A Study of Environmental Health of the Industrial Area of St Croix

University of the Virgin Islands
Eastern Caribbean Center

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Acknowledgments

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Table of Contents

EXECUTIVE SUMMARY

DEMOGRAPHIC CHARACTERISTICS

- **There were more females living near the South Shore Industrial Zone (SSIZ) (58%) and the reference area (53%) than males—42% and 47%, respectively.**

- **In the target area, 16% of the children were under 18 years compared to 12% in the reference (or control) area.**

- **Thirty-four percent (34%) of the residents who were sampled and who lived in the vicinity of the SSIZ were 55 years and over, and were proportionately smaller than the 40% of the same age in the control area.**

- **The disparity by race and ethnicity is evident in that proportionately more Blacks (74%) live closer to the industrial area than in the reference area (66%), and similarly, a smaller percentage of Whites (2%) live near to the target area than in the reference area (9%).**

- **The pattern of Latino residency is similar to that of Blacks: a larger percentage live within the shadow of the industrial zone (34%) than at a distance from the zone (31%).**

- **In comparing the two areas under study, the less educated—41% with less than high school diploma—tend to live near the SSIZ compared to 28% in the reference area, and the proportion with college degrees and above was 15% in comparison with 21% in the reference section.**

ENVIRONMENTAL IMPACTS IN THE TARGET AND REFERENCE ZONES

- **Residents in the target area expressed the frequent the presence of, or reported higher frequencies of the occurrence of, (1) strong and irritating odors, (2) mold, (3) transportation emissions and exhaust and (4) factory smoke.**

- **There is indication that the residents of the reference area do not consider themselves to be impacted to the same intensity as residents in the target zone.**

- **The order of the impacting environmental conditions is not the same for both zones, indicating that the residents who live at a distance from the industrial zone do not experience the same level of morbidity as those who live in proximity to the industrial zone.**

- **The order of impact of environmental conditions on residents near the south shore area are strong and irritating odors, followed by factory smoke and then by mold, in the control area the order is mold, followed by strong and irritating odors, followed by transportation emissions and exhaust.**

- **Red mud dust is ranked fourth most by those who live near the industrial zone. However, it ranks very low in respect of its impact on the health of those who live at a distance from the industrial zone.**

- **The target area is least impacted by industry drainage and runoff, incorrect disposal of chemical waste and improper sewage disposal; in the reference zone the lowest impact is imparted by incorrect disposal of chemical waste, industry drainage and runoff and red mud dust.**

INFERENCES FROM THE FIELD DATA COLLECTION

- **A difference-of-means test was conducted to reveal any statistically significant difference between the means of the groups concerning their perceptions of the impact of environmental conditions.**

- **The mean measure for the target group was higher than the mean measure for the reference group.**

- **The difference-of-means test concluded that there was a statistically significant difference between the target and reference mean measures.**

- **One can conclude that persons within the target zone were much more likely, than those in the reference zone, to report that their households were impacted by negative environmental conditions.**

DISEASES IN THE TARGET AND REFERNCE ZONES

- **About 1 in every 5 persons (21.3%) in the target area reported they had experienced asthmatic conditions within the last five years, and this compares with 1 in 8 (12.5%) in the reference area.**

- **There were more than twice as many residents near the industrial zone who indicate having chronic bronchitis—10.4%—compared to residents who live in the reference area—4.1%.**

I

INTRODUCTION

A. Background to the Environmental Health Study

Around the world, scientists have searched for confirmation that pollution is harmful to life on earth. Indeed, many studies have provided evidence to support the above stated hypothesis, but opposing studies have stated otherwise. Environmental factors, especially pollutants in the air, water and soil, adversely affect the health of four to five billion persons worldwide annually. A number of specific research projects in various geographic locations around the world provide preliminary evidence of the relationship that is posited between a polluted environment and morbidity.

In the United States itself, there is an implicit admission that the basic information about the health of Americans and the environment must be made available before the nation could take advantage of the new knowledge of the links between genetic predisposition and such factors as exposure to pollutants in the environment. Research has shown that long-term exposure to air pollution is linked to an increased risk of chronic respiratory illnesses (Nuvolone et al., 2011). In addition, studies of short-term exposures to high concentrations of air pollution have been associated with higher rates of asthma, bronchitis and other respiratory symptoms (Nuvolone et al., 2011).

Within the US Virgin Islands, there is widespread speculation that environmental pollutants on St Croix, mainly of industrial sources, have adversely affected the health of many of the island's residents. For decades, residents have hypothesized that living and working in the South Shore Industrial Zone (SSIZ) have caused many to become afflicted with several respiratory diseases. In the South Shore area of St Croix, a noticeably unpleasant smell—similar to odors present in many urbanized, industrial areas of the mainland US—has intermittently plagued residents over many years.

In February 2011, the Environmental Protection Agency (EPA) began a study of air pollution on St Croix. Results, released on August 18, 2011, indicated that concentrations of specific air pollutants measured at the three locations were below levels of concern, associated with health problems that result from short- or long-term exposure to toxins (Coward, 2011). Specifically, two of the 60 different compounds, benzene and 1,3 butadiene, measured by the monitoring devices were shown to appear at lower levels of health concern.

The findings of the EPA were encouraging, but rest assured, that short-term study did not quell the complaints of health personnel concerning the potential impact of air pollution on health conditions in St Croix. Since May 2011, several incidences have occurred at Central High School, in which a foul odor sickened students and caused some to be sent some to the emergency room. In fact, Central High School was found to be uninhabitable and was closed on March 18, 2014 and did not reopen for the remainder of the school year. This was a strong indicator that more research on air pollution and its effects was essential on St Croix and the entire Territory.

B. Purpose of the Study

The deep-seated concerns of many Crucian residents within a one-mile radius of the industrial south-shore complex appear justified from a number of events prior to, and within, the current year. As a response to the expressed anxieties of residents of St Croix, the Delegate to Congress for the US Virgin Islands, Dr Donna Christensen, invited the Eastern Caribbean Center (ECC) of the University of the Virgin Islands (UVI) to initiate a study on the impact of environmental factors on health conditions in the SSIZ of St Croix. Upon examination of the necessary costs to conduct the study, researchers at ECC applied for, and received, funding for a Technical Assistance Grant from the Office of Insular Affairs of the US Department of the Interior.

The proposed study aimed to seek out or to collect empirical evidence in relation to the belief that living in certain areas of St Croix contributed to the prevalence of health risk factors. In other words, researchers wanted to identify if a relationship exists between environmental conditions in and around the South Shore Industrial Zone and reports of adverse health conditions. The original plan included a comparison of environmental and health conditions of the SSIZ and an area of St Thomas. Upon examination of the contrasting socio-economic differences between St Thomas and St Croix, researchers decided to choose a control (or reference) area on St Croix.

Indeed, this study addresses the apprehension of many residents of St Croix, and aspires to produce answers that may lead to solutions toward better environmental conditions and healthier surroundings.

II

METHODS

A. Selection of the Study Areas

It was explained in the previous chapter that the original intent was to conduct a scientific sample survey in the marginal areas of the South Shore Industrial Zone (SSIZ) in St Croix, as well as in a geographic area of roughly similar size in St Thomas that would serve as a control. It was further explained that demographic characteristics appeared different enough to suggest the confinement of the study areas to St Croix only.

The target and reference zones for this study were based on the location of estates in relation to the SSIZ. The SSIZ is bounded on the north along Route 68 from the intersection with Route 62 (Camacho's Wholesale - Humbug Road) on the east. The SSIZ continues west until it meets the intersection with Route 681, then runs north until it reaches the Melvin H. Evans Highway (MHE Highway - Route 66) intersection at Sunny Isle. At this intersection, the zone turns west and runs along the MHE Highway's west-bound lane until it intersects with the West Airport Road (Route 64). The western boundary continues south along the West Airport Road and intersects with the western boundary of Estate Betty's Hope and continues in a straight line to the island's southern shoreline. At the end of the SSIZ, the southern boundary runs east along the island's southern shoreline and ends at the Estate Cane Garden parcel that intersects with the bend of Route 62, then continues north until it meets the intersection with Route 68, the northeastern extent of the SSIZ.

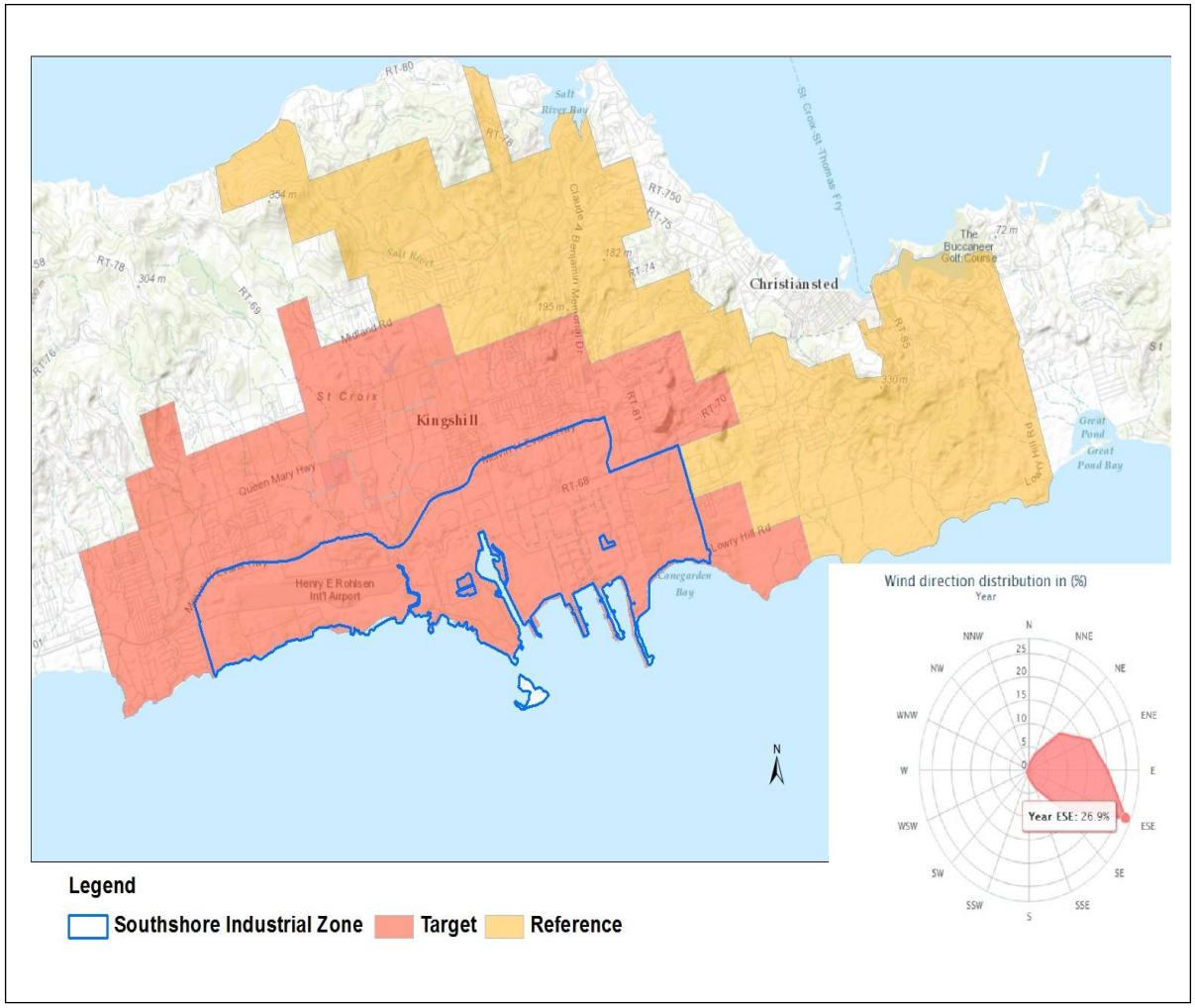
The Virgin Islands Zoning Code has designated two zoning districts for industrial land-use activities: I-1 Industry—Heavy, and I-2 Industry—Light. The total acreage on St. Croix with I-1 and I-2 designation equals approximately 3,861.47 acres. Ninety-seven percent (3,583.83 acres) of the acreage designated I-1 or I-2 is in the SSIZ. All of the estates that are within a one-mile buffer of the SSIZ comprise a part of the target zone of this study. Air quality monitoring stations identified used in previous EPA studies are also within the target zone boundaries.

Figure 2.1 below shows a map of the central portion of St Croix that includes the industrial zone in the south central part of the island. The primary occupants of the SSIZ are Hovensa, LLC; the Diageo USVI, Inc. rum distillery; the St Croix Renaissance Group; the Anguilla Landfill; and the now-closed Harvey/ALCOA Alumina plant and its piles of residual red dust. An eight-year (August 2003 to June 2011) wind rose shows that the prevailing winds are from the east, varying from northeast to southeast. This strongly implies that residential estates in the zone defined by winds blowing from the northeast and southeast are very likely to impact the environment with airborne particulates from within industrial zone. The map also shows the demarcation of a geographic area that is defined by a perimeter of one mile around the industrial zone.

The residential estates—among others—in the immediate vicinity of the industrial zone that were sampled include Barren Spot, Bethlehem Old Works, Clifton Hill, Diamond East, Mount Pleasant West, Profit, Ruby, Sion Farm, Strawberry Hill and Williams Delight (Figure 2.2). In the periphery of the

industrial zone, 833 housing units (HUs) were selected probabilistically from among all housing units in the 29 estates in this classification.

Figure 2.1 The Geographic Target and Reference Areas of St Croix



During the geographical conceptualization of the study design, it was decided that a control or reference area roughly similar in size in terms of the units to be selected was to be located in St Thomas. Upon further reflection, this plan gave way to the selection of a control area in St Croix that was distant enough from the industrial zone and in an upwind location. Care was observed to include residential areas that reflected essentially the same characteristics of

those estates on the periphery of the industrial zone. In this reference area, 690 HUs were randomly selected for interviewing.

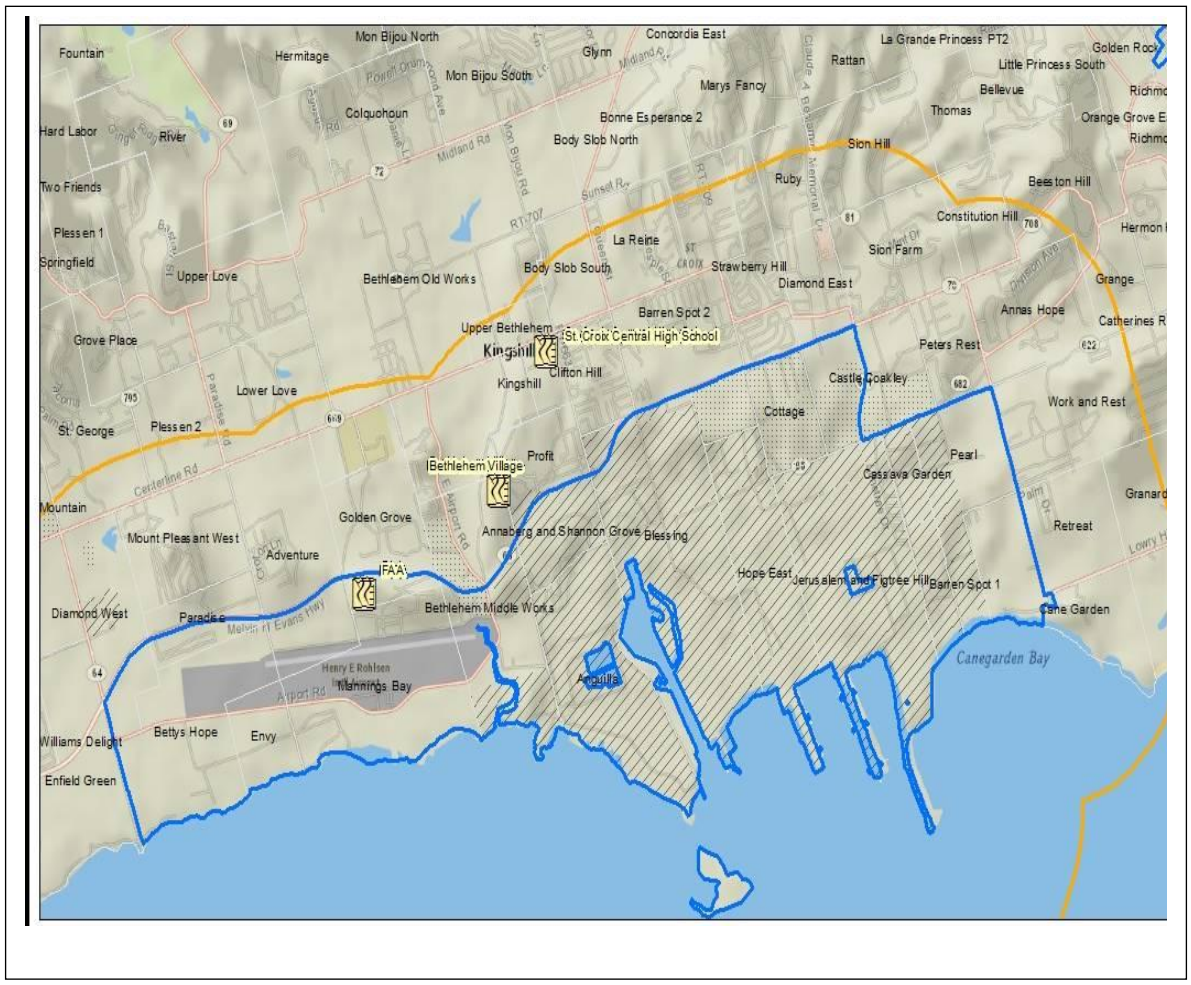
The geographic areas that contributed most units to the sampled estates include Altona, Beeston Hill, Glynn, Mary's Fancy, Mon Bijou South, Mt Welcome, Rattan, Sion Hill, St Peters, and Work and Rest.

B. Sampling Design

The primary consideration in the choice of a sample size is that it should provide sufficient information to meet the objectives of the survey, i.e., to make valid inferences from the survey data. The specific survey sample design is systematic sampling, in which, like simple random sampling, every unit of the population has an equal probability of selection. This feature is particularly useful in situations in which population elements are available in a list form, as it is relatively easy to select every *k*th element after a random start.

Before the sampled units were drawn in the two geographic areas of interest—each of which comprised several estates—all housing units in the designated areas were mapped with the use of Garmin GPS hand-held units. This procedure was the preferred mode of listing as it was uniquely precise in the field location of any HU, thus making it enormously easy to relocate any selected HU during the actual survey. This factor is of great value in an island where streets and roads without names are the norm. Field workers were trained in the use of these hand-held units and in the methods of geographic mapping, and were required to canvass all streets and roads within assigned

Figure 2.2 The Target Area in Proximity to the Industrial Zone



areas. Every occupied and vacant livable structure in the two designated areas was recorded in the GPS unit with its latitude and longitude that is unique to that structure alone. When one structure housed multiple residential units, each unit would have the identical latitude and longitude designation, but would be differentiated in the master list on separate lines of the list.

Once the field listings of all estates in the study areas were complete, their contents were dumped into another file at the main office that would allow the probabilistic selection of a specified number of HUs. Based on sampling

theory, it was decided that $n_t = 833$ randomly selected units would provide adequate estimates with a margin of error of 4% in the target area adjacent to the SSIZ. Systematic sampling methods were also applied to the list of the total number of HUs in the target zone, and in this fashion the 833 units were marked for interviews. In a similar way, each HU in the reference area was listed with its latitude and longitude, from which $n_r = 690$ HUs were selected in a systematic random way. The desired margin of error for estimates in the reference area was also 4%.

The training period for the interviewers was followed by the data collection phase, in which interviewers were equipped with a list of the housing units in which they were expected to conduct interviews, except for selected HUs that were vacant at the time of the visit. These field workers used their Garmin GPS units to quickly negotiate their way to the randomly selected HUs on the list, and then attempted to conduct an interview in the occupied dwelling.

C. IRT and the Survey Instrument

The development of a framework is essential precondition prior to the construction of an effective instrument. It is fundamental because it is the step that is necessary to establish clearly in the researcher's mind what it is that one is trying to measure. In this context, the term *construct* refers to the various attributes of the environment and their individual or collective impact on the health of the residents of the peripheral industrial zone, and which are of interest to be measured. It is therefore defined as a single characteristic, attribute, or dimension that is assumed to underlie a set of items. *Latent trait* is also used synonymously with construct. One can regard environmental health

as a latent trait because it is not directly visible, and is a concept that can take on ratings from low to high.

One primary intent of the survey was to measure the perceived environmental effect on the health of residents in the vicinity of the industrial zone, and to assess the degree of self-identified morbidity among residents near the zone. This construct is herein referred to as *Morbidity in the Vicinity of the Industrial Zone*. Since one cannot directly measure a construct, items were devised to tap into the construct. As long as the items were directly related to what it is desirous of being measured, the construct is likely to be unidimensional. This is a desirable psychometric property for an instrument, for it ensures that there is only one single dimension in the construct of interest, and the level of this construct is the focus of the measurement. The method of measurement departs significantly from the Classical Test Theory method of treating ordinal categorical values as if they were linear interval measures. Instead, it makes use of Item Response Theory, from which a metric of desirable measures derived and on which parametrical statistics analysis can be conducted[1].

Considerable thought was given to the core items that constituted the survey instrument. Since the unidimensionality of the construct *Morbidity in the Vicinity of the Industrial Zone* demanded that the items be all directly related to the core dimension of impact on health conditions, a number of questions were adopted from previously tested questions in other national and international surveys, and adapted to the specific needs of this survey (see Bhopal et al., Toren et al., Najjar, and Nuvolone).

[1]Item Response Theory (IRT) has rapidly become mainstream as the theoretical basis for measurement …. due to the more theoretically justifiable measurement principles and the greater potential to solve practical measurement problems." (Embretson, S.E., & Reise, S.P. (2000).

The principal advantages of the Likert format in the standard questionnaire are that it is familiar, that it is relatively easy for respondents to answer well-formulated questions, and that it often does not consume a lot of time (refer to Chapter 3 for a detailed description of the questionnaire). However, because the responses produce raw-score data at an ordinal level of measurement, the traditional practice of transforming the scores into percentages for ordering purposes may be misleading due to the fact that the distances between the percent scores do not have direct meaning. (For example, the difference between 90 and 95 percent satisfaction on two items does not represent the same intensity of satisfaction as that between two other items at 75 and 80 percent.) It is therefore highly inappropriate to compute averages and standard deviations on these ordinal data, as the results can be rather deceptive.

The Rasch Rating Scale Model (RSM) was applied to the survey data to transform them from an ordinal into an interval scale with the measurement property of equal units upon which standard arithmetic operations can be performed. The values of the items in Sections A and B in the survey instrument were rescaled from *logits* to range from 0 to 100—although this latter scale is not a percent scale—in order to produce a meaningful scale for score interpretation and parametric data analysis[2]. The smaller the number on the transformed scale—i.e., the closer to 0 of the lowest item measure or item calibration—the easier it was for the respondent to endorse the frequency of the impact of environmental effects on the respondent's health, and the greater morbidity among residents. On the other hand, the bigger the number—i.e., the closer to 100 is the highest item measure—the more easy it was for the respondent to endorse the item as *never* having, or only *scarcely* having, an

[2]The *logit* is a unit of measurement that results when the Rasch Rating Scale Model is used to transform raw scores obtained from ordinal data to log-odds ratios on a common interval scale.

impact on their health conditions. Consequently, the lower the level of the environmental factor on the scale, the bigger the impact on residents in the zone, and the higher the item on the continuum, the smaller was the extent of the effect on the residents.

While the percent distribution of each item provides basic information of the raw scores, the counts themselves are not able to differentiate between the levels of morbidity. Moreover, percentages cannot be treated as if they are on an interval scale because the distances between them have no direct meaning. All that one can infer is that there is an ordering of the percent values for the items, but one cannot say with any certainty what the size of the gap is. By transforming the raw scores into an interval scale the reader is able to readily determine which items are reflective of a high degree of impact, and which ones are reflective of low degrees of influence.

Advantages in the use of the method applied here are that with interval-scale measures, immediate responses are available for the questions: What is the prevalence rate of morbidity among residents in the proximity of the industrial zone compared to residents who live in a selected area further afield? Is there a significant difference between the mean measure of the environmental impact in the industrial zone compared to the reference area? What does a hierarchical ranking of the intensity of the environmental impacts say about residency and health in the two geographic areas? How can the logit[3] calibrations of the items along the morbidity continuum be used for direct comparison with measures among those who experience inhalants at work, or those who work with the industrial zone?

[3] A *logit* is a pure, abstract, interval-level unit of measurement that results when the Rasch model transforms ordinal raw scores to a common metric.

Additional results that are forthcoming from the application of the model include: data on an hierarchical ranking of the level of impact, a measure that helps to locate each environmental item on the unidimensional continuum of the morbidity construct, a measure of the reliability of each statement that is used in the instrument, and a measure of the validity of each question or statement. (The terms *statement*, *item* and *question* are used interchangeably in this report.) Perhaps the model's most substantive feature is that the measures that are produced are all at an interval level, thus enabling the construction of an objective hierarchy of all the statements. They also permit one to say by how much one environmental condition is ranked above, or below, another.

Another valuable feature of the RSM analysis is that unlike the traditional method of comparing raw-score means and standard deviations from different surveys in different locations—which is inappropriate—measures derived from the application of the RSM can be compared statistically for the significance of differences. For example, it is possible to compare the mean of the measures from the target area with that from the reference area.

III

FIELD DATA COLLECTION

A. The Environmental Health Study Questionnaire

The survey instrument for this research study was developed by researchers at the Eastern Caribbean Center of the University of the Virgin Islands. The final instrument consisted of four sections: (1) environmental incidences, (2) adverse health conditions, (3) exposure to smoke and harmful inhalants and (4) demographic questions (see Appendix II). The first section required participants to reveal their perceptions of the impact of eleven (11) environmental incidences within their households in the last five years by responding *Never*, *Scarcely*, *Sometimes* or *Always*. Those environmental incidences included red mud dust, transportation emissions and exhaust, factory smoke, mold, incorrect disposal of waste, industry drainage and runoff, improper sewage disposal, contaminated drinking water, strong and irritating odors, landfill odor and other materials in the cistern.

The second section asked participants to indicate if someone in their household suffered from ten (10) health conditions within the last five years by responding *Yes* or *No*. If the response was *Yes*, participants were asked to indicate the number of household members who suffered from the particular health condition. The health conditions included asthma, chronic bronchitis, lung cancer, emphysema, chronic obstructive pulmonary disease (COPD),

allergies, black lung disease, acute respiratory distress syndrome (ARDS), airborne substances, and mesothelioma.

The third section of the questionnaire asked about exposure to smoking and harmful inhalants at work. The three (3) questions in this section inquired if the respondent smoked within the last five years and, if yes, the frequency of the smoking (e.g. *Daily*, *Once a month*, *1-2 times a year*, *Never*). The same question was asked about anyone in the household, in order to reveal exposure to second-hand smoke. The third question in this section asked if anyone in the household was consistently exposed to harmful inhalants at work.

The final section asked a series of demographic questions, including the respondent's age, ethnic background, income, etc. Due to the fact that only one person in the household was responding to the survey, a method of selecting the person for whom the demographic questions would refer to was utilized. Specifically, if only one person lived in the household, that person's information was recorded in the demographic section. However, if more than one person lived in the household, the following process was used to select the person for whom the demographic questions would refer. If one (1) person in the housing unit suffered from a condition mentioned in Section B, that person's demographic information was recorded. If more than one (1) person in the housing unit suffered from a condition, the person (with a condition) with the most recent birthday was selected for demographic responses. If no one in the HU has suffered from a condition, the person with the most recent birthday was selected for responses in the demographic section.

B. Training and Data Collection

Upon selection of the sample, a training of twenty-four (24) field interviewers and two (2) field supervisors took place on Saturday, March 29, 2014. The majority of the field interviewers and both of the supervisors were experienced survey interviewers who previously worked with the Eastern Caribbean Center on the annual Virgin Islands Community Survey and decennial Census. During the training, interviewers carefully reviewed the survey instrument and interviewing techniques. Additionally, the GIS analyst facilitated a three-hour segment of the training on finding selected housing units. During this segment of the training, the GIS analyst reviewed proper map use, functions of the GPS unit and held an exercise in the field.

Data collection began on April 4, 2014 and concluded on May 2, 2014. Field interviewers reported that residents in selected households were very cooperative and eager to complete the survey interview. The willingness of participation among residents demonstrated the sincere concern regarding environmental conditions and their impact on health conditions on St Croix.

IV

ANALYSIS OF DATA

A. Demographic Characteristics of Respondents

The survey instrument that was used in the field appears in Appendix II. Section D houses the demographic questions that were posed to the respondents. In each randomly selected housing unit (HU) in both of the two areas under study, only one person in the unit was selected for the interview. If one occupant of the HU had experienced any of the morbidities listed, that person's demographic information was recorded. In situations in which more than one occupant suffered one of the listed conditions, the one with the most recent birthday was selected for interview. This approach introduced a degree of randomness that minimized bias in the source of the information. If no one in the household had suffered a disease or illness, the occupant with the most recent birthday was selected. Of those for which demographic information was collected, a total of 306 persons in the target district and 175 in the reference district were classified as having suffered from one of the listed conditions.

Tables 27-34 in Appendix I show the demographic characteristics of the persons that suffered from any of the illnesses. Proportionately, there were more females in the target area (58%) and the reference area (53%) than males—42% and 47%, respectively. In the target area, 16% of the children were under 18 years compared to 12% in the reference area. However, 34% of the residents who were sampled and who lived in the vicinity of the SSIZ were

55 years and over, and were proportionately smaller than the 40% of the same age in the control area. The disparity by race and ethnicity is evident in that proportionately more blacks (74%) live closer to the industrial area than in the reference area (66%), and similarly, a smaller percentage of whites (2%) live near to the target area than in the control area (9%). The pattern of Latino residency is similar to that of blacks: a larger percentage live within the shadow of the industrial zone (34%) than at a distance from the zone (31%).

In comparing the two areas under study, the less educated—41% with less than high school diploma—tend to live near the SSIZ compared to 28% in the reference area, and the proportion with college degrees and above was 15% in comparison with 21% in the reference section.

While interviewees asserted that they spent virtually the same number of hours, i.e., 12 hours of more, in their neighborhoods—76.5% and 76.0% in the target and reference sections, respectively—13% of respondents who lived in the reference district worked in the industrialized belt, compared to 7% who lived nearby and worked in the SSIZ.

B. Environmental Health Impacts in the Target and Reference Areas

Health is often regarded as the most highly valued human asset. Hence any persistent threat to that desirable state, be it environmental or otherwise, tends to arouse strong reactions in potential victims. Morbidity, disease and poor health derived from environmental conditions are of no less concern to residents who believe they are negatively impacted, for these afflictions not only affect

the quality of life, but also life expectancy. This section presents the reaction of residents to perceived threats to their health, and this is captured in Tables 1 to 11 in Appendix I.

The responses were provided to one of four response categories in each of 11 statements—*Never*, *Scarcely, Sometimes* and *Always*. The assumption is made that when a household occupant responded *Never* to a statement in Section A of the questionnaire, the intent was to indicate that there is no impact that has ever been felt or perceived from the particular morbidity. Similarly, a response of *Always* demonstrated the highest level of reaction to the health stimulus, and that *Scarcely* reflected some degree of impact, but less than *Sometimes*. There is thus a gradient of effect in health condition from *Never* to *Always*. The first effort here then is to combine, for each item, all the responses that could be labeled as showing some level of impact by the environmental condition, hence providing evidence of the level of illness.

The impactive conditions of health to which occupants responded included the following: red mud dust; transportation emissions and exhaust; factory smoke (with fine, suspended particulate matter); mold; incorrect disposal of chemical waste; industry drainage and runoff; improper sewage disposal; contaminated drinking water; strong and irritating odors; landfill odor; and other materials in the cistern (i.e., things other than water).

C. Environmental Health Impacts in the Target Zone

One source asserts that "raw scores have special conditions, restrictions, and assumptions which make them very treacherous to analyze and too ambiguous for the solution of contemporary measurement problems."[4] In order for the arithmetic of statistical analysis to be useful, it must be done with equal interval, constant-unit, linear measures. To this end, the Rasch Rating Scale Model was utilized to construct linear measures from the concrete raw response data for which counts are the media. These measures are also required for the derivation of sound, reliable and valid inferences about the group from which the data are collected.

Table 4.1 presents measures for the 11 items of environmental impact that were implicitly rated by the randomly selected residents in the target zone. Column (3) shows the scaled measures corresponding to the serial number of the items on the instrument (in column (1)), with a label of each item given in column (2). The scaled measures in column (3) illustrate that the items in their transformed state from their raw scores are in a range from 0 to 100, with a mean of 49.8. The measures are ordered in size from the largest at the top to the smallest at the bottom, and these collectively create the construct or latent trait—*Morbidity in the Vicinity of the Industrial Zone*—described in II.B above. The scaled values are interpreted to mean that the closer they are to the bottom of the column, the greater the endorsability of the residents of those environmental factors that impact them. Similarly, the closer the item is to the top of the column, the lower is the endorsability of the residents on those

[4]Bezruczko, N. & Linacre, J.M. (2005). Measurement theory foundations. In N. Bezruczko (Ed.). *Rasch measurement in health sciences* (8-34). Maple Grove, MN: JAM Press.

environmental conditions that hardly, or do not, impact them. Column (5), with the item calibrations in logits, presents the same information as in column (3) on another scale.

Table 4.1. **Measures and Rank of Environmental Impacts in the Target Zone**

Item No. (1)	Item (2)	Measure (3)	S.E. (4)	Measure (in logits) (5)	Rank (Least impact to most impact) (6)
5	Incorrect disposal of chemical waste	66.0	1.44	1.48	1
6	Industry drainage and runoff	65.1	1.39	1.39	2
7	Improper sewage disposal	60.8	1.19	1.00	3
10	Landfill odor	54.2	0.96	0.40	4
11	Other materials in the cistern	52.9	0.93	0.29	5
8	Contaminated drinking water	47.6	0.80	-0.20	6
1	Red mud dust	45.3	0.76	-0.41	7
3	Factory smoke	42.8	0.72	-0.63	8
2	Transportation emissions and exhaust	41.3	0.70	-0.77	9
4	Mold	38.1	0.67	-1.07	10
9	Strong and irritating odors	33.5	0.63	-1.48	11
Mean		49.8	0.93	0.00	
S.D.		10.4	0.28	0.95	
Reliability			0.99		

Note: The numbers in col. (1) refer to the serial numbers of the items in the survey instrument (see Appendix II). The measures in col. (3) are rescaled to range from 0 to 100, and are equivalent to the logit measures in col. (5).

A hierarchical ranking of the items is provided in column (6), from the environmental condition with the least effect at the top to the most numerously cited impacting condition at the bottom. Column (4) provides a measurement index of reliability for each item. All of the items have acceptable infit mean square values—not shown in the table—between -0.5 and +0.5. These fit

values impart whether an item is compatible, or not compatible, with the model. Acceptable fit values lie between 0.5 and 1.5 logits.

From column (3), one observes that item 9—*Strong and irritating odors*—with a transformed scale value of 33.5, has the smallest measure of all. This signifies that the item in relation to occasions of pungent and foul odors was the easiest for residents to endorse as having an effect on their health. Similarly, item 4 with a measure of 38.1—*Mold*—was the second most frequently endorsed item affecting their health. The third easiest item that residents endorsed in relation to its effect on their wellness was *Transportation emissions and exhaust.*

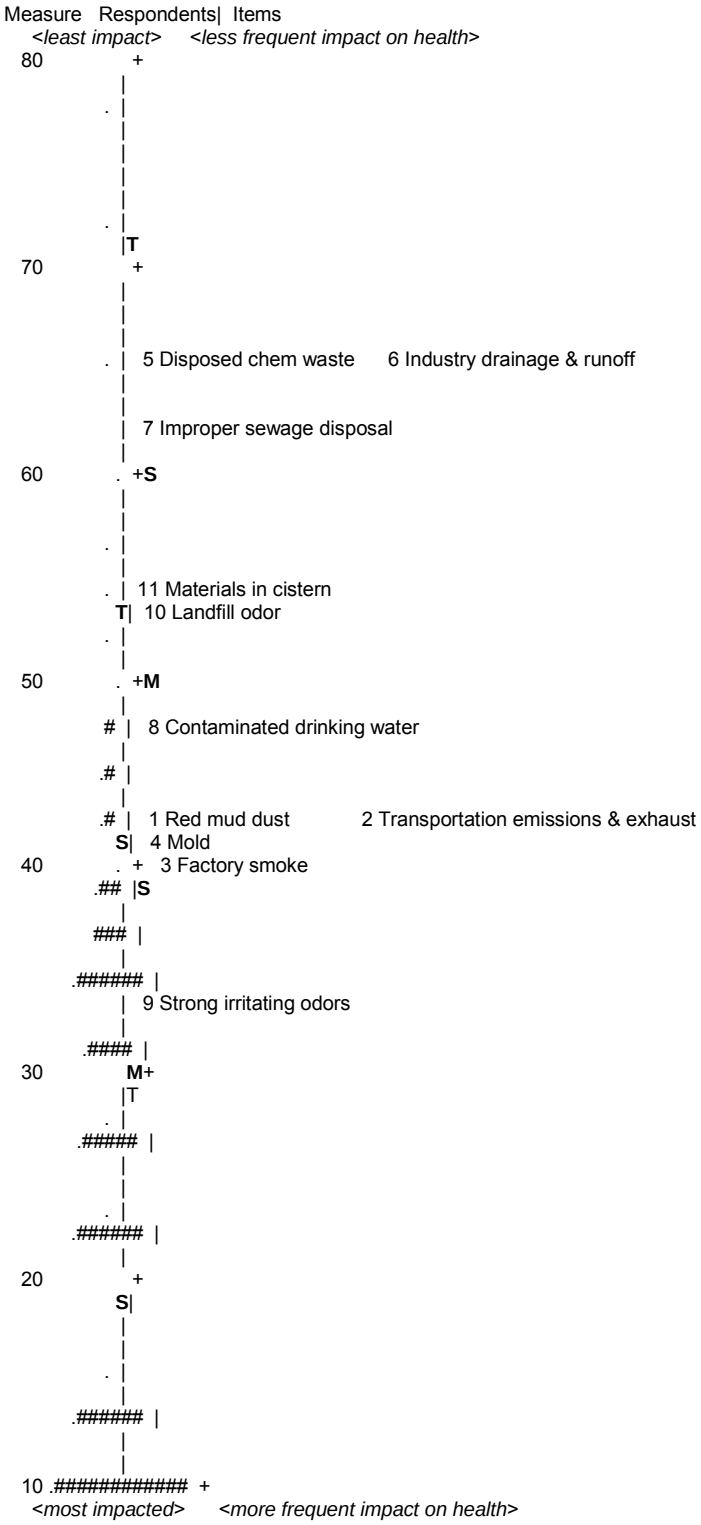
At the other end of column (3), starting at the top, the largest item calibration—item #5 on *Incorrect disposal of chemical waste*—has a value of 66.0, and was concomitantly identified by the residents in the vicinity of the industrial zone as the least of the set of conditions that impact their health. This item was ranked last. Table 5 in Appendix I confirms that less than 1 in 10 (or 9.4%) respondents identified this item as having an impact on their health. This would seem logical, given that any disposal of waste would be limited in geographical scope. The condition with the second least impact is that of item 6 with a measure of 65.1—*Industry drainage and runoff*. This is not surprising relative to the similarity in type to the previous item. About 92% of those responding have never been affected by this environmental condition. The item that speaks to *Improper sewage disposal*, with a measure of 60.8, ranks the third lowest in terms of impact on residents adjacent to the SSIZ.

The ranking of all of the other items in between these mentioned may be read from the table with the help of the last column.

Figure 4.1 presents a graphic illustration of the information in columns (1), (2), (3) and (6) in Table 4.1. It maintains the same rank order of the items as in the table, with the items that elicited the most frequent impact on health at the bottom of the graphic, and the least frequent form of ill effects at the top. It allows the reader not only a quick view of the location of all of the items on the health impact continuum, but it also permits a comparison of the relative gap between any pair of items. The map also shows the distribution of respondents on the left of the vertical line and of the items on a common logit metric. The values that are listed on the left margin derive from the logit scale that has been transformed to range between 0 and 100. The mean of the items is generally set to 0.0 logits, which on the transformed scale is 49.8, and for the residents the mean is 28.2. The means of the distributions of the respondents and the items are shown with the letter **M** on each side of the vertical line, and **S** represents ±1 standard deviation while the **T** represents two standard deviations.

A valuable characteristic of the map is the illustrated vertical distance between the items. It is not only useful to decision makers to know that one item has a higher impact on residents than another, but *by how much* may be even more important. This is a valuable property of the logit scale of the measures that is not inherent in a comparison of percentages that is derived by adding and dividing raw scores. Since the transformed scale is also an interval scale, the equal distances anywhere up and down the map scale are of equal size.

Figure 4.1 **Section A Item-Respondent Map of Residents Near the Industrial Zone**



D. Environmental Health Impacts in the Reference Zone

In experimental research, the control or reference group, for the sake of comparison, does not receive *the treatment the experimenter is interested in studying.* The *treatment* in this case is exposure to the immediate environment of the industrial zone on the south shore. The location of reference zone was therefore deliberate in the selection of an area that was demographically similar in most respects to the target zone, and more particularly, outside of the immediate area of impact by its upwind location.

Table 4.2. **Measures and Rank of Environmental Impacts in the Reference Area**

Item No. (1)	Item (2)	Measure (3)	S.E. (4)	Measure (in logits) (5)	Rank (Least impact to most impact) (6)
5	Incorrect disposal of chemical waste	68.7	3.52	1.75	1
6	Industry drainage and runoff	62.3	2.69	1.14	2
1	Red mud dust	58.7	2.32	0.78	3
10	Landfill odor	58.7	2.32	0.78	4
7	Improper sewage disposal	58.2	2.28	0.73	5
11	Other materials in the cistern	50.6	1.74	0.00	6
3	Factory smoke	50.0	1.71	-0.06	7
8	Contaminated drinking water	48.7	1.64	-0.20	8
2	Transportation emissions and exhaust	37.8	1.23	-1.25	9
9	Strong irritating odors	33.6	1.14	-1.66	10
4	Mold	30.0	1.09	-2.02	11
Mean		50.7	1.97	0.00	
S.D.		11.8	0.71	1.15	
Reliability			0.96		

Note: The numbers in col. (1) refer to the serial numbers of the items in the survey instrument (see Appendix II). The measures in col. (3) are rescaled to range from 0 to 100, and are equivalent to the logit measures in col. (5).

The format of Table 4.2 is similar to that of Table 4.1. It addresses the same 11 environmental impact items that were posed to residents in the target area.

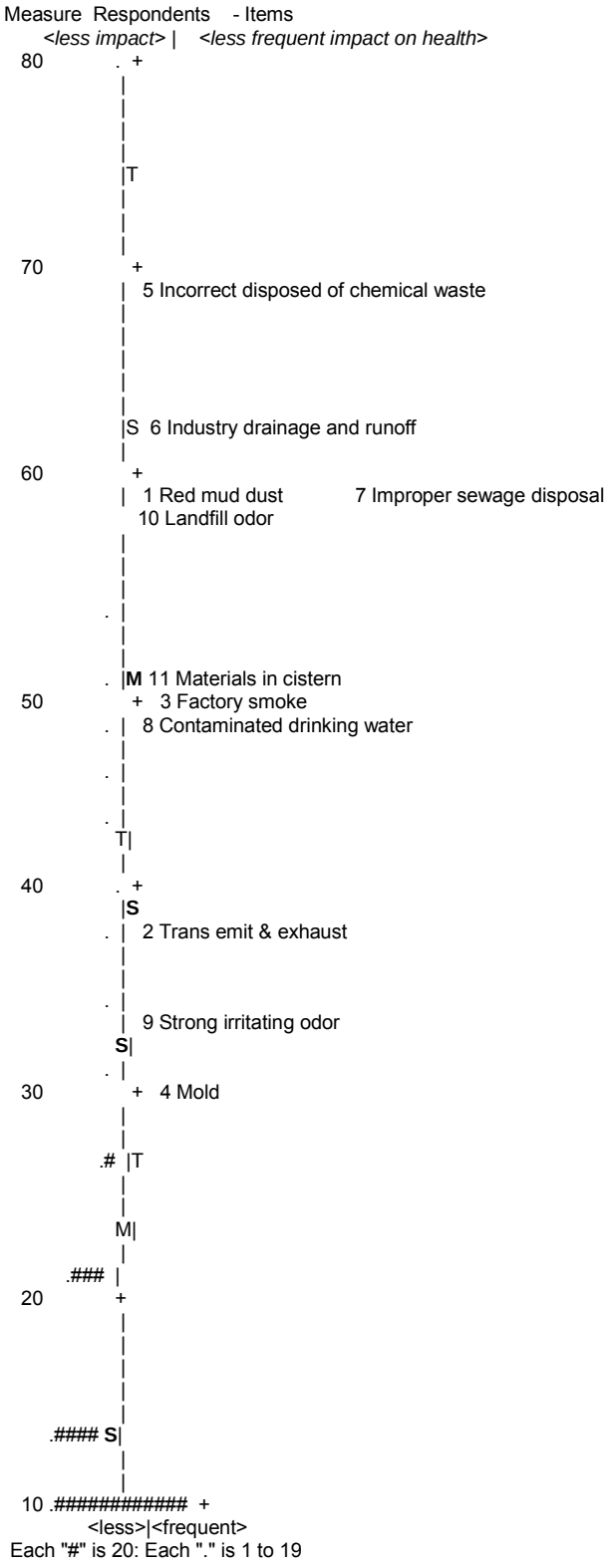
One of the first points of note is that the mean of the item measures in the control area is almost about the same as in the target area in Table 4.1. This is a positive indication that the respondents in the target and reference areas were interpreting the statements in essentially the same way. There is indication, however, that the residents of the reference area do not consider themselves to be impacted to the same intensity as residents in the target zone. A second aspect that is noticeable in Table 4.2 is that the rank order of the items is not the same, indicating that the residents who live at a distance from the industrial zone do not experience the same level of morbidity as those who live in proximity to the industrial zone. Thirdly, whereas the order of impact on those near the south shore area are strong and irritating odors, followed by factory smoke and then by mold; in the control area the order is mold, followed by strong and irritating odors, followed by transportation emissions and exhaust. Fourth, while red mud dust is ranked fourth by those who live near the industrial zone, it ranks very low in respect of its impact on the health of those who live at a distance from the industrial zone. Fifth, while the target area is least impacted by industry drainage and runoff, incorrect disposal of chemical waste and improper sewage disposal; in the reference zone the lowest impact is imparted by incorrect disposal of chemical waste, industry drainage and runoff and red mud dust.

The mean of all respondents in the target zone—as distinct from the mean of the items—was 30.4 (SD = 11.2). This may be observed from the map in Figure 4.1 above. The map in Figure 4.2 displays similar information for the respondents in the reference area. The mean of the respondents on this map is 23.1 (SD = 9.7). The higher mean value of the respondents in the target zone is a reflection of the more frequent responses of *Always*, *Sometimes* or *Scarcely*

compared to *Never*. The lower mean value that residents in the control area gave is attributed to the frequency with which they responded to the lower categories like *Never* to indicate that it was only on occasion that they were subjected to environmental distress.

The map provides another opportunity to visually observe the gaps between the different levels of impact of environmental conditions as expressed by the respondents who are in close proximity to the industrial and those who reside further afield. One observation that is evident is the relatively high level of occurrence of red mud dust that is noted on the south shore periphery, whereas it ranks third from the bottom in the reference area in terms of a health issue.

Figure 4.2 **Section A Item-Respondent Map of Residents in the Control Area**



E. Diseases in the Target and Reference Zones

In a study on air toxins in St Croix, the EPA regional administrator was quoted as saying, "Improving air quality for the people of St Croix is a priority for EPA. The communities near these industrial facilities face health and environmental challenges from air pollution."[5] The same source indicated that both Bethlehem Village and Central High School were impacted by two key pollutant volatile organic compounds, benzene and 1,3-butadiene, which are associated with pollution from refineries. It was also reported that the chemical carbon disulfide, which is associated with strong odors, was highest at Bethlehem Village and was likely the effluent of a nearby rum distillery.[6] Another study indicated that "air pollution has been the cause of numerous health problems including asthma and cancer" (Najjar, 2011).

Section B of the questionnaire addresses a number of specific illnesses that were put to respondents. These included: asthma, chronic bronchitis, lung cancer, emphysema, COPD (chronic obstructive pulmonary disease), allergies, black lung disease, ARDS (acute respiratory distress syndrome), airborne substances, mesothelioma and any other environmentally induced ailment. The data results are reported in Tables 12 to 22. Each respondent was asked whether she or he had suffered from asthma in the last five years. The two simple responses were either *Yes* or *No*.

Table 12 and Figure 12 in Appendix I show that about 1 in every 5 persons (21.3%) in the target area reported they had experienced asthmatic conditions within the last five years, and this compares with 1 in 8 (12.5%) in the reference area. This does indicate a substantive difference, and it appears to conform to

[5] Mhtml:file://C:\OIA\STXZONE\PROPOSAL\EPA Issues Final. Downloaded 9/20/14
[6] Ibid.

the current knowledge that residents in the industrial zone's periphery are exposed to air pollutants that contribute to this disease. The prevalence of chronic bronchitis, shown in Table 13 and Figure 13, is exhibited in a similar pattern: proportionately, there were more than twice as many residents near the industrial zone who indicate having chronic bronchitis—10.4%—compared to residents who live further afield—4.1%.

The most frequently reported illness in both geographic areas under study was the occurrence of allergies (Table 17 and Figure 17). Near the south shore industrial area, 37.1% of the respondents in the survey indicated that they suffered from allergies, and 27.4% of those responding in the reference area admitted to having allergies. For most of the other illnesses, the percentage of occurrence among the respondents was less than five percent.

Another aspect of Section B was that if the respondent within the selected household answered in the affirmative that someone living in the household had suffered from a specific illness, the respondent was then asked how many within the household suffer from that condition. These results were captured in Table 23 and illustrated in Figure 23 (in Appendix I). It is not surprising that the illnesses that stand out were allergies, 21.5% and 15.3%, in the industrial zone and reference area, respectively, asthma (11.0% and 5.6%), and chronic bronchitis (5.2% and 1.8%).

The effect of smoking is evident in the data in Table 24. The top panel of the table refers to the person in the household who was responding. Among those who reported being ill, the percentage was higher for those who smoked daily (10.2%) compared to those who did not report any illness (8.3%). Among the other members in the household, the disparity is even more evident: among

daily smokers, 7.1% reported illness compared to 3.9% who were not ill. The pattern was similar in the graph in Figure 24.

The data in Table 25 indicate an incipient relationship between illness and the presence of harmful inhalants at work. In each classification of exposure — *1 to 2 times a year*, *Once a month*, and *Daily*, — the percent of those reporting illness was always higher than those without illness. One notes that those who report an illness present (10.6%) were more than twice that of those without an illness (4.7%). This relationship between the report on one's health and regular exposure to inhalants at work will be analyzed further below.

F. Inferences of Field Data Collection

(1) Differences in the Level of Impact of Environmental Factors

Before conducting any advanced statistical tests on the data, scores produced from the environmental incidences and adverse health conditions sections were transformed into measures. Specifically, the ordinal scores derived from the participants' responses (e.g., *Always*, *Scarcely*, *Sometimes*, *Never*) were analyzed by a statistically rigorous methodology within the field of Item Response Theory (IRT). This statistical method transformed ordinal level responses into interval level measures that can be subjected to arithmetic operations.

A difference of means test, or t-test, was conducted to reveal any statistically significant difference between the means of the groups concerning their perceptions of the impact of those listed environmental conditions in their households. The mean measure for the target group was 30.43 and the mean

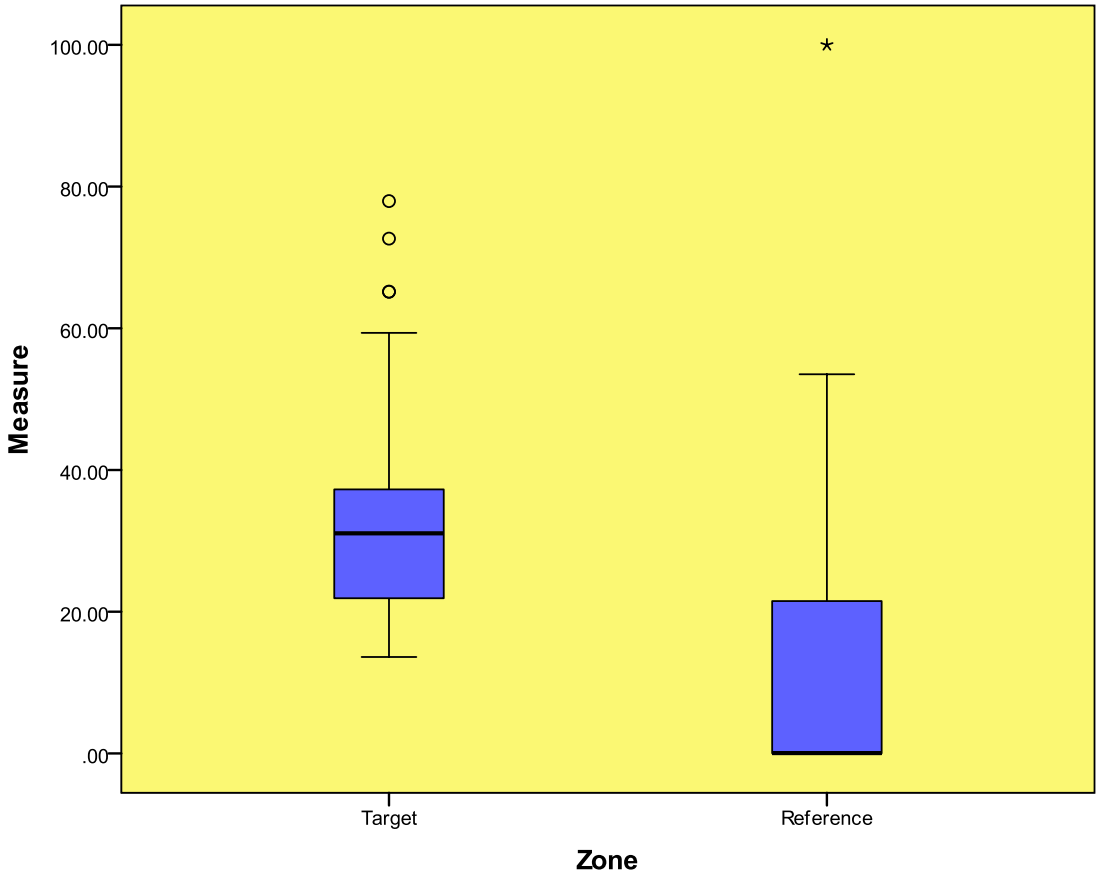
measure for the reference group was 11.36. It is noticeable that the mean measure for the target was higher than the mean measure for the reference group, showing a difference of 19.07. The *t*-test for independent samples produced a *t* value of 23.60 and a *p* value of .000. Therefore, the *t*-test concluded that there was a statistically significant difference between the target and reference mean measures. One can conclude that persons within the target zone were much more likely, than those in the reference zone, to report that their households were impacted by negative environmental conditions.

Figure 4.3 utilized the box plot graph to illustrate the difference between the measures of the two groups. A box plot is a graphical representation of a five-number summary of a distribution that includes the minimum, the maximum, and the three quartiles – the 25^{th}, 50^{th} and 75^{th} – and captures other important features of the distribution. The horizontal line in the box represents the median of the distribution, or the middle score. Half of the measures, or 50%, lie above the median and half of the measures lie below the median. Whiskers extend from both ends of the box. On the lower end of the distribution, the whisker extends to the lowest measure that is not an outlier. An outlier is an observation point (or a measure, in this case) that is distant from other observations. On the upper end, the whisker also extends to the highest value that is not an outlier. The circles beyond the whiskers on the lower and upper end of the distribution of the measures for the target and reference groups represent the outliers. The asterisk on the upper end of the reference zone represents an extreme outlier.

The box plots of the target and control zones in Figure 4.2 demonstrate the vast difference between the groups' perceptions of the presence of negative

environmental factors. The median of the reference group is aligned with the first quartile. Therefore, it is apparent that an overwhelming number of respondents in the reference area did not perceive that their households were impacted by the listed environmental conditions (e.g., red mud dust, strong and irritating odors, etc.). The two distributions represented in the box plot illustrate the distinction between the reported conditions of those living in the separate zones. Moreover, one can conclude that target area residents found it easier to endorse the fact that they have been exposed to air pollution and other forms of harmful environmental substances.

Figure 4.3. **Box plot of target and reference measures**



2) Relationship between Health Impact and Two Independent Variables

In Section C above, measures were provided for respondents in the target zone. These measures of items were given in Table 4.1 and shown graphically in Figure 4.1. The focus at that time was on the construct *Morbidity in the Vicinity of the Industrial Zone*, to determine if there was a unidimensional construct along which the items could be hierarchically ordered. This effort was successful as there was only one item that showed very slight misfit.

Equally important in the graphic was the distribution of the respondents on the left side of the vertical line. Each of the 496 respondents in the target area had a measure that was derived from the raw scores each provided in the ordinal categories of the 11 rated items. Each of these *person* measures reflects the location of each respondent relative to the items on the latent variable. They also reflect the situation in which a respondent who answered *Sometimes* or *Always* frequently to environmental impacts would have a higher raw score than one who frequently answered *Never* or *Scarcely* to the same items. High *person* measures would place a respondent high on the logit or transformed scale, and low measures would locate a respondent low on the scale.

The purpose of this section is to estimate the statistical relationship between the outcome variable—the measure of environmental health impact—and two independent variables, and to determine if there is interaction between the two predictor variables.

The *person* measures comprise the outcome variable for the factorial or two-factor ANOVA as the interval scale of this variable meets the criterion for the dependent variable in this type of linear model. The two main factors derive from date in two questions on the questionnaire. Question 25 asked if anyone in the responding household was consistently exposed to harmful inhalants

while at work. The other predictor variable was Question 36 which asked if the respondent worked in the South Shore Industrial Area.

The two factors were dichotomized. Responses to Question 25 on harmful inhalants were reclassified into two categories, *Never* and *Sometimes*, the latter combining *daily*, *once a month*, and *1 to 2 times a year*. Question 36 that relates to work in the South Shore Industrial Area is already in binary form, *Yes* or *No*.

The (SAS) output presented in Table 4.3 immediately informs us whether any of the two independent variables had an effect on the dependent variable. The first panel of the table tells us about the overall significance of the model—the F value is 2.74, with 3, 492 *df*, and this is statistically significant, $p < 0.05$. The important aspects of the second panel in the table are the significance values of the independent variables. The first noticeable feature is that there is a significant main effect of consistent exposure to harmful inhalants at work. The F-ratio is highly significant, indicating that the attitude of a worker about environmental impacts is affected by her or his persistent exposure to harmful inhalants. This means that even when the place of work is ignored, the consistent exposure to harmful inhalants influences one's perception of environmental conditions.

The table further informs that the main effect IndusZ is not significant, with $p = 0.402$. This imparts that if the place of work of a respondent is in the SSIZ, which alone does not affect her or his attitude to the overall impact of the environment. It is further noticeable from the second panel that the IndusZ*Exposed interaction of the two predictor variables is not significant, with $p = 0.645$. This further means that one predictor variable does not

influence the other. (In graphic form, not shown, the two predictor lines are parallel, further affirming the lack of interaction between the two variables.)

Table 4.3 **Two-Way ANOVA**

Source	df	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	1028.01	342.67	2.74	0.0427
Error	492	61487.90	124.98		
Corrected Total	495	62515.91			

Source	df	Type III SS	Mean Square	F Value	Pr > F
IndusZ	1	87.91	87.91	0.70	0.4021
Exposed	1	606.62	606.62	4.85	0.0280
IndusZ*Exposed	1	26.63	26.63	0.21	0.6446

Note: IndusZ is Work in industrial area, Exposed is Exposed to harmful inhalants at work.

IV

SUMMARY

Research on air pollution provides evidence of a relationship between long-term exposures to airborne toxins and a higher prevalence of asthma, bronchitis and other adverse respiratory conditions. The vast majority of studies on air pollution were conducted in industrial areas of the mainland United States and other urban environments. In highly populated, urban environments, human contact with environmental conditions that negatively influence respiratory health is not startling news. Outside of the Caribbean, many people would be surprised to hear that some residents of the beautiful island of St Croix have been consistently exposed to harmful pollutants in the air. For years, residents of St Croix have discussed the damaging effects, on human health, of working and/or living in the South Shore Industrial Area. This study of the environmental health of the industrial area of St Croix came forth to provide evidence toward, or against, the discussions that positively correlate environmental conditions and respiratory illnesses on the island.

This study sought out to reveal differences, if any, between the perceptions of residents of the target and reference areas concerning the presence of environmental occurrences and the prevalence of adverse health conditions. Indeed, differences between the target and reference groups were apparent regarding the reporting of the impact of negative environmental conditions in the households of the target area residents. In fact, target area residents were more likely to report that their households were impacted by

strong and irritating odors, mold, transportation emissions and exhaust and factory smoke. The lower mean of the measures in the reference group reflected the higher frequency of responses of *Never* concerning the occurrences of negative environmental conditions. In fact, results of the IRT analysis of the data indicated that that the residents of the reference area do not consider themselves to be impacted to the same intensity as residents in the target zone. Furthermore, inferential statistics displayed a statistically significant difference between the intensity of environmental conditions in the target versus reference zones. In other words, more residents in the target zone reported the existence of those environmental conditions within their households and neighborhoods.

In conclusion, the results of this study have offered empirical evidence that adverse environmental conditions that could lead to declining respiratory health exist at higher levels for residents in and around the South Shore Industrial Area of St Croix. Indeed, the conversations that many Crucians have met a premature death as a result of environmental conditions in the industrial area may be more than that of suspicion. This study represents a new beginning of scientific study of the relationship of industrial emanation and respiratory health of residents in industrial areas of St Croix. We encourage the results of this study to be shared with health care providers, educators, policy makers and all residents of the Territory. This research is not only important for the health and future of St Croix residents, but it is necessary for the overall prosperity of the entire US Virgin Islands.

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Appendix I
Frequency and Percentage Tables

Appendix I
Percentage Charts

Table 1. **Frequency of Impact of Red Mud Dust on Household by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**504**	**100.0**	**486**	**100.0**
Never	307	60.9	465	95.7
Scarcely	31	6.2	6	1.2
Sometimes	84	16.7	14	2.9
Always	82	16.3	1	0.2

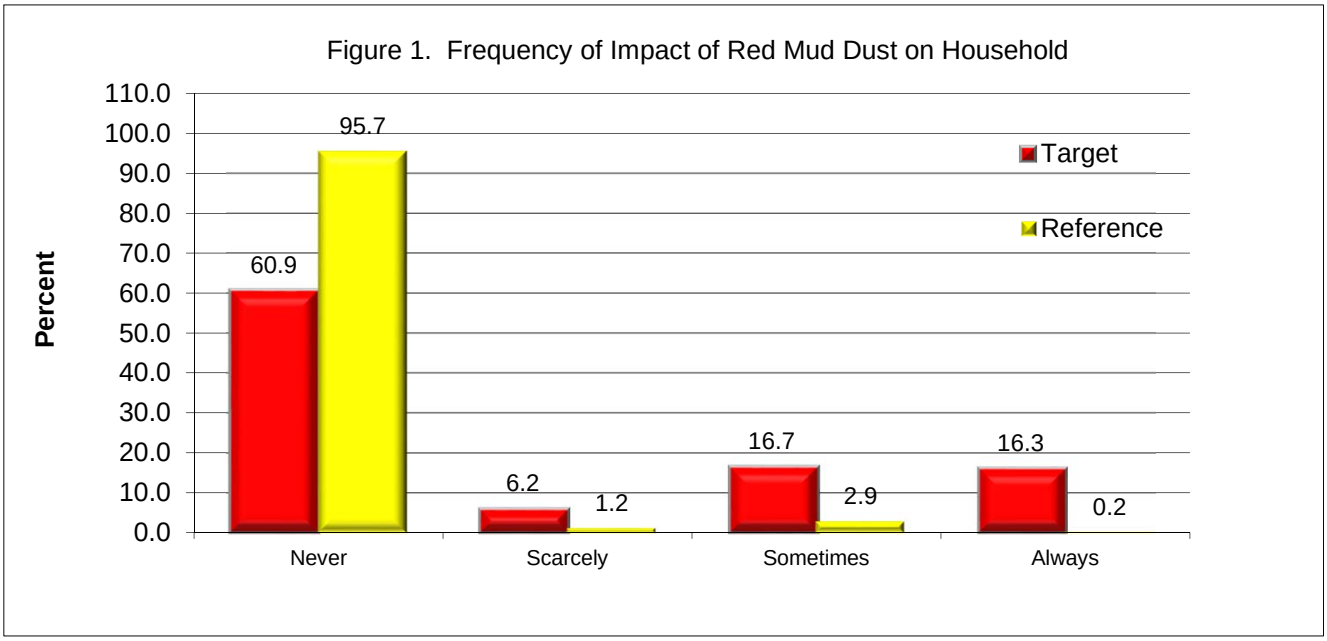


Table 2. **Frequency of Impact of Transportation Emissions and Exhaust on Household by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**504**	**100.0**	**486**	**100.0**
Never	283	56.2	398	81.9
Scarcely	46	9.1	21	4.3
Sometimes	119	23.6	48	9.9
Always	56	11.1	19	3.9

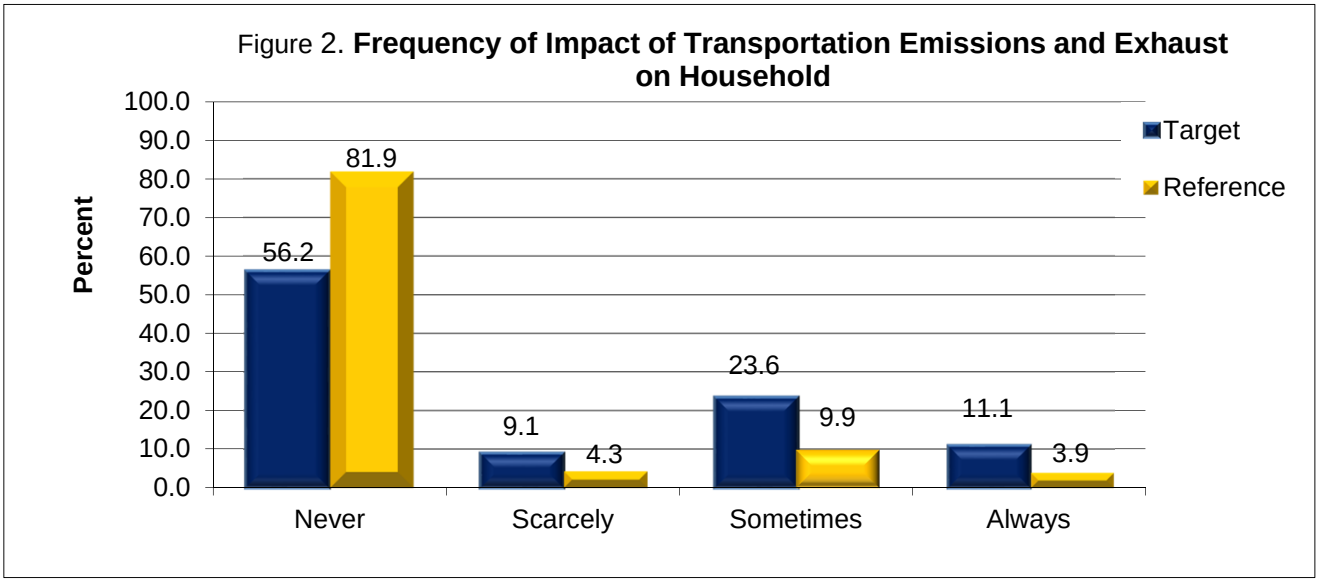


Table 3. **Frequency of Impact of Factory Smoke on Household by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**502**	**100.0**	**486**	**100.0**
Never	241	48.0	448	92.2
Scarcely	60	12.0	12	2.5
Sometimes	156	31.1	19	3.9
Always	45	9.0	7	1.4

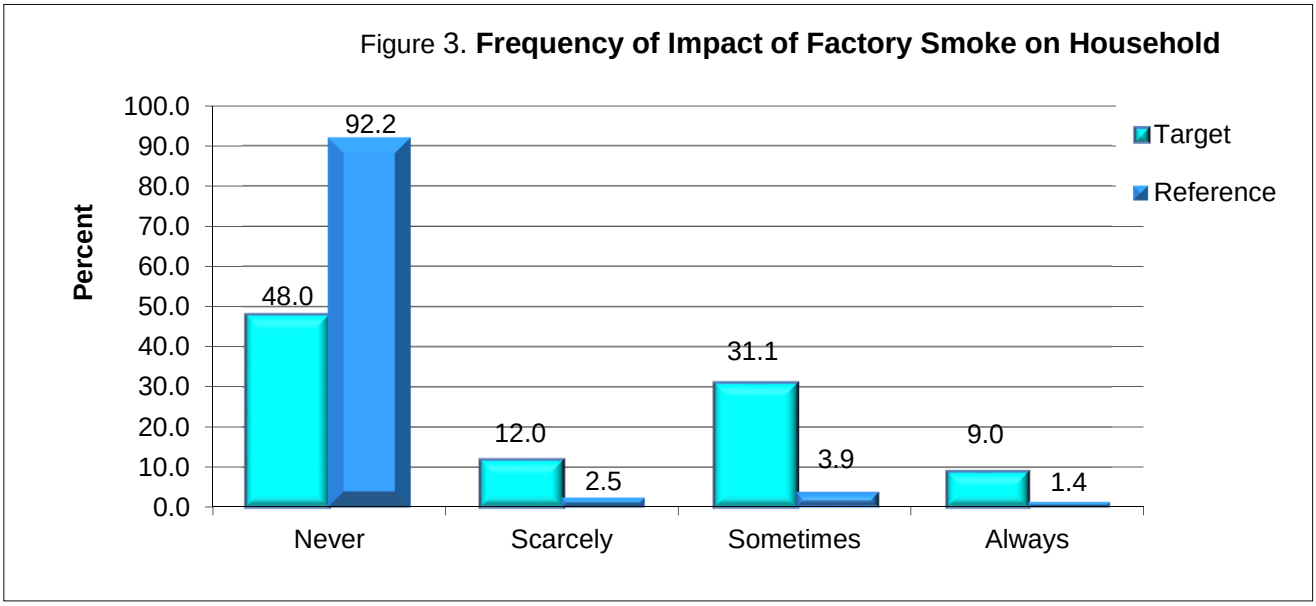


Table 4. **Frequency of Impact of Mold on Household by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**504**	**100.0**	**486**	**100.0**
Never	285	56.5	355	73.0
Scarcely	36	7.1	24	4.9
Sometimes	109	21.6	70	14.4
Always	74	14.7	37	7.6

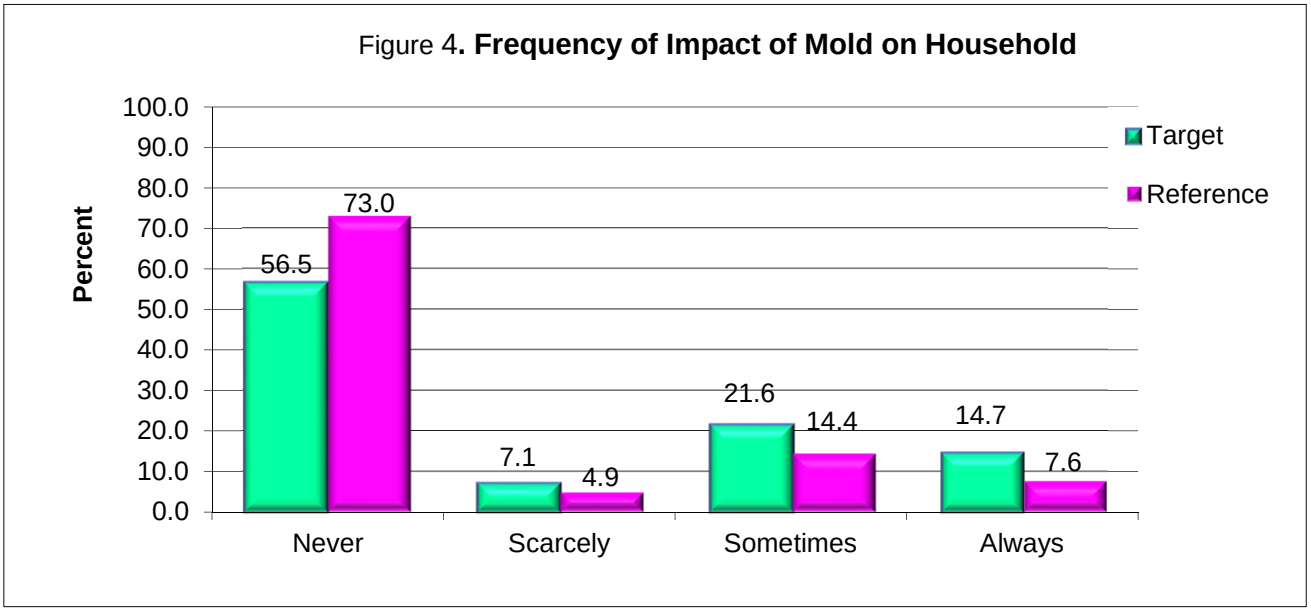


Table 5. **Frequency of Impact of Incorrect Disposal of Waste on Household by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**504**	**100.0**	**486**	**100.0**
Never	457	90.7	478	98.4
Scarcely	13	2.6	2	0.4
Sometimes	24	4.8	5	1.0
Always	10	2.0	1	0.2

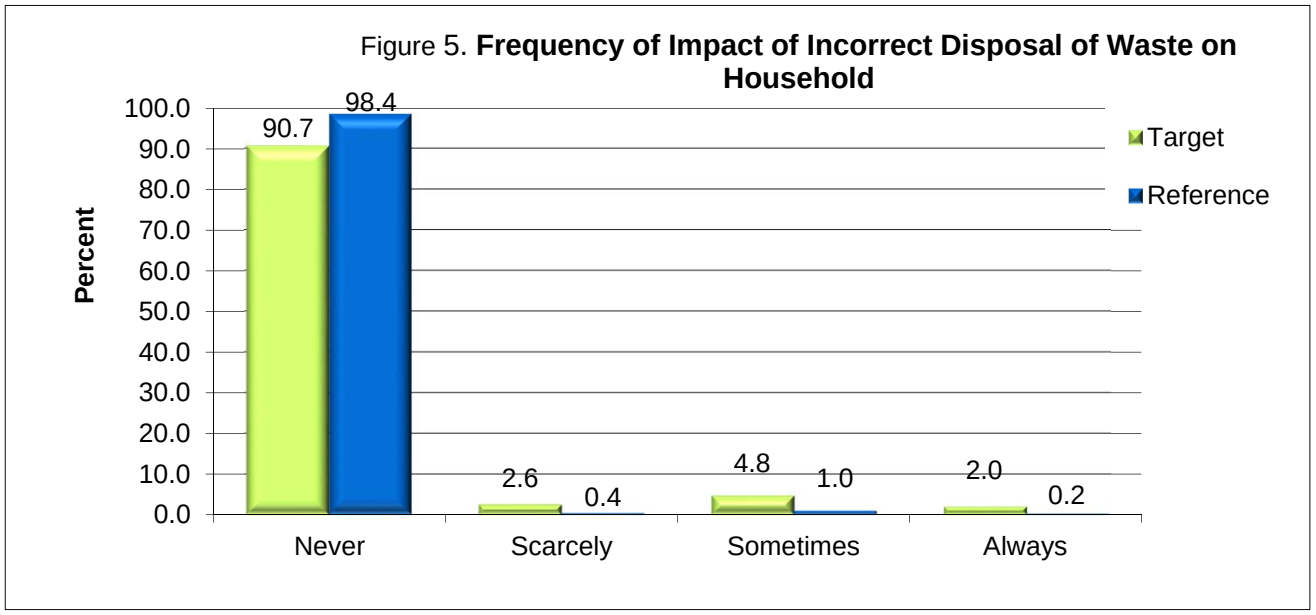


Table 6. **Frequency of Impact of Industry Drainage and Runoff on Household by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**504**	**100.0**	**486**	**100.0**
Never	466	92.5	471	96.9
Scarcely	3	0.6	3	0.6
Sometimes	18	3.6	11	2.3
Always	17	3.4	1	0.2

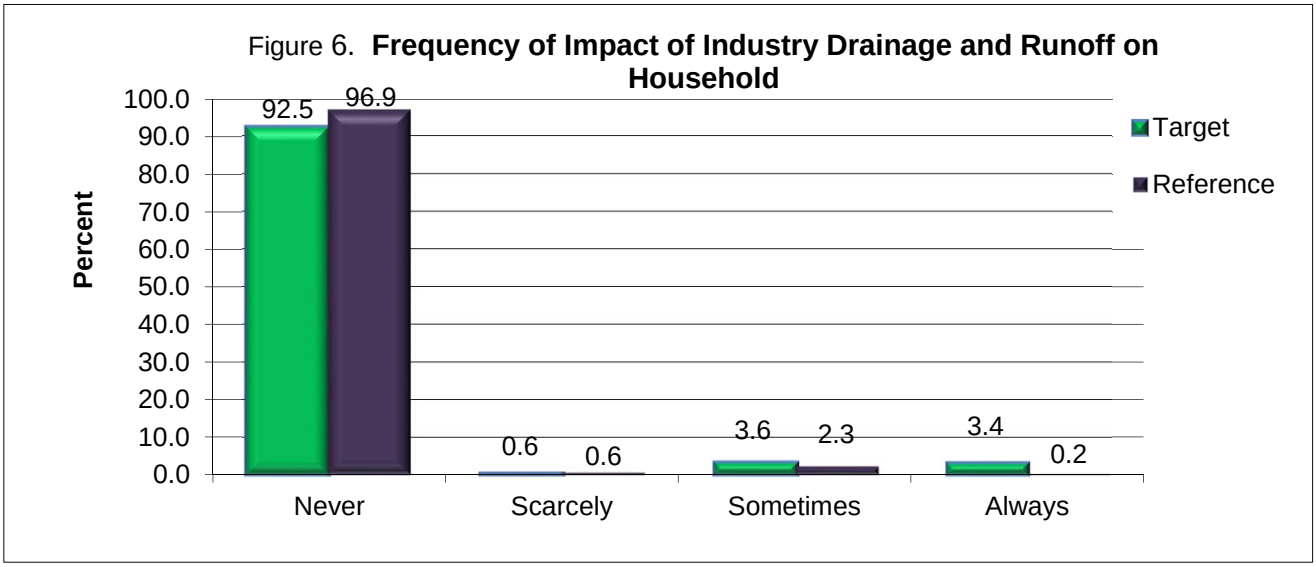


Table 7. **Frequency of Impact of Improper Sewage Disposal on Household by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**504**	**100.0**	**487**	**100.0**
Never	445	88.3	468	96.1
Scarcely	13	2.6	3	0.6
Sometimes	28	5.6	12	2.5
Always	18	3.6	4	0.8

Figure 7. **Frequency of Impact of Improper Sewage Disposal on Household**

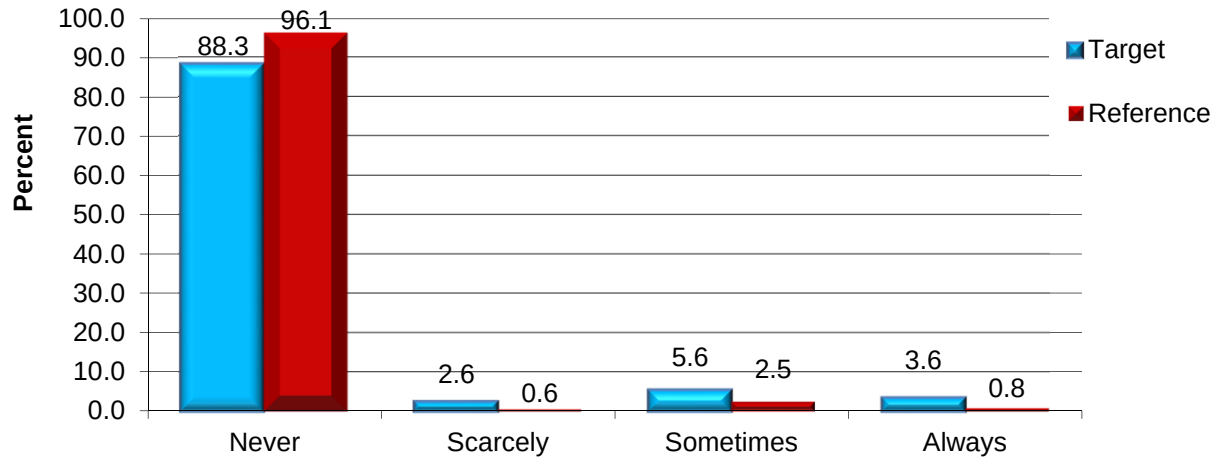


Table 8. **Frequency of Impact of Contaminated Drinking Water on Household by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**502**	**100.0**	**486**	**100.0**
Never	348	69.3	447	92.0
Scarcely	24	4.8	6	1.2
Sometimes	75	14.9	21	4.3
Always	55	11.0	12	2.5

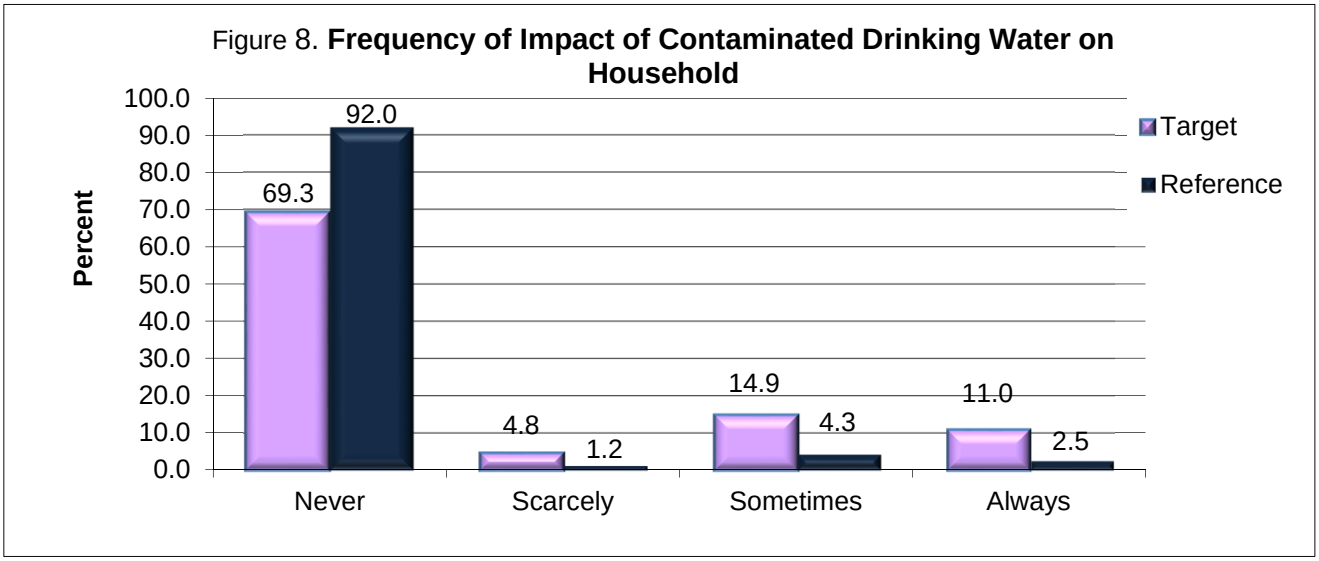


Table 9. **Frequency of Impact of Strong and Irritating Odors on Household by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**503**	**100.0**	**486**	**100.0**
Never	133	26.4	363	74.7
Scarcely	62	12.3	32	6.6
Sometimes	237	47.1	76	15.6
Always	71	14.1	15	3.1

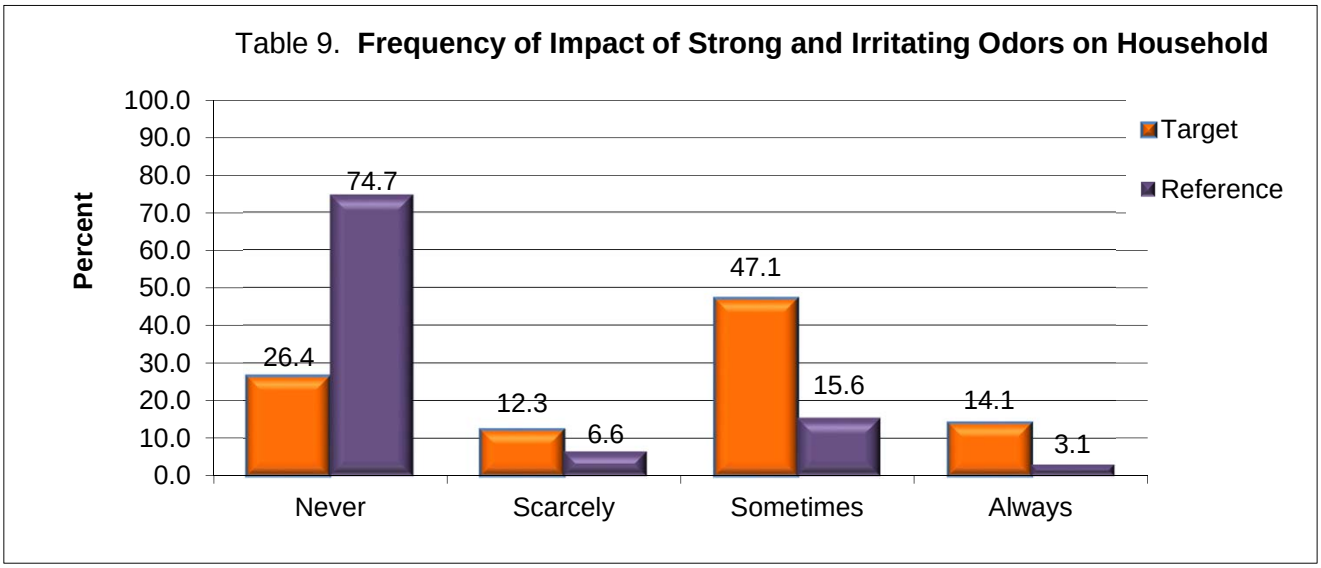


Table 10. **Frequency of Impact of Landfill Odor on Household by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**504**	**100.0**	**486**	**100.0**
Never	378	75.0	466	95.9
Scarcely	41	8.1	5	1.0
Sometimes	69	13.7	13	2.7
Always	16	3.2	2	0.4

Figure 10. **Frequency of Impact of Landfill Odor on Household**

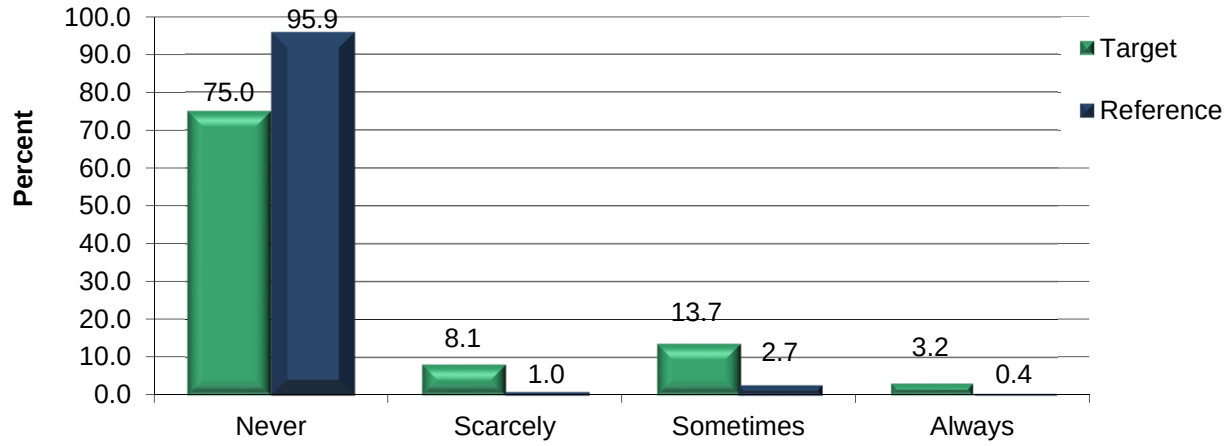


Table 11. **Frequency of Impact of Other Materials in the Cistern on Household by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**500**	**100.0**	**485**	**100.0**
Never	399	79.8	448	92.4
Scarcely	28	5.6	9	1.9
Sometimes	38	7.6	22	4.5
Always	35	7.0	6	1.2

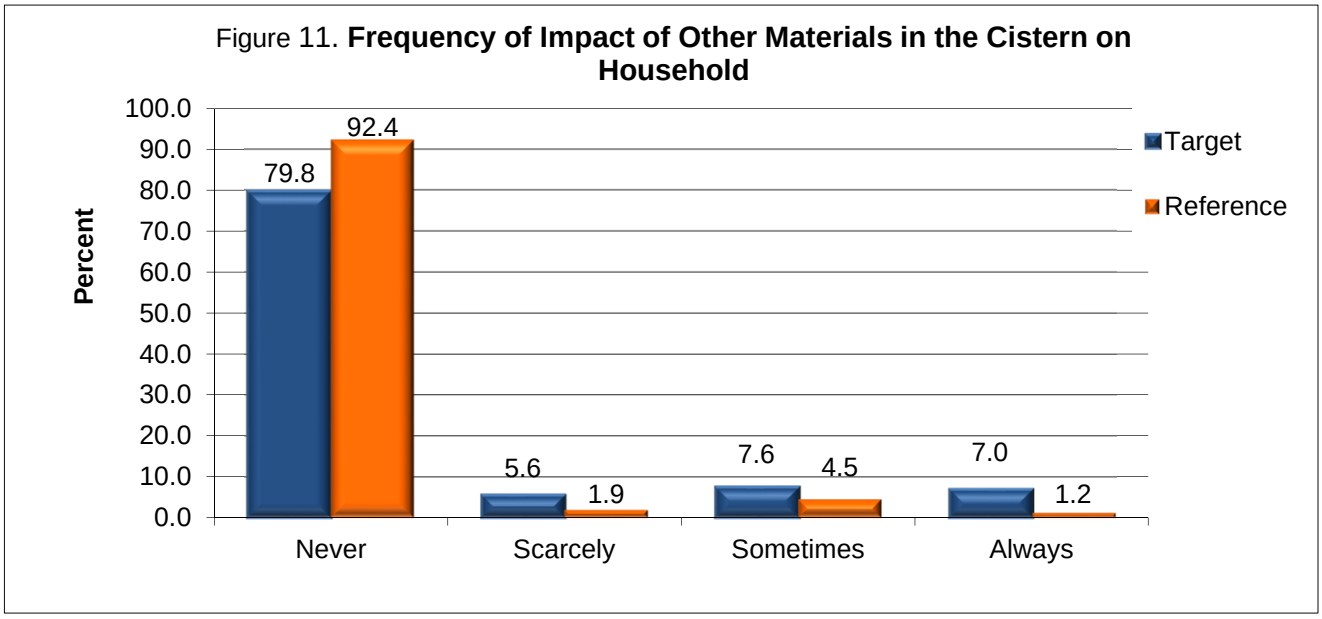


Table 12. **Someone in Household has Suffered from Asthma by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**653**	**100.0**	**487**	**100.0**
Yes	139	21.3	61	12.5
No	514	78.7	426	87.5

Figure 12. **Someone in Household has Suffered from Asthma**

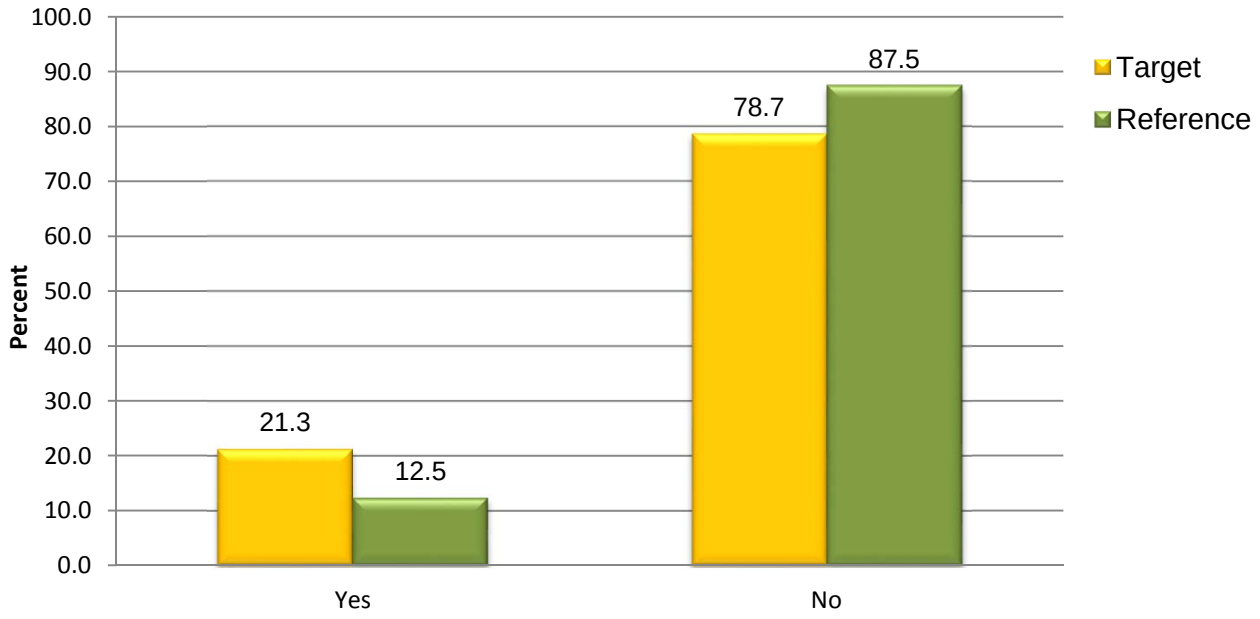


Table 13. **Someone in Household has Suffered from Chronic Bronchitis by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**653**	**100.0**	**487**	**100.0**
Yes	68	10.4	20	4.1
No	585	89.6	467	95.9

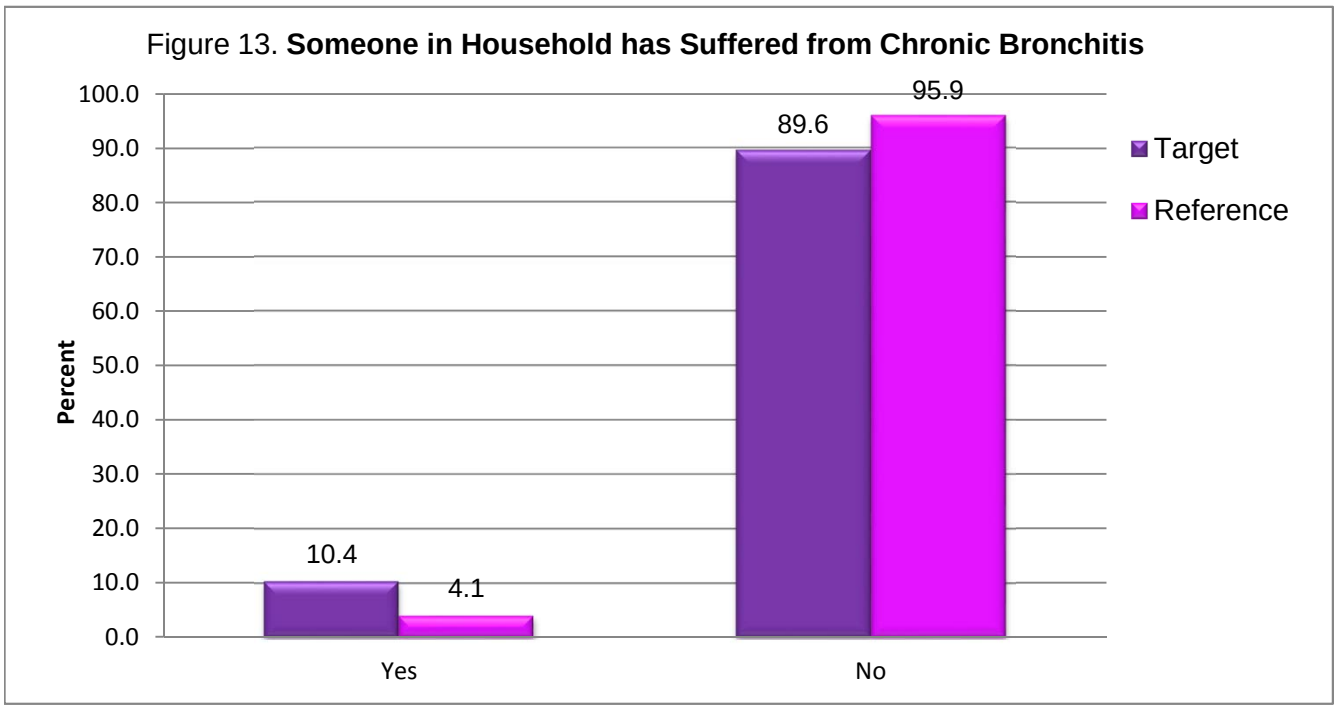


Table 14. **Someone in Household has Suffered from Lung Cancer by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**653**	**100.0**	**486**	**100.0**
Yes	6	0.9	2	0.4
No	647	99.1	484	99.6

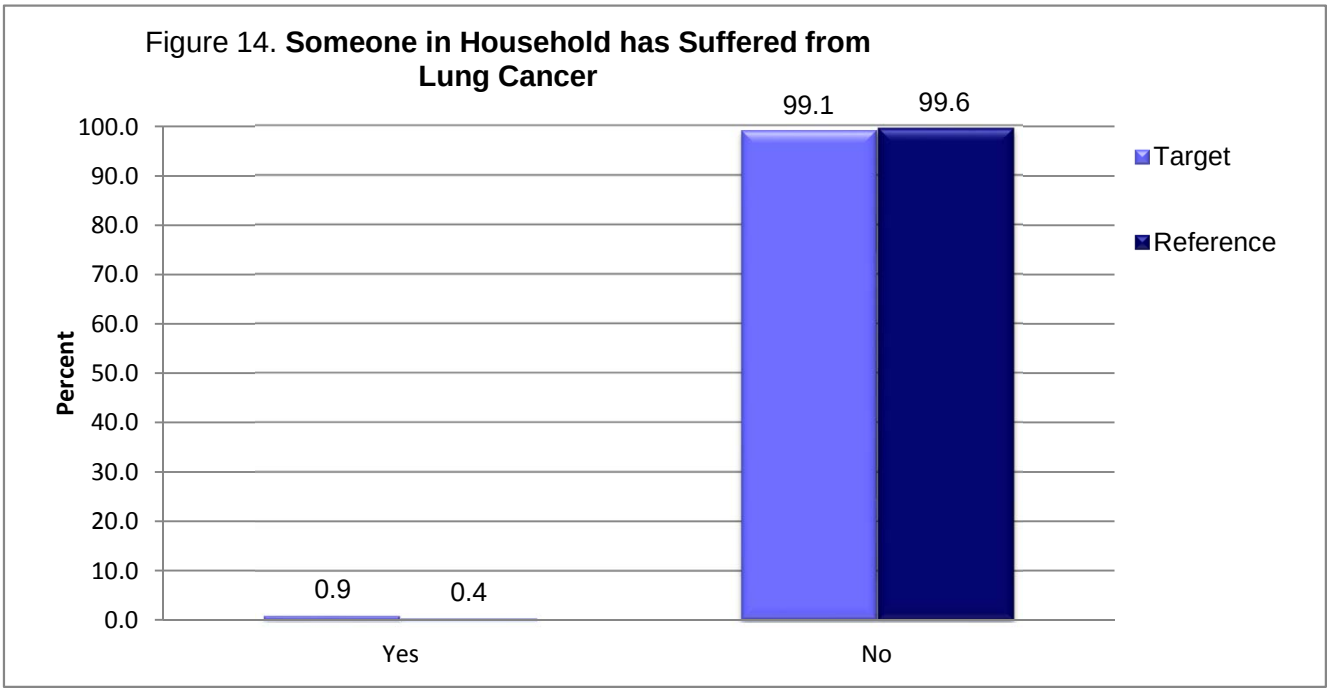


Table 15. **Someone in Household has Suffered from Emphysema by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**653**	**100.0**	**485**	**100.0**
Yes	7	1.1	1	0.2
No	646	98.9	484	99.8

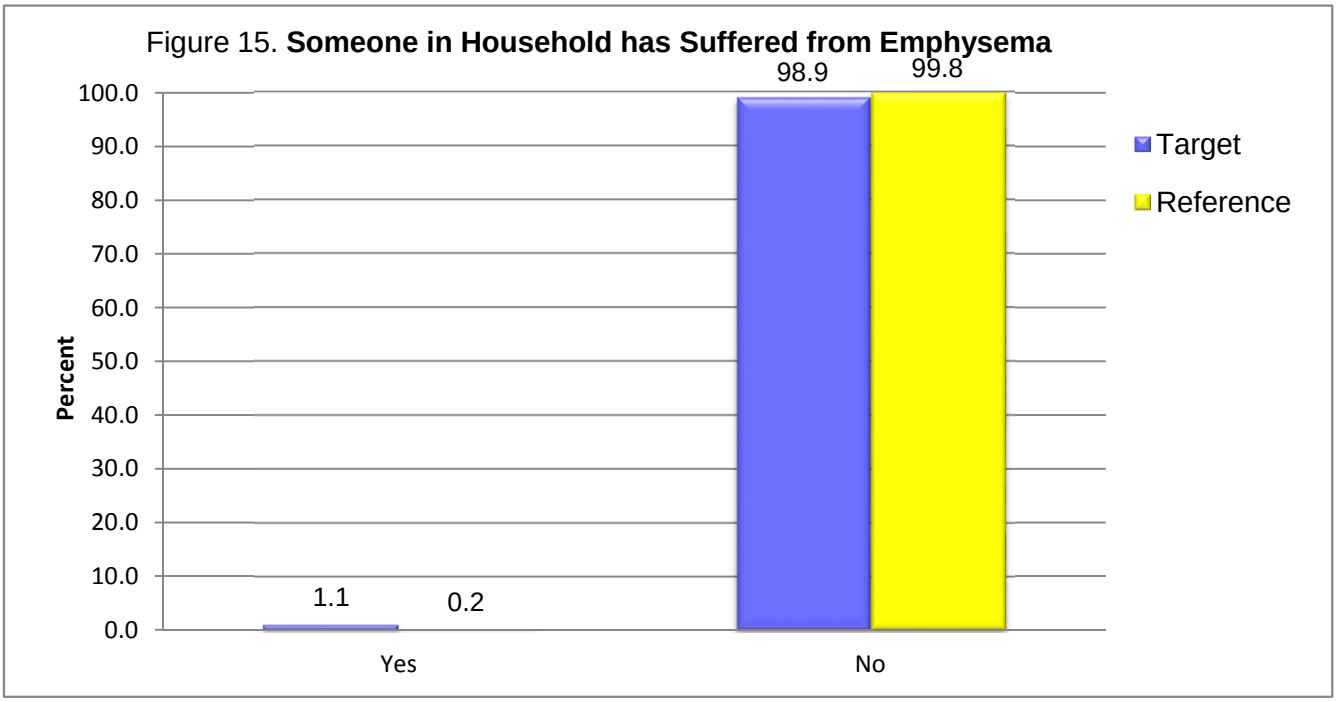


Table 16. **Someone in Household has Suffered from Chronic Obstructive Pulmonary Disease (COPD) by Z**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**653**	**100.0**	**483**	**100.0**
Yes	11	1.7	7	1.4
No	642	98.3	476	98.6

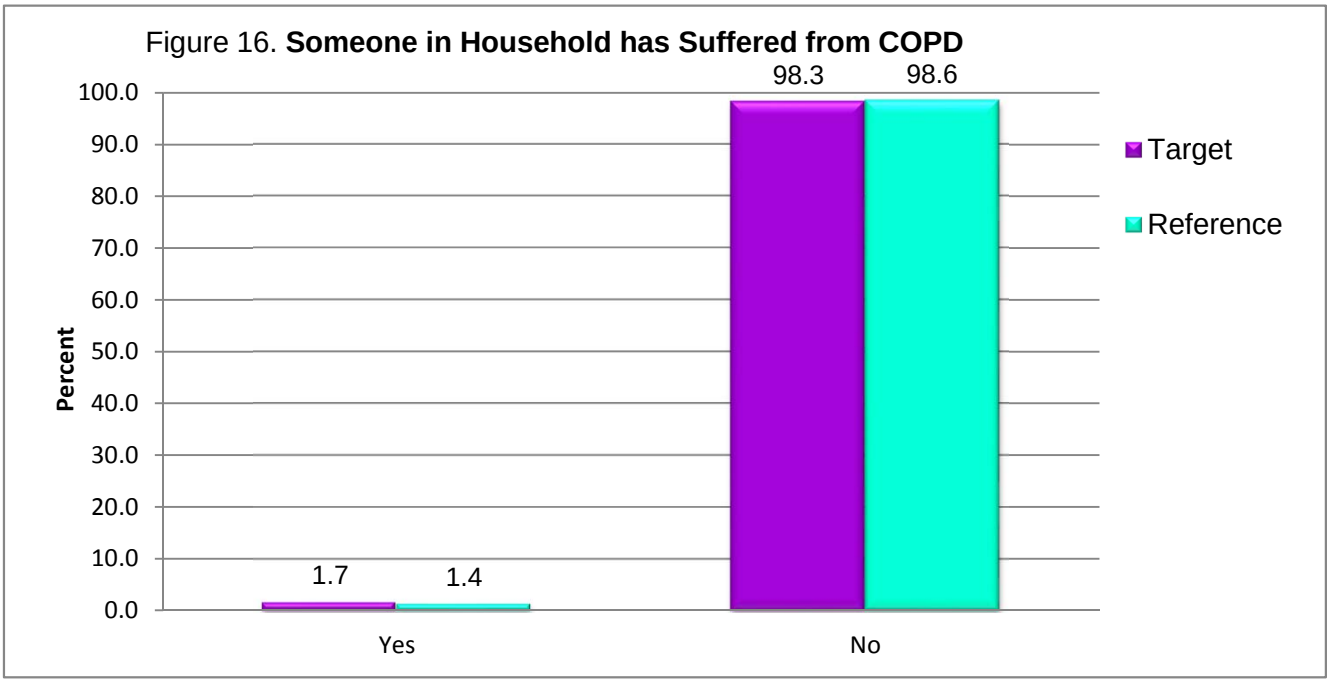


Table 17. **Someone in Household has Suffered from Allergies by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**653**	**100.0**	**486**	**100.0**
Yes	242	37.1	133	27.4
No	411	62.9	353	72.6

Figure 17. **Someone in Household has Suffered from Allergies**

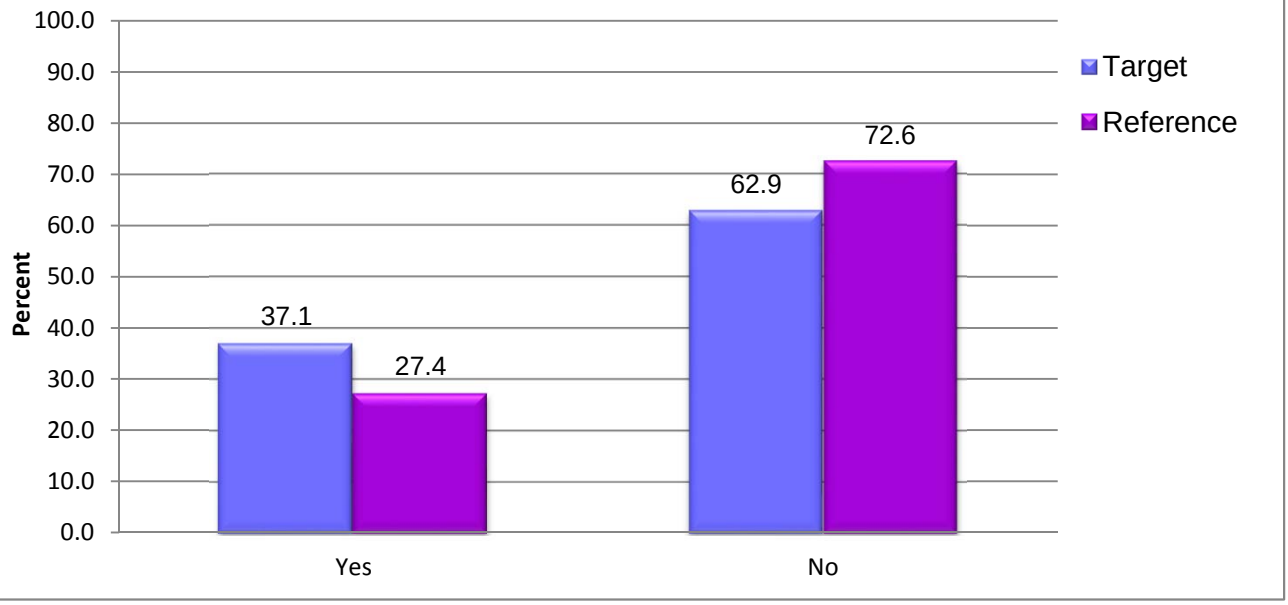


Table 18. **Someone in Household has Suffered from Black Lung Disease by Zone**

	Target		Reference	
Responses	Number	Percent	Number	Percent
Total	**652**	**100.0**	**485**	**100.0**
Yes	1	0.2	1	0.2
No	651	99.8	484	99.8

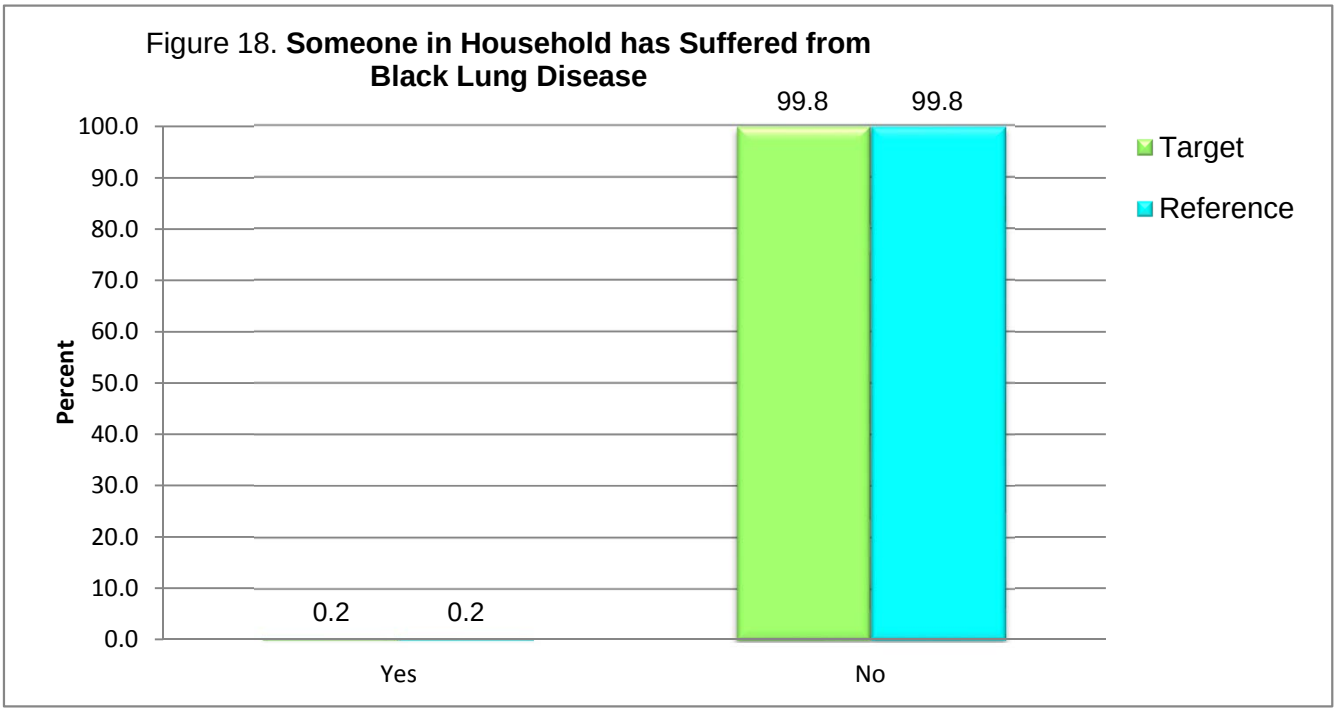


Table 19. **Someone in Household has Suffered from Acute Respiratory Distress Syndrome (ARDS) by Zon**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**653**	**100.0**	**486**	**100.0**
Yes	20	3.1	12	2.5
No	633	96.9	474	97.5

Figure 19. **Someone in Household has Suffered from ARDS**

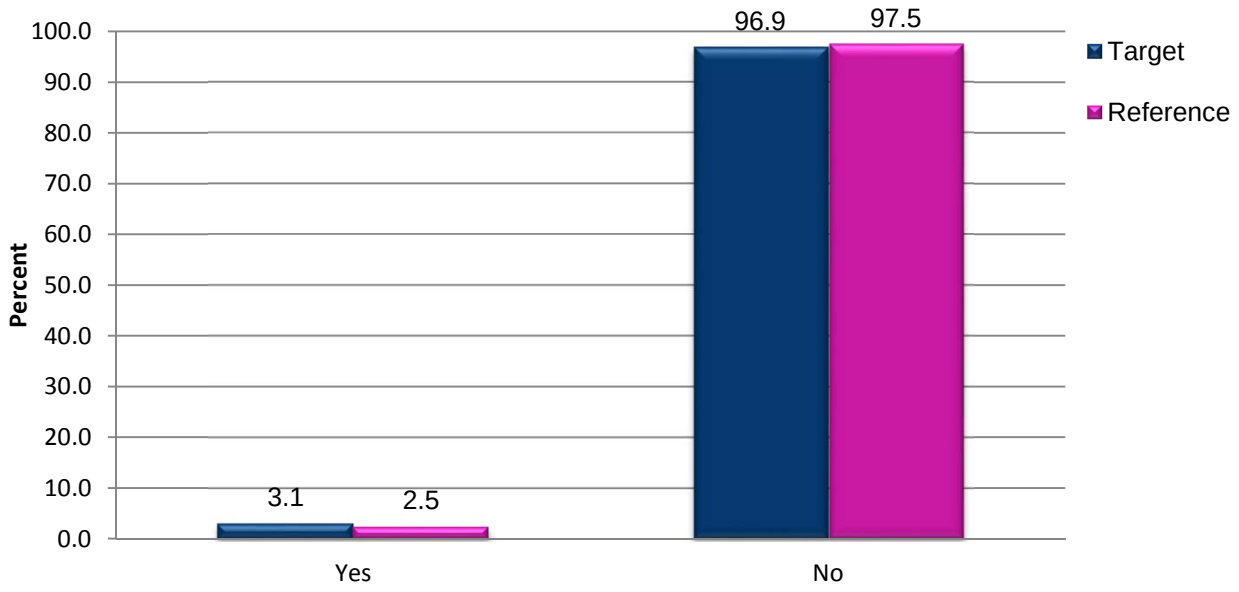


Table 20. **Someone in Household has Suffered from Airborne Substances by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**652**	**100.0**	**486**	**100.0**
Yes	27	4.1	14	2.9
No	625	95.9	472	97.1

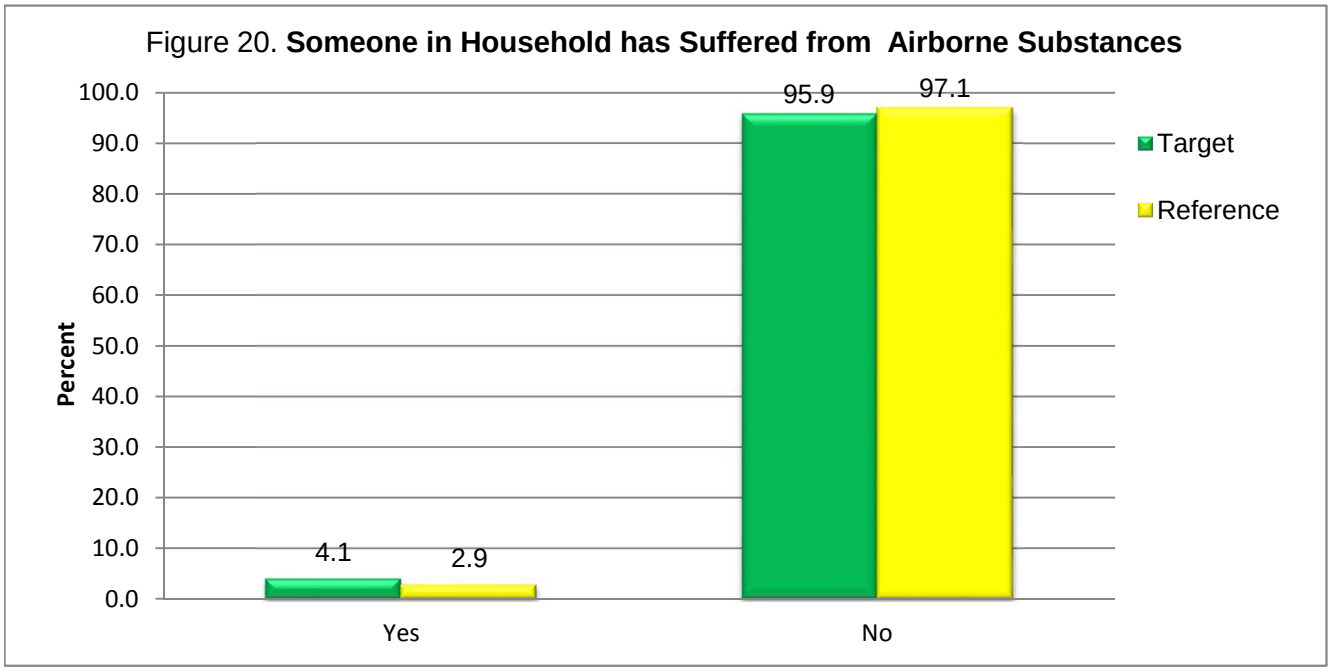


Table 21. **Someone in Household has Suffered from Mesothelioma by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**653**	**100.0**	**483**	**100.0**
Yes	6	0.9	3	0.6
No	647	99.1	480	99.4

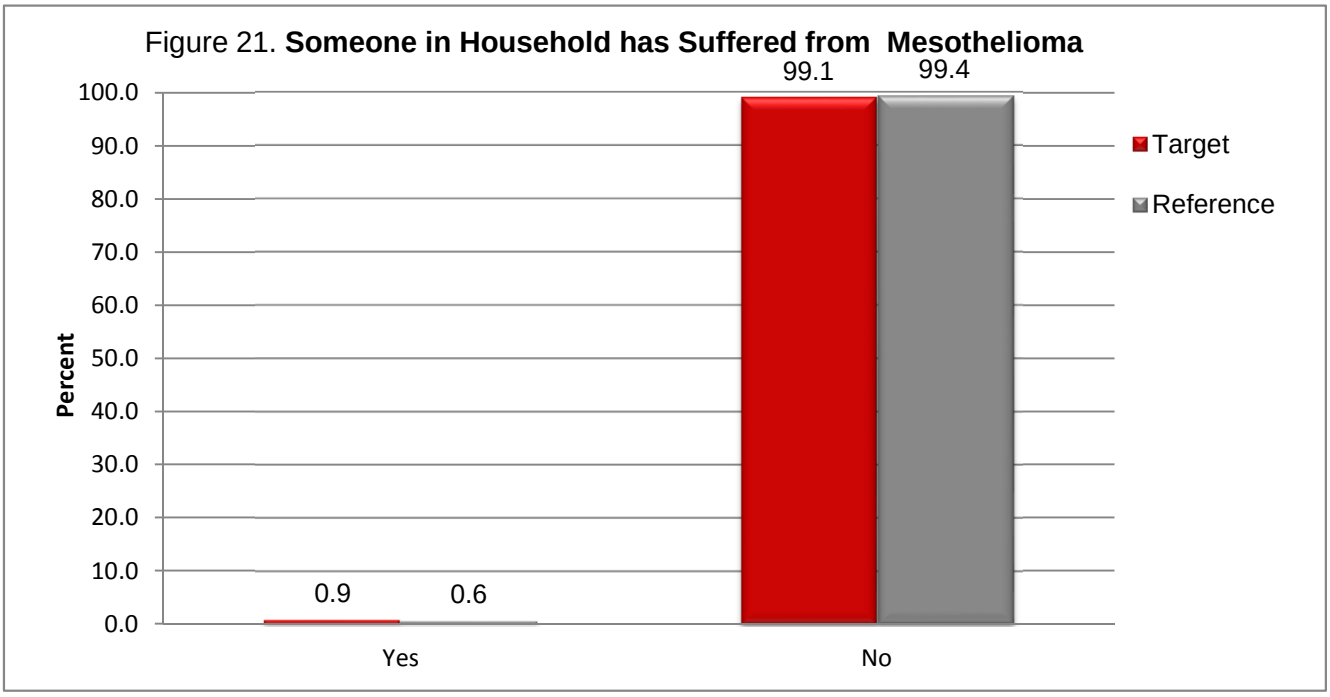


Table 22. **Someone in Household has Suffered from Some Other Illness by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**829**	**100.0**	**684**	**100.0**
Yes	9	1.1	7	1.0
No	820	98.9	677	99.0

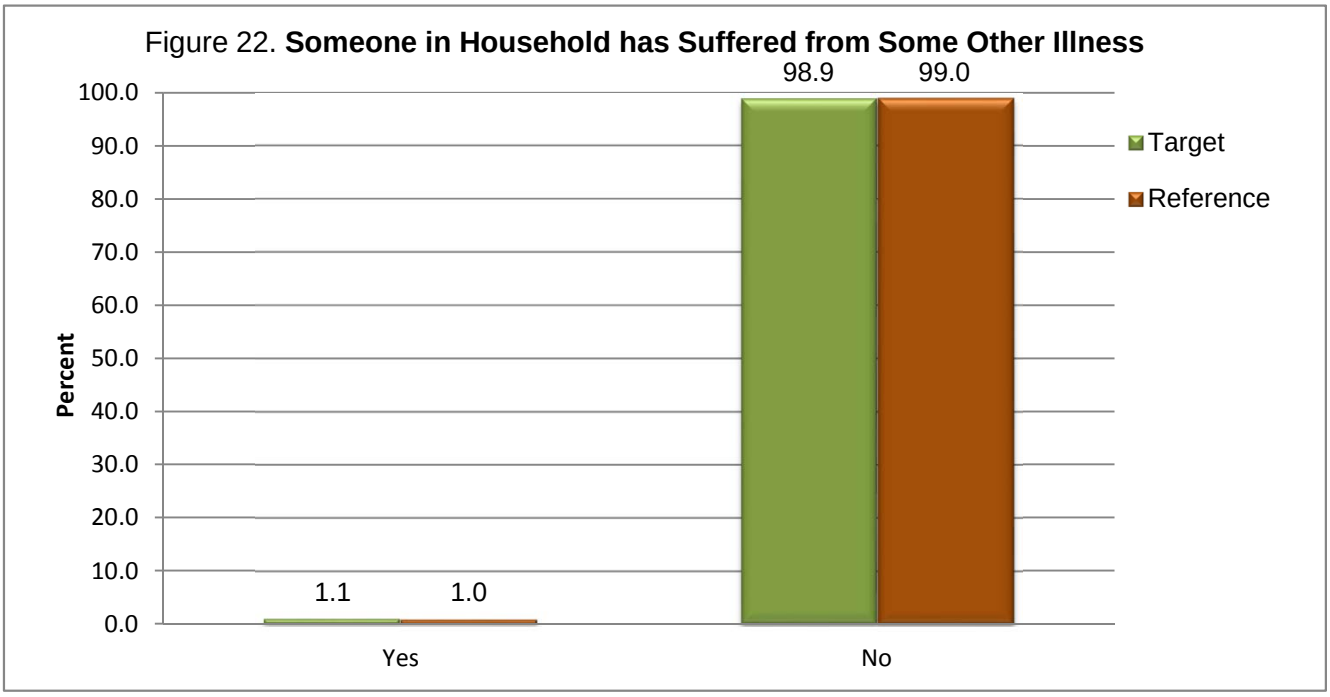


Table 23. **Persons who Suffered from Illness by Zone**

Illness	Target		Reference	
	Number	Percent	Number	Percent
Total Number of Persons in Responding Households	**1,741**	**100.00**	**1,285**	**100.0**
Asthma	191	11.0	72	5.6
Chronic Bronchitis	91	5.2	23	1.8
Lung Cancer	6	0.3	2	0.2
Emphysema	9	0.5	1	0.1
COPD	13	0.7	7	0.5
Allergies	375	21.5	196	15.3
Black Lung Disease	1	0.1	1	0.1
ARDS	25	1.4	15	1.2
Mesothelioma	6	0.3	3	0.2
Other	13	0.7	9	0.7

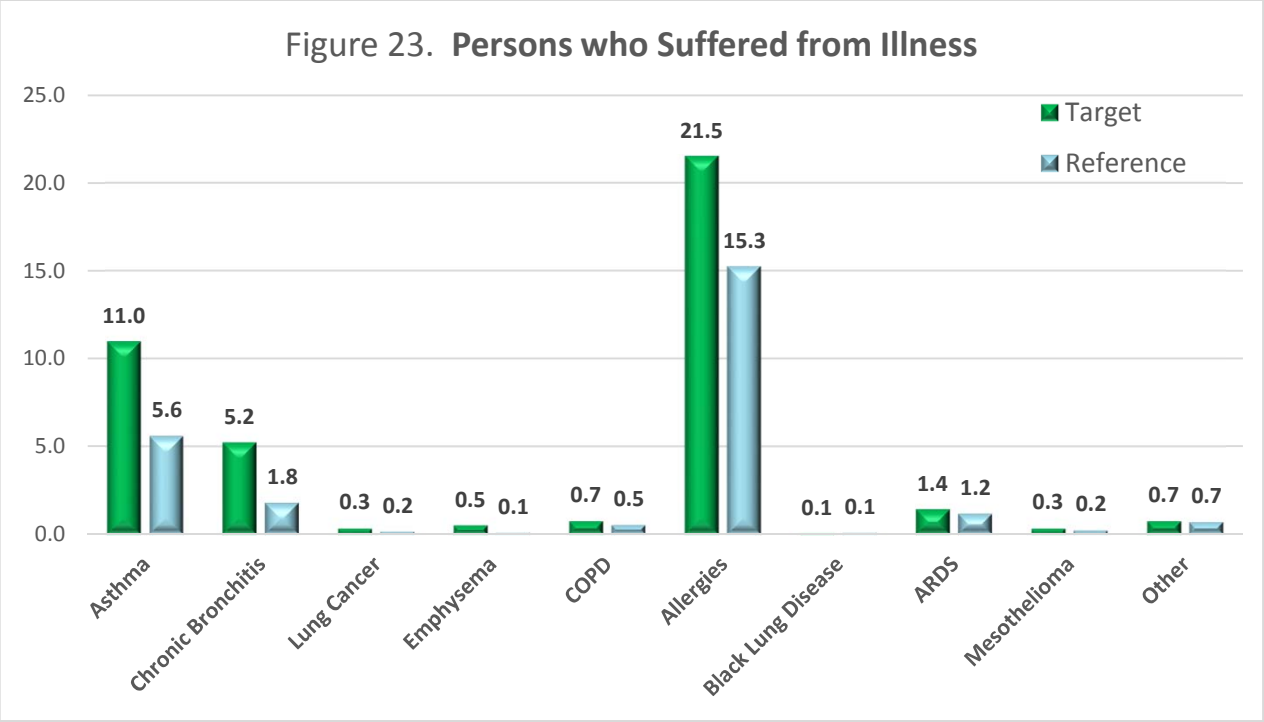


Table 24. **Smokers in Household by Presence of Any Illness**

Responses	No Illness		Illness Present	
	Number	Percent	Number	Percent
Respondent is a Smoker				
Total	**659**	**100.0**	**481**	**100.0**
Never	583	88.5	420	87.3
1 to 2 times a year	6	0.9	1	0.2
Once a month	15	2.3	11	2.3
Daily	55	8.3	49	10.2
Other Household Member is a Smoker				
Total	**659**	**100.0**	**481**	**100.0**
Never	626	95.0	431	89.6
1 to 2 times a year	4	0.6	4	0.8
Once a month	3	0.5	12	2.5
Daily	**26**	**3.9**	**34**	**7.1**

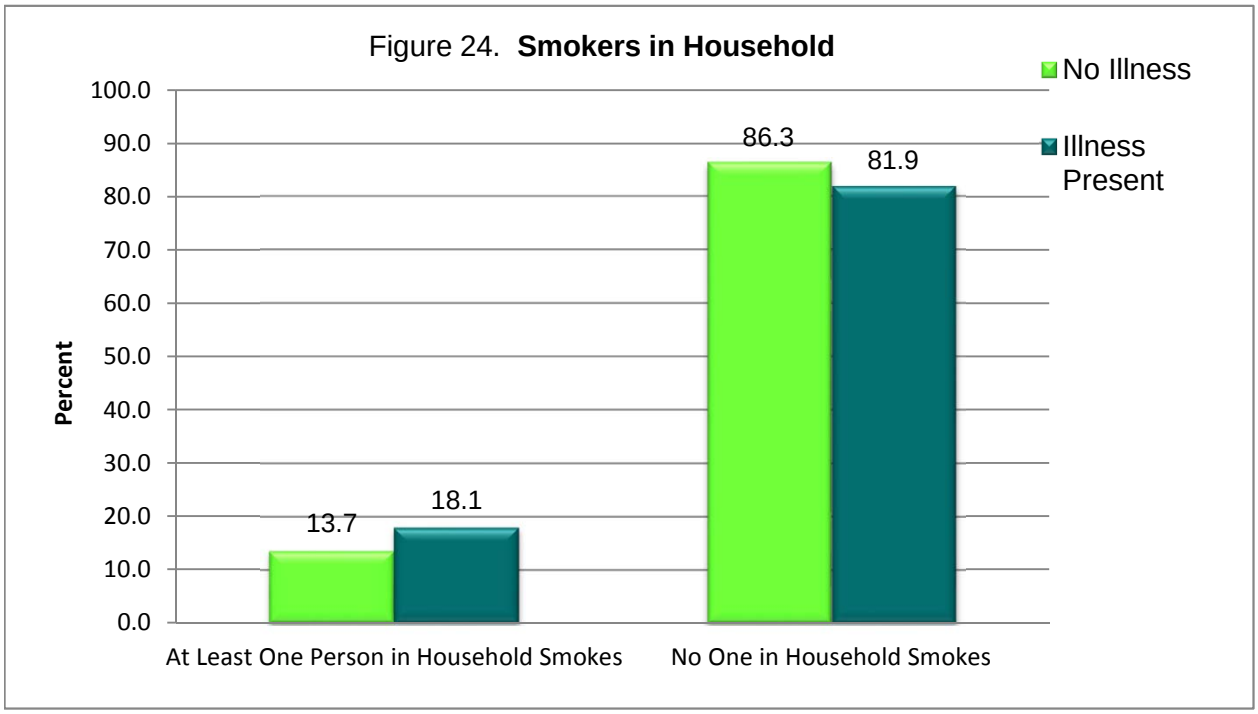


Table 25. **Someone in Household Exposed to Harmful Inhalants at Work by Presence of Any Illness**

	No Illness		Illness Present	
Responses	Number	Percent	Number	Percent
Total	**659**	**100.0**	**481**	**100.0**
Never	611	92.7	414	86.1
1 to 2 times a year	9	1.4	7	1.5
Once a month	8	1.2	9	1.9
Daily	31	4.7	51	10.6

Figure 25. **Exposure to Harmful Inhalants at Work**

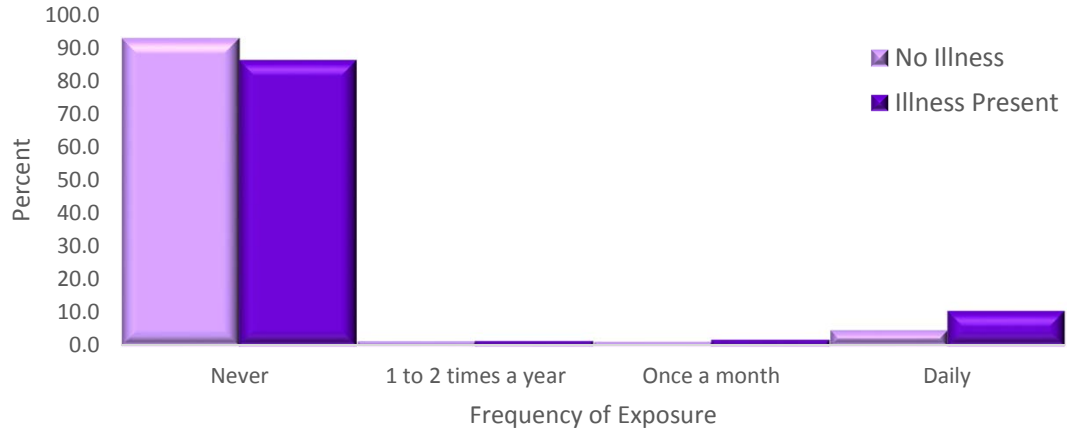


Table 26. **Income of the Respondent Households by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**571**	**100.0**	**431**	**100.0**
Less than $5,000	85	14.9	52	12.1
$5,000-$9,999	53	9.3	14	3.2
$10,000-$14,999	51	8.9	41	9.5
$15,000-$24,999	94	16.5	53	12.3
$25,000-$34,999	114	20.0	79	18.3
$35,000-$49,999	96	16.8	83	19.3
$50,000-$74,999	50	8.8	62	14.4
$75,000-$99,999	19	3.3	25	5.8
$100,000 and over	9	1.6	22	5.1

Figure 26. **Income of the Respondent Households**

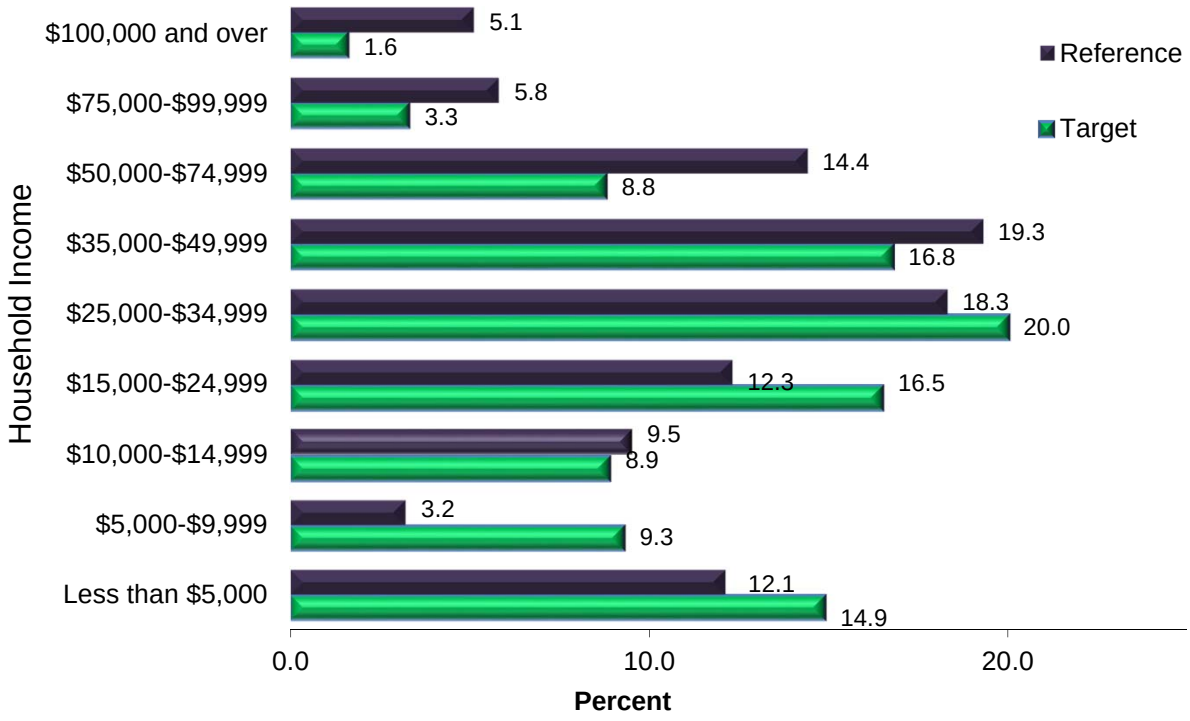


Table 27. **Sex of Persons who Suffered from Illness by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**307**	**100.0**	**176**	**100.0**
Male	130	42.3	83	47.2
Female	177	57.7	93	52.8

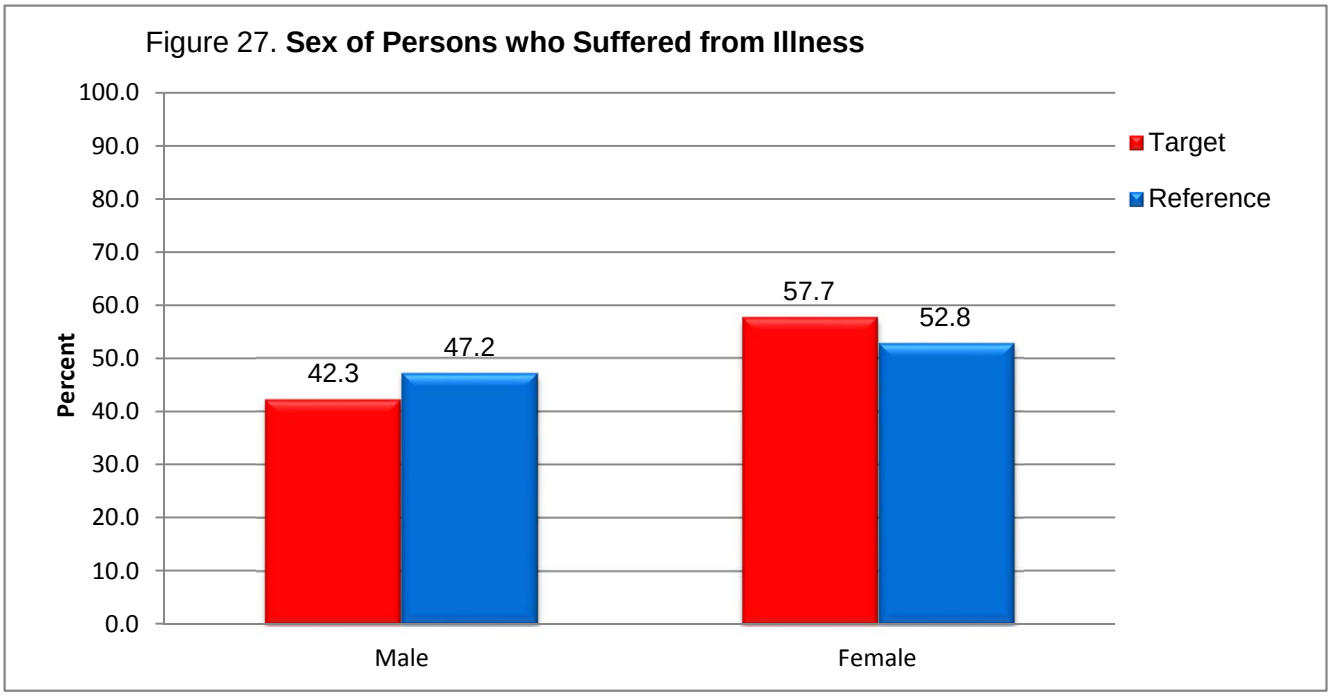


Table 28. **Age of Persons who Suffered from Illness by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**307**	**100.0**	**176**	**100.0**
Under 18	49	16.0	21	11.9
18-24	26	8.5	17	9.7
25-39	47	15.3	21	11.9
40-54	80	26.1	47	26.7
55-69	77	25.1	51	29
70+	28	9.1	19	10.8

Figure 28. Age of Persons who Suffered from Illness

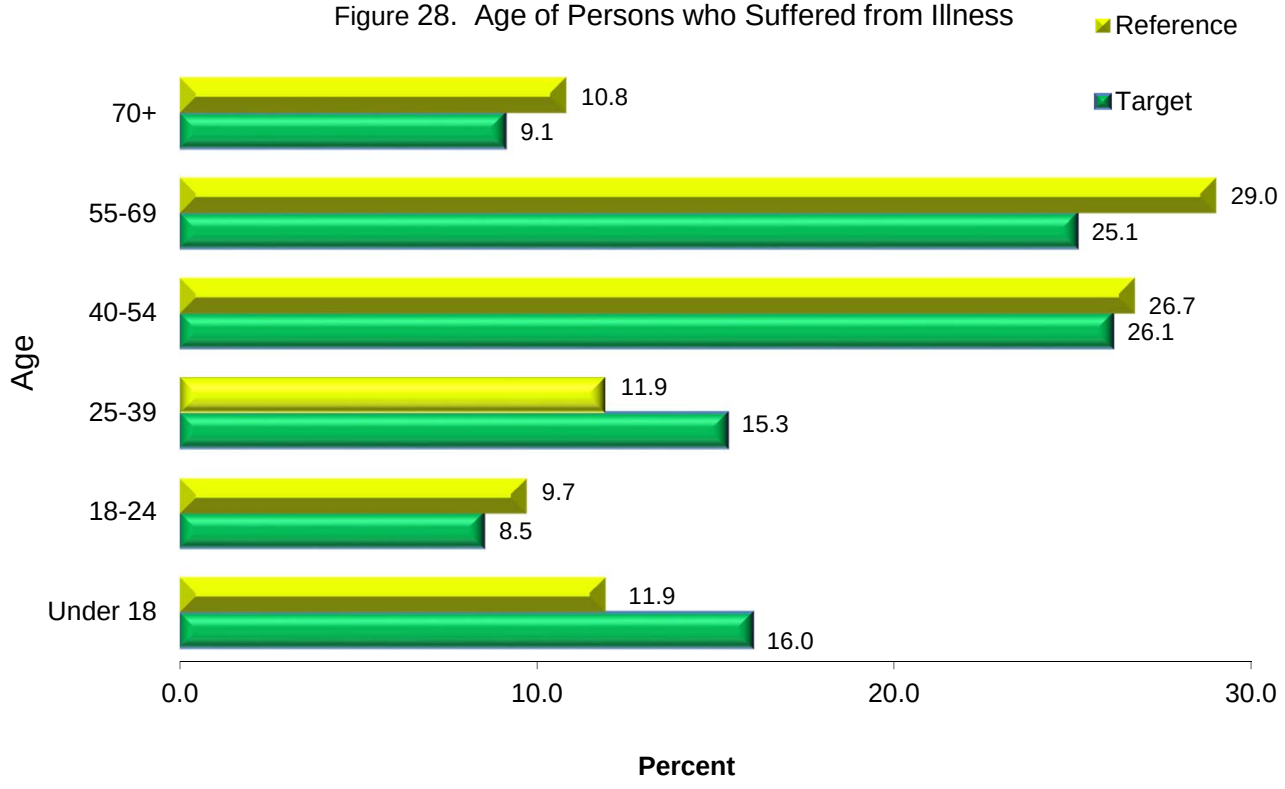


Table 29. **Race of Persons who Suffered from Illness by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**307**	**100.0**	**175**	**100.0**
Black	228	74.3	116	66.3
White	6	2.0	16	9.1
Asian	0	0.0	1	0.6
Native American	6	2.0	3	1.7
Pacific Islander	2	0.7	0	0
Other	65	21.2	39	22.3

Figure 29. **Race of Persons who Suffered from Illness**

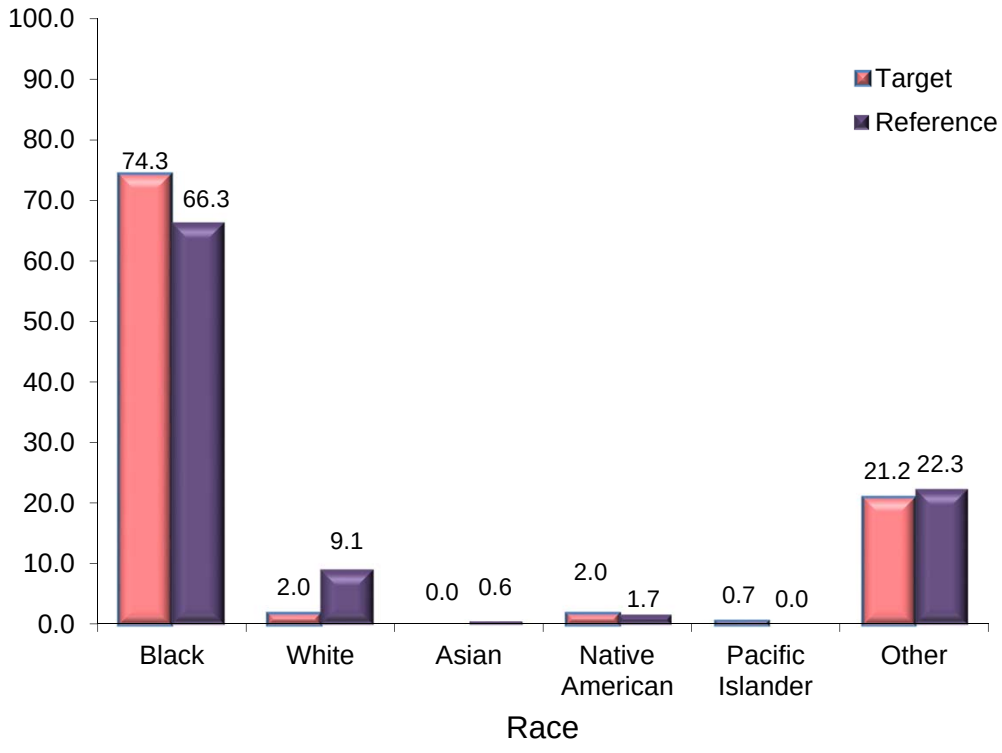


Table 30. **Ethnicity of Persons who Suffered from Illness by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**307**	**100.0**	**176**	**100.0**
Not Hispanic	201	65.5	121	68.8
Hispanic	106	34.5	55	31.3

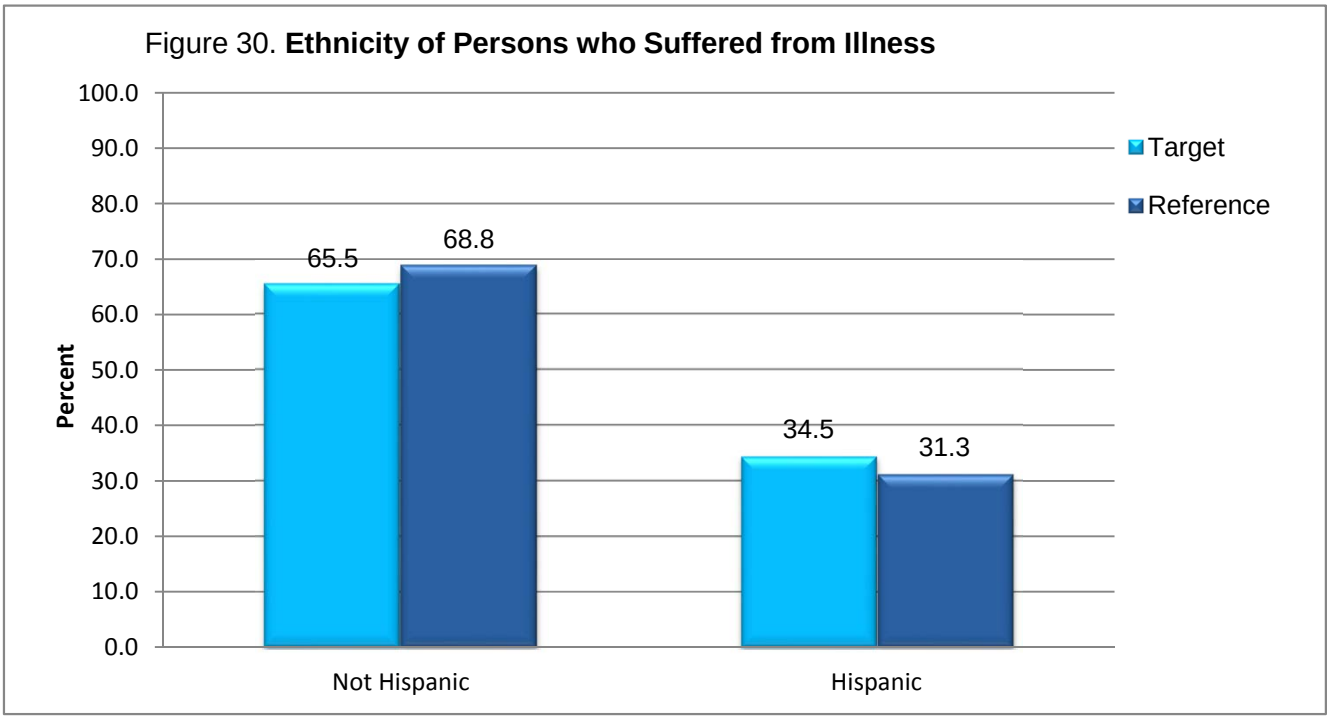


Table 31. **Years in Residence of Persons who Suffered from Illness by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**306**	**100.0**	**175**	**100.0**
Less than 1 year	17	5.6	14	8.0
1 to 5 years	74	24.2	28	16.0
6 to 10 years	59	19.3	31	17.7
11 years or more	156	51.0	102	58.3

Figure 31. **Years in Residence of Persons who Suffered from Illness**

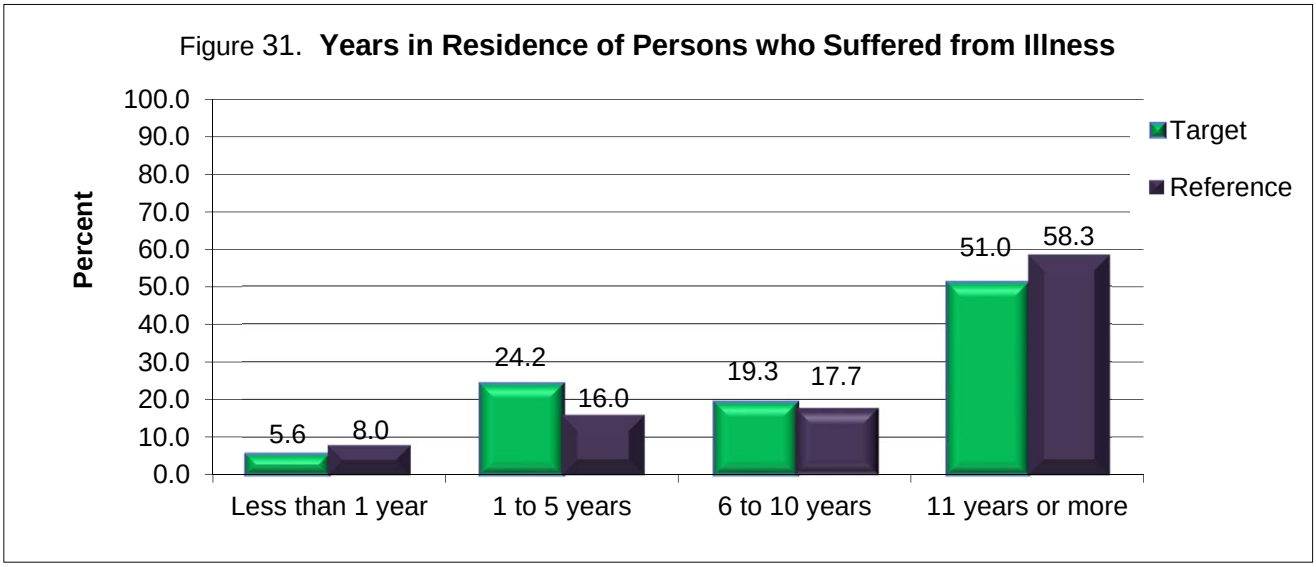


Table 32. **Hours Spent in Neighborhood of Persons who Suffered from Illness by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**306**	**100.0**	**175**	**100.0**
Less than 12 hours	72	23.5	42	24.0
12 hours or more	234	76.5	133	76.0

Figure 32. **Hours Spent in Neighborhood of Persons who Suffered from Illness**

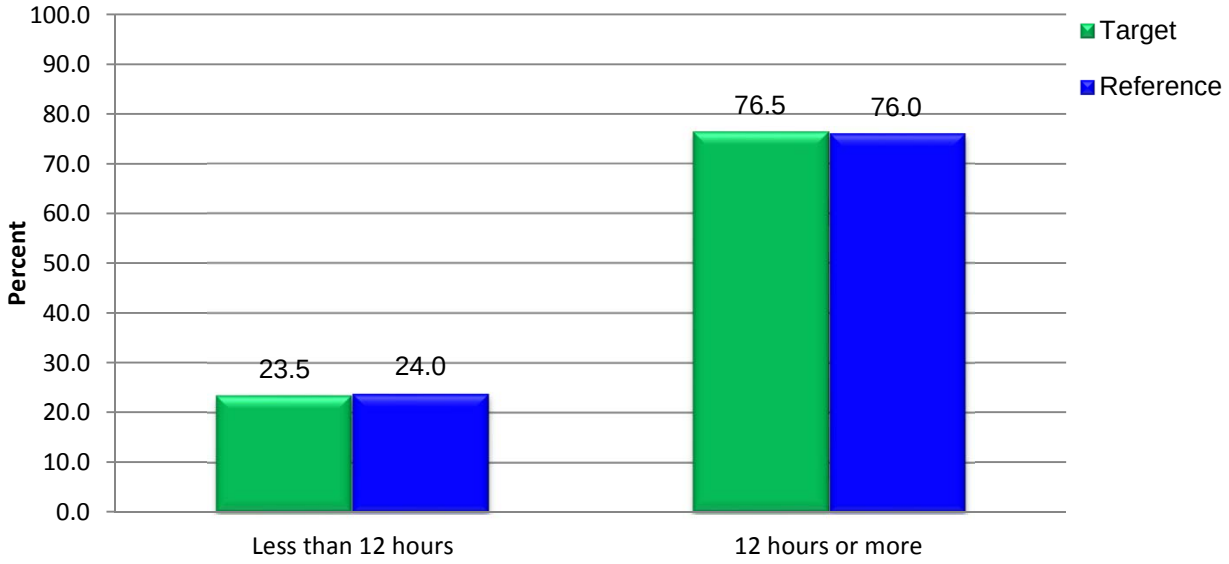


Table 33. **Area of Work of Persons who Suffered from Illness by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**306**	**100.0**	**175**	**100.0**
South Shore Industrial Area	22	7.2	22	12.6
Other	284	92.8	153	87.4

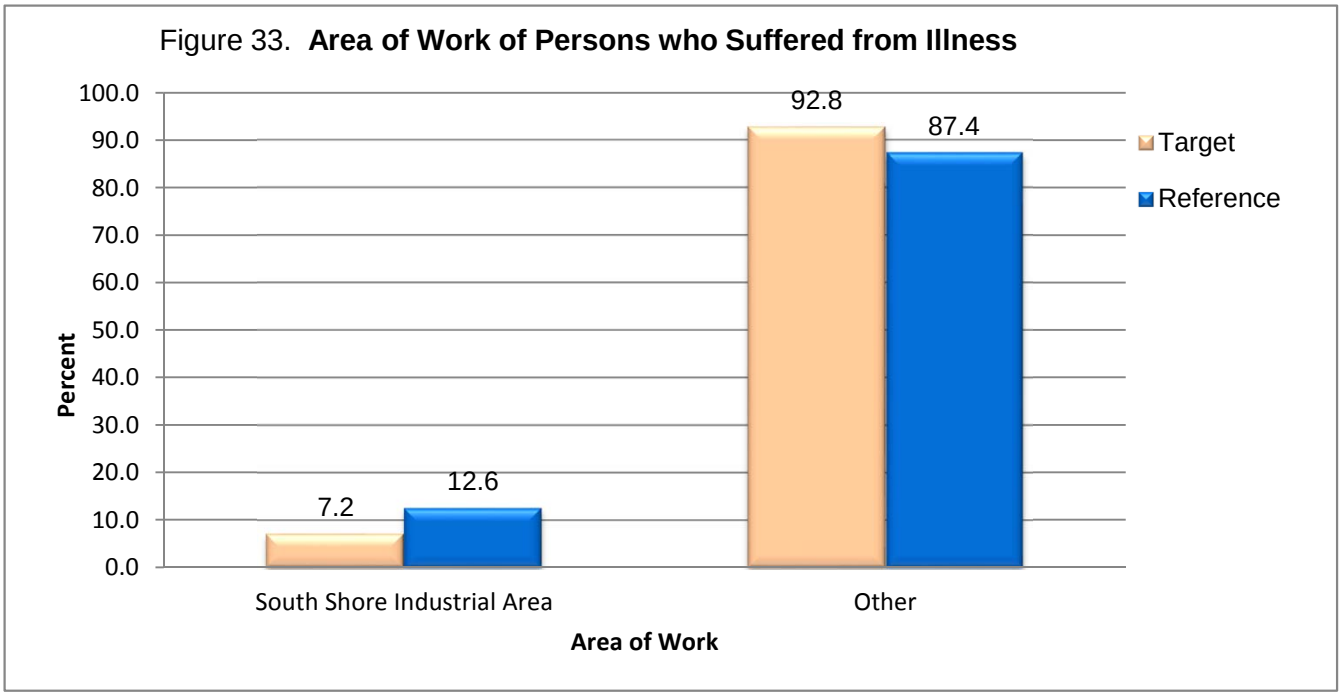
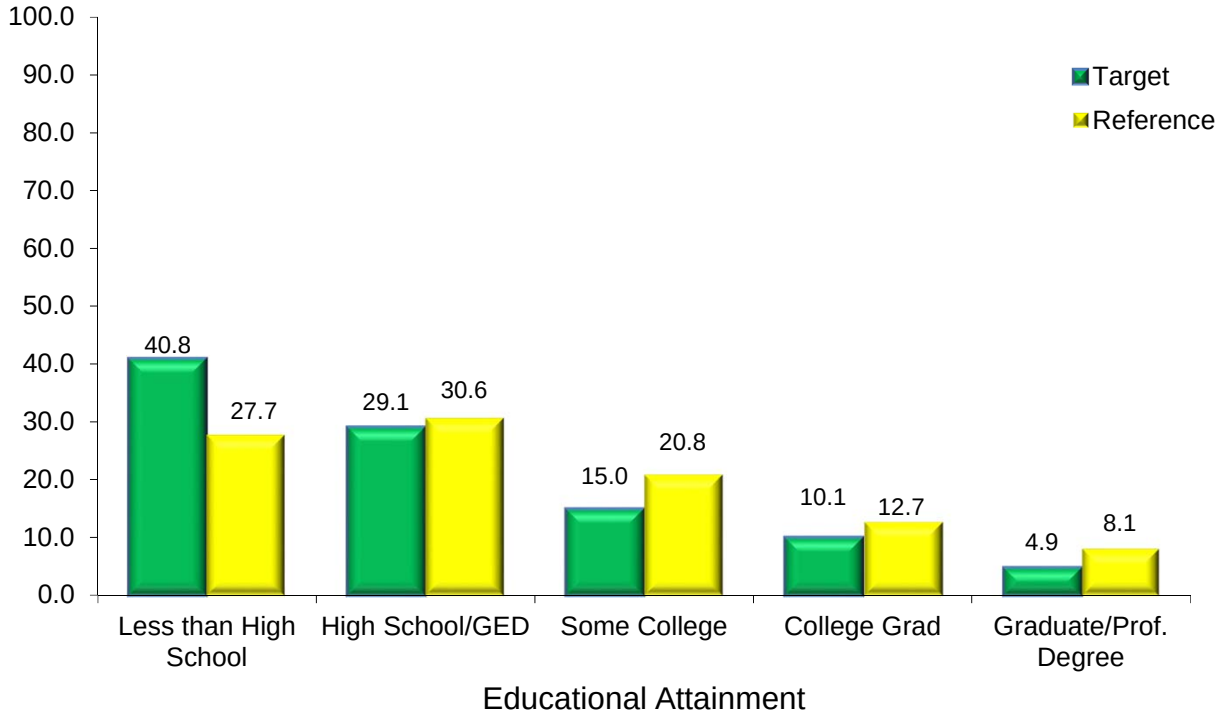


Table 34. **Educational Attainment of Persons who Suffered from Illness by Zone**

Responses	Target		Reference	
	Number	Percent	Number	Percent
Total	**306**	**100.0**	**173**	**100.0**
Less than High School	125	40.8	48	27.7
High School/GED	89	29.1	53	30.6
Some College	46	15.0	36	20.8
College Grad	31	10.1	22	12.7
Graduate/Prof. Degree	15	4.9	14	8.1

Figure 34. **Educational Attainment of Persons who Suffered from Illness**



APPENDIX II

Environmental Health Study

Interviewer's Name_____ Date ___/___/___

HU ID#_____

Vacant ◯ UHE ◯

Final Disposition - **ECC use only** ① ② ③ ④ ⑤ ⑥ ⑦ ⑧

Place barcode ID sticker here

Good day, my name is (*your name*). The University of the Virgin Islands is conducting a survey about health conditions in this area.

Your housing unit was randomly selected to participate in this survey. The purpose is to gather information from residents on St Croix regarding conditions that affect one's health. All information obtained is strictly confidential. May I continue with the interview? Please respond to each statement or question as they refer to you (or your housing unit).

Section A:

Please indicate the frequency of each event by stating *Never*, *Scarcely*, *Sometimes* or *Always* for each statement.

Within the last 5 years, this household has been impacted by……

	Never	Scarcely	Sometimes	Always
1. Red mud dust	◯	◯	◯	◯
2. Transportation emissions and exhaust	◯	◯	◯	◯
3. Factory smoke	◯	◯	◯	◯
4. Mold	◯	◯	◯	◯
5. Incorrect disposal of chemical waste	◯	◯	◯	◯
6. Industry drainage and runoff	◯	◯	◯	◯
7. Improper sewage disposal	◯	◯	◯	◯
8. Contaminated drinking water	◯	◯	◯	◯
9. Strong and irritating odors	◯	◯	◯	◯
10. Landfill odor	◯	◯	◯	◯
11. Other materials in the cistern (i.e., things other than water)	◯	◯	◯	◯

Section B:

Please respond to each statement by answering *Yes* or *No*.

Within the last 5 years, someone living in your household has suffered from…	Yes	No	If yes, how many persons in this household suffer from (or suffered from) this condition?
12. Asthma	◯	◯	____
13. Chronic bronchitis	◯	◯	____

	Yes	No	If yes, how many persons in this household suffer from (or suffered from) this condition?
14. Lung cancer	○	○	____
15. Emphysema	○	○	____
16. Chronic obstructive pulmonary disease (COPD)	○	○	____
17. Allergies	○	○	____
18. Black Lung Disease	○	○	____
19. Acute respiratory distress syndrome (ARDS)	○	○	____
20. Airborne substances (explain) _____	○	○	____
21. Mesothelioma	○	○	____
22. Other (explain) _____			____

Section C:

Please indicate the level of occurrence by stating *Daily, Once a month, 1 to 2 times a year or Never* for each statement.	**Daily**	**Once a month**	**1 to 2 times a year**	**Never**
In the past 5 years…				
23. Did you smoke cigarettes or some other substance?	○	○	○	○
24. Did some other person in your household smoke cigarettes or some other substance?	○	○	○	○
25. Was anyone in this household consistently exposed to harmful inhalants at work?	○	○	○	○

Section D:

The following section asks demographic questions. *Answer the questions about the one (1) selected person.*

- *If one (1) person in the HU has suffered from a listed condition, use that person for Section D.*
- *If more than one (1) person in the HU has suffered from a condition, choose a person (with a condition) with the most recent birthday for Section D.*
- *If no one in the HU has suffered from a condition, choose the person with the most recent birthday for Section D.*

	Male	Female
26. Is (*the selected person's name*)…?	○	○

	Under 18	18-24	25-39	40-54	55-69	70 +
27. Which age category best describes him/her?	○	○	○	○	○	○

	Black	White	Asian	Native American	Pacific Islander	Other
28. What is his/her ethnic background?	○	○	○	○	○	○

29. Is he/she Latino/Hispanic?

Yes	No
○	○

30. Which category describes his/her current level of education?

Less than high school	High school graduate/GED	Some college	College graduate	Graduate or Professional degree
○	○	○	○	○

31. Which category best describes the annual income of this household?

- ○ Less than $5,000
- ○ $5,000 to $9,999
- ○ $10,000 to $14,999
- ○ $15,000 to $24,999
- ○ $25,000 to $34,999
- ○ $35,000 to $49,999
- ○ $50,000 to $74,999
- ○ $75,000 to $99,999
- ○ $100,000 and over

32. How long has he/she lived in this home?

- ○ Less than 1 year
- ○ 1 to 5 years
- ○ 6 to 10 years *(Skip to #34)*
- ○ 11 years or more *(Skip to #34)*

33. Where did he/she live before moving here?

_____

(*If in St Croix, write the name of the estate. If other than St Croix, write the name of the island, state or country.)*

34. On April 1, 2014, how many people lived in this household?

① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

○ 10 or more

35. The number of hours per day that he/she spends at home or in this neighborhood is…?

Less than 12 hours	12 hours or more
○	○

36. Does he/she work in the South shore industrial area?

Yes	No
○	○

Thank You!

(turn over)

Notes:

_____

_____

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Interviewer's Signature:_____


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1962