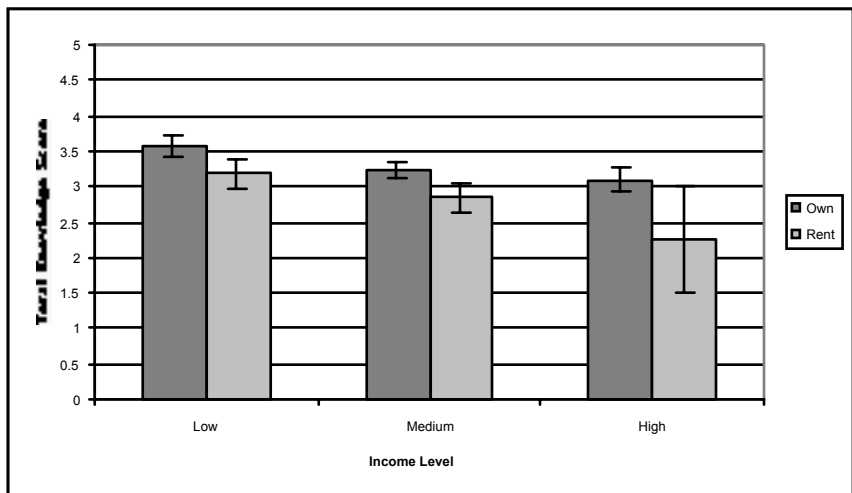


Figure 3: Knowledge Level Based on Housing Status and Income

\*Sample sizes for Rent/Own and Income: Own/High (OH) = 70, Own/Medium (OM) = 129, Own/Low (OL) = 61, Rent/High (RH) = 4, Rent/Medium (RM) = 56, and Rent/Low (RL) = 33.



	DF	Mean Square	F-Value	P-Value
Rent/Own	1	11.31	6.33	0.012
Ethnicity	1	0.14	0.081	0.777
Residual	360	1.79		

Table 4: Two-way ANOVA for Ethnicity and Homeownership based on Total Knowledge Level

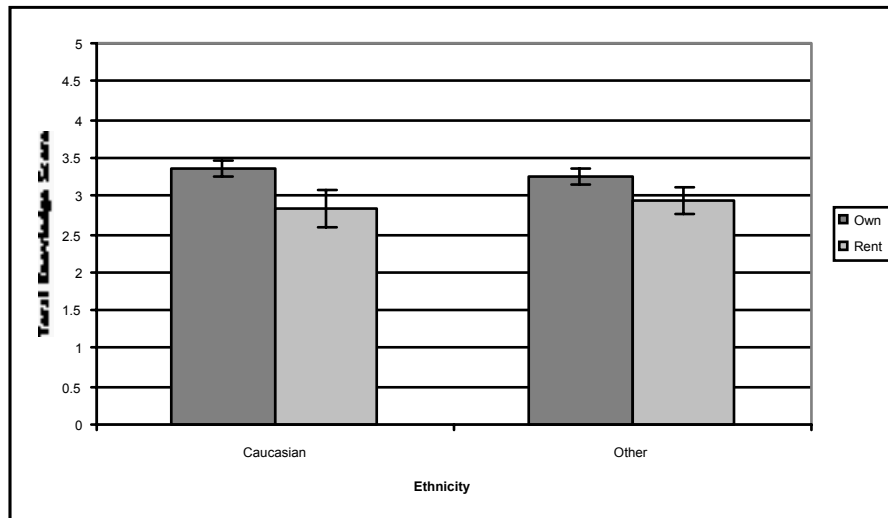


Figure 4: Knowledge Level Based on Housing Status and Ethnicity

\*Sample sizes for Rent/Own and Ethnicity: Own/Caucasian (OC) = 136, Own/Other (OO) = 134, Rent/Caucasian (RC) = 41, and Rent/Other (RO) = 52.

## Discussion

There are some interesting findings as a result of this study and some troubling ones as well. One troubling issue is that a high level of non-response did exist with regards to this survey and it is most likely due to language barriers as well as a lack of interest in the subject matter. The fact that only 19% of those surveyed responded possibly signifies a lack of concern in the community concerning the threat posed by the chemical plants. While language barriers and illiteracy could be an issue, with such a low response rate there is more likely something else at play here. It is unfortunate that the response rate was not higher, as higher numbers could be useful in making the findings more statistically significant.

Another problem associated with the lack of response is whether the surveyed population was a representative sample of the entire population of Richmond, CA as a whole. Comparing the data of this survey with U.S. Census data from 2000 it does not seem that the respondents of

this survey are distributed in the same proportions as the citizens of Richmond. In 2000, Richmond citizens categorized themselves as 31% Caucasian and 67% Other (Bay, 2000), and in this survey there was a much more inflated representation of Caucasians (47%). There was an even bigger discrepancy when looking at homeowners and renters, with the 2000 Census reporting 53% homeowners and 47% renters (Bay, 2000), while this survey had 74% homeowners. Finally in the education level category there was the most dramatic difference between census data and the respondents of this survey. In the 2000 census 77.6% of citizens reported to be high school graduates or below, 14.1% reported to have a Bachelor's degree, and 8.3% said they had their graduate degree (Bay, 2000). Comparing this to the survey results of 50% high school, 25% Bachelor's, and 25% graduate, there seems to be overrepresentation of the more educated population. So in sum this survey had higher percentages of Caucasians, homeowners, and college graduates than the 2000 census reports for the entire city of Richmond. The lack of a representative sample creates a problem when trying to relate the results of the study to the city of Richmond as a whole. However, due to the fact that I am comparing different groups of citizens I do not need a representative sample in order to have useful results.

For hypothesis one, self knowledge versus actual knowledge, the four Mann-Whitney U tests show that people with lower knowledge tend to have a lower self assessment, and visa versa. Due to the low p-values it can be concluded that the correlation between low assessment scores and low knowledge scores is not random, and that people are aware of the amount of knowledge they have. This is important because if they tended to think they knew more than they actually did it would most likely mean that they had a false sense of security, and there by they would be at risk during a chemical emergency. The fact that people seem to realize their low or high levels of knowledge is a move in the right direction for educating the public. If they think that their knowledge level is low then they will most likely be more apt to read pamphlets, watch informational commercials, etc.

Turning to hypothesis two, renters knowledge levels versus homeowners knowledge levels, the Mann-Whitney U test shows that renters do have a lower knowledge of the warning sirens than homeowners. With a median total knowledge score of 4 (out of 5 possible) for the homeowners and only 3 for the renters it does appear that putting informational pamphlets in the water bills does hurt the knowledge level of renters. This data fuels the need for a different approach in educating the public that does not exclude renters from access to the information.

Finally for hypothesis three, other factors that may influence knowledge levels, the two-way ANOVA tests show that highest level of education and income level do significantly influence knowledge level, while ethnicity does not. The interesting point about the effect of education and income level on total knowledge score is that they are the reverse of what is expected. Most people would think that the higher your level of formal education or income level, the more you would know about the sirens, however the exact opposite is true. Most likely the explanation for seeing the reverse of what one would expect is that people with less formal education and lower income tend to live closer to refineries than people with higher education and higher income. Thus, due to their proximity to danger and increased awareness of incidents they may be more likely to pay closer attention to informational pamphlets, etc.

Another interesting point about the influence of formal education on knowledge level is that the previous findings of homeowners knowing more than renters still holds when respondents are grouped by high, medium, and low education level and income level. As shown in Figures 2 and 3, there is a trend downward in knowledge level when moving from low formal education to high formal education and low income level to high income level, and homeowners scores continued to be above that of renters. When respondents were divided up by ethnicity and rent versus own the trend of homeowners above renters was still present, however the results of the ANOVA were not statistically significant. This shows us that the influence of ethnicity on knowledge level is not as strong as that of education and income on knowledge level.

The results of this study show some interesting findings that point towards the need for a change in the techniques used to educate the public about the warning sirens. The fact that notices can be sent for free in water bills is not enough of a reason to overlook renters who aren't receiving the water bill and therefore are not getting necessary information. A mass mailing that encompasses all households and businesses would be more effective as it would reach everyone, not just homeowners. The problem with this, however is the cost of sending out this many notices would be enormous, a possible alternative solution would be television advertisements in multiple languages. It is also important to take into consideration the fact that the level of knowledge for citizens with lower formal education is higher than that for people with higher education, and the same is true for income level. This is important to note because possibly people with higher education and higher income are somehow overlooked in the information process because they are thought of as knowledgeable citizens. This study has provided

statistically significant data that points out the shortcomings in current education techniques. This data will hopefully be used to develop methods of education that are available to all members of the community at large, not just to those who receive a water bill.

### **Acknowledgements**

I would like to thank Tony Semenza, Michael Youngblood, Pamela Bray, Ian Bray, Matt Orr, John Latto, and Manish Desai for all their help throughout this difficult and lengthy project.

## References

- Bay Area Census. 2000. City of Richmond. [Online], [www.bayareacensus.ca.gov/cities/Richmond.htm](http://www.bayareacensus.ca.gov/cities/Richmond.htm)
- Chang, Roger. Consultant, Evans/McDonough, Oakland, California. 2002, personal communication.
- Contra Costa County Community Awareness and Emergency Response (CCCCAER). 2001. Contra Costa Community Warning System. Handout.
- Contra Costa County Community Awareness and Emergency Response (CCCCAER). 2001. Community Warning System. Pamphlet.
- Evans/McDonough Company (EMC). 2002. Richmond Chevron: Presentation of survey results. EMC 02-2580. Oakland, CA. Prepared for Contra Costa Health Services.
- Margai, Florence. 2001. Health risks and environmental inequity: A geographical analysis of accidental releases of hazardous materials. *The Professional Geographer* **53**(3): 422-34.
- Petel, Efrain. 2001. Integrated community warning system. Hormann America Inc. Martinez, CA.
- Piazza, Tom. Research Assistant, U.C. Berkeley Survey Research Center, Berkeley, California. 2002, personal communication.
- Semenza, Tony. Executive Director, Contra Costa County Community Awareness and Emergency Response (CCCCAER), Martinez, California. 2002, personal communication.
- Sherman, Scott. 2000. Environmental justice case study: West county toxics coalition and the Chevron refinery. University of Michigan. [Online]. [www.umich.edu/~snre492/sherman.html](http://www.umich.edu/~snre492/sherman.html)
- U.S. House of Representatives. 1999. Oil refineries fail to report millions of pounds of harmful emissions. Committee on Government Reform. Washington, D.C. Prepared for Representative Henry Waxman. [Online]. [www.house.gov/reform/min/pdfs/pdf\\_inves/pdf\\_enviro\\_oil\\_refine\\_Rep.pdf](http://www.house.gov/reform/min/pdfs/pdf_inves/pdf_enviro_oil_refine_Rep.pdf)

## Appendix

My name is Sarah Sanchez and I am an undergraduate student in the Department of Environmental Sciences at the University of California at Berkeley. I would like to invite you, the head of household, to take part in my senior thesis research study, which looks at how well people are informed about the refinery sirens in Richmond, CA. There are no known risks to you from taking part in this research, and no foreseeable direct benefit to you either. However, it is hoped that this research will benefit others by providing new information on the best way to educate the public on what to do in case of an emergency.

All of the information that I obtain from you will be kept anonymous and confidential. Your participation in this research is voluntary. You are free to refuse to take part and you may refuse to answer any questions. If you have any questions about the research, you may contact me by email: sarmike@uclink4.berkeley.edu or by phone at #(510) 643-3021.

If you agree to take part in this research, please fill out the survey below and return it in the envelope provided. Please do not include your address on the return envelope in order to have your responses remain anonymous. If you have any questions regarding your rights as a participant in this research project, please contact the University of California at Berkeley's, Committee for Protection of Human Subjects at #(510)642-7461. Thank you for taking the time to complete this survey and returning it; please accept the enclosed magnet as a token of my appreciation.

**Gender (circle one):** Male / Female                      **Number of adults (18+) who live in the household:** \_\_\_\_

**Age:** \_\_\_\_\_                                              **Number of children who live in the household:** \_\_\_\_

**Highest level of education for yourself (circle one):**

- a. Some High School   b. High School diploma   c. Some College   d. Bachelor degree   e. Graduate degree

**Income bracket for household (circle one):**

- a. \$0 - 20,000   b. \$20,000 - 40,000   c. \$40,000 - 60,000   d. \$60,000 - 100,000   e. above \$100,000

**Ethnicity (circle one):**

- a. Native-American   b. African-American   c. Asian-American   d. European-American  
e. Hispanic-American   f. Mixed Races

**Do you rent or own your home? (circle one):** Rent / Own

**Please estimate your level of knowledge on each of the follow subjects, please circle a number for each subject:**

	Knowledge Level				
	None				High
a. Community Warning System	0	1	2	3	4
b. What the sirens signal	0	1	2	3	4
c. Proper course of action upon hearing a siren	0	1	2	3	4
d. TV and Radio channels to listen to for information	0	1	2	3	4

**What day of each month do they test the sirens? (circle one):**

- a. Don't Know   b. second Tuesday   c. first Wednesday   d. first Monday   e. They are not tested

**At what time are the sirens tested? (circle one):**

- a. Don't Know   b. 11 a.m.   c. They are not tested   d. 4 p.m.   e. 9 a.m.

**What is the correct course of action when the sirens sound for an emergency? (circle one):**

- a. Don't Know   b. Stop, Drop, and Roll   c. Go outside   d. Shelter, Shut, and Listen   e. No action required

**What do the sirens signal? (circle one):**

- a. Don't Know   b. chemical emergency   c. any emergency   d. storm conditions   e. fire

**Which radio station should you turn to for information? (circle one):**

- a. Don't Know   b. 97.3 FM   c. 580 AM   d. 121.3 FM   e. 740 AM

\*This completes the survey, thank you very much for your time. Please mail this form back in the stamped envelope provided.