# RESIDENTIAL BEHAVIOR AND ENVIRONMENTAL HAZARDS IN ARIZONA-SONORA COLONIAS: A CONTINUATION PROJECT

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## INTRODUCTION

This research project reports the second year of a two-year project designed to describe and quantify the environmental pollution produced by residential behavior of inhabitants of marginalized communities in Mexico along the Arizona-Sonora border. The rationale for this study has been presented previously (Sadalla, Swanson, and Velasco 1998), but for expository purposes, will be repeated here. The present report contains a full analysis of the data collected during the initial year of the investigation.

The project is based on the assumption that studies of the environmental impact of industrial practices in this region should include data pertaining to the pollution produced by industrial workers in their residential environment. In 1994, Mexico's *maquila* program was composed of 2,173 manufacturing plants employing 544,500 workers. Because of their living conditions, workers in the *maquila* industry may well produce a greater environmental impact in their residential communities than they do in the workplace.

Since the La Paz Agreement of 1983 the federal governments of both the United States and Mexico have defined *colonias* as substandard residential communities, incorporated and unincorporated, within 100 kilometers of the U.S.-Mexican border. In Mexico, communities with very inadequate infrastructure and services are commonly referred to as *colonias marginales*, or *colonias precarias.*

Although *colonias* have been in existence for more than 30 years, the number of communities and the number of residents of such communities dramatically increased in the 1980s and 1990s. Between 1990 and 1995, for example, the population along the U.S.-Mexican border grew by more than 25% (EPA 1996).

The growth of population along Mexico's northern border has been associated with the development of the manufacturing plants (the *maquila* industry) in this region. As Tamayo (1993) points out, "the significant role played by the *maquila* in Northern Mexico's recent urbanization is unmistakable. It is also evident the border urbanization occurred at a much higher rate than the growth of municipal facilities, e.g., the construction of water and sewage lines."

Analyses of the environmental impact of the *maquila* on the U.S.-Mexican border region has to date focused primarily on the contribution of industrial practices (e.g. Bath 1986; Brannon and James 1994; Trevino and Fernandez 1992). Considerably less is known of the environmental degradation engendered by substandard living conditions in the communities populated by the workforce of the *maquiladoras*. Because of the size of the population attracted by the *maquila* industry, the environmental impact of the inhabitants of substandard communities is likely to be quite significant.

The present research was designed to assess the environmental hazards produced by the living conditions and residential behavior of inhabitants of *colonias marginales* in Nogales, Sonora**.** These communities are populated primarily by workers and their families who have been attracted to the border region by the *maquiladoras*. The size of this population, when combined with inadequate infrastructure, has increased the level of environmental degradation in and around Nogales and has exposed increased numbers of residents to health risks.

The pollution caused by the combination of population size and inadequate infrastructure is sometimes quite obvious. Trevino and Fernandez (1992) report that raw sewage can be seen seeping through cracks in the streets in the Nogales area. They also note that studies of air quality indicate that the region has consistently exceeded EPA maximums for particulates since measurement began. Prior to this project, however, no systematic investigation of the impact of residential *colonias* on the regional environment has been conducted.

Because of deficits in housing and infrastructure, residents of *colonias* tend to produce environmental pollution disproportionally. Practices such as the burning of garbage and hazardous materials (for heating and cooking) tend to produce air pollution. The absence of sewers combined with substandard latrine construction causes waste to pollute the local area and eventually drain into local aquifers. Residents of *colonias marginales* are consequently at increased risk from environmental hazards associated with air pollution, inadequate plumbing, poor access to clean water, and makeshift sewage disposal systems.

The environmental hazards generated by substandard living conditions in *colonias* are not limited to the residents of *colonias*. Since residents on both sides of the border share ecosystems, air sheds, and watersheds, the pollution generated in *colonias* may impact a much larger population (Bath 1986; Mumme and Nalven 1988). In the language used by Morehouse (1995), neither neighborhood boundaries nor national boundaries act as “filters” for environmental pollutants.

## RESEARCH OBJECTIVES

The first year of this project involved three interrelated objectives:

- Construct a survey instrument to assess the environmentally relevant behaviors of residents of several *colonias* in Nogales, Sonora
- Conduct a survey of behaviors related to environmental degradation such as trash burning, residential burns for heating and cooking, water storage methods, and waste disposal practices
- Assess residents' perception of risks to their own health

Assessment of such behavior is a necessary antecedent to the development of intervention programs. There is, for example, little or no data concerning the degree to which residents contribute to air pollution by burning household wastes, or by burning materials for heating the home. There is little data concerning the type of fuels used for residential heating. Anecdotal evidence suggests that some of the amount and type of residential burning (for example, residents frequently burn trash and some residents have been observed burning tires for heating) results in air pollution and, consequently, in health risks for residents and their neighbors.

Questions on risk perception were designed to evaluate whether residents have a reasonably accurate perception of the environmental hazards that may affect their health. In some cases the lack of knowledge of environmental hazards can have tragic consequences. For example, local records indicate that last year, 12 people residing in Nogales *colonias* died from carbon monoxide poisoning resulting from the use of charcoal to heat unventilated indoor spaces. Measurement of perceived risk can be used as a guide to educational outreach programs designed to mitigate hazardous behaviors.

The objectives of year two of this project involved:

- A detailed analysis of the data collected during year one
- An analysis of the relationship between risk perception and hazardous behavior
- The development of guidelines for educational interventions designed to modify those behaviors that contribute to environmental pollution and pose hazards to the health of *colonia* residents

Since previous studies have shown that *colonia* residents are willing to modify their behavior when provided with relevant information, this part of the project is anticipated to have an impact on the health of residents and the level of environmental pollution produced by these communities.

## RESEARCH METHODOLOGY

The methodology consisted of the construction and administration of a Residential Behavior Survey designed to assess behaviors that produce environmental pollution or health hazards. The survey focused on behavior relevant to air quality, water quality, and waste disposal. With respect to air quality, the survey collected information on the type and amount of fuel

consumed for heating, the type and amount of fuel consumed for cooking, and the method and amount of trash burning was assessed. With respect to water quality, residents were interviewed concerning the source of the water used for drinking, cooking, and bathing; water sterilization practices; water storage practices; and water disposal practices. With respect to waste disposal, the survey assessed the types of toxic wastes in the home, the methods of toxic waste disposal, the methods of ordinary waste disposal, and the location of and construction of toilet facilities. The complete survey may be found in Appendix A of this report. Native speakers of the language conducted all surveys in Spanish.

The interview also assessed residents' beliefs and knowledge about the health risks that are produced by their residential environment and by the behavioral practices surveyed above. The research literature indicates that subjective estimates of risk are influenced by different factors than are objective estimates of risk, and therefore typically do not match objective estimates of risk (Slovic 1987; Tversky and Kahneman 1981). For this reason it is possible that *colonia* residents may not be concerned about factors that greatly influence their health, but at the same time remain quite concerned about factors that have minimal health impact. Since in most cases it is an individual's perception of risk (rather than actual risk) that guides behavior, it is important to assess residents' perception of the dangers inherent in their residential environment.

The survey was administered to a subset of residents that were randomly selected from the total population of dwellings among designated *colonias* in the region of Nogales, Mexico. Sample size was computed based on a 95% level of confidence so that the sample proportion would vary within a 5% margin of error from the population mean. For purposes of computing sample size, we assume an equal (50%) probability of positive and negative responses to each question (This is the most conservative choice as any other proportion would reduce sample size).

The project used the formula for a simple random sample (Kish 1965):

Simple random sample $= (\text{alpha level})^2 \ (p\ q)/(\text{Error})^2$
or $= (1.96)^2 \ (.5 \times .5)/(5\%)^2$
$= 3.8 \times .25 / .0025$
$= 384$

The survey was administered to residents of 400 dwellings in three different study areas in Nogales, Sonora. The three study areas – Area 1 in the southwest, Area 2 in the northwest, and Area 3 in the northeast of Nogales – contained a total of 16 *colonias*. Figure 1 depicts the study areas.

The research described in this proposal resulted from a collaboration between the principle investigators, Colegio de la Frontera Norte (COLEF) and the Arizona Department of Environmental Quality Border Team.

COLEF, Nogales, was our university partner in this research project. COLEF consists of eight campuses along the U.S.-Mexican border, staffed by graduate students and degreed

professionals that conduct ongoing research funded by the Mexican government. The researchers at COLEF, Nogales, are familiar with the social and environmental problems posed by *colonias precarias* in the area and were experienced in conducting survey research these communities.

## RESEARCH FINDINGS

The survey questionnaire and the data resulting from the survey are displayed in Appendix A. In the section below we discuss both the highlights of the data collected on residential behavior as well as a series of structural equation models that were used to analyze the relationship between risk perception and residential behavior.

*Background information*
The initial questions on each survey assessed background information concerning the residents and characteristics of the dwelling.

The average duration of residence in the sample is 4.8 years. Area 2 had the longest average duration of 6.6 years, Area 3 averaged five years, and Area 1 averaged 3.2 years.
As expected, the data indicate that the majority of *colonia* residents were relatively recent migrants to the area. Only 15.8% of the sample indicated that they were born and raised in Nogales. Sixty percent of the sample indicated they lived in Nogales more than five years, 20.5% reported that they lived in Nogales between one and five years, 3.8% lived in Nogales less than a year. Figure 2 depicts this data.

Quality of living conditions in marginalized communities is positively correlated with length of residence. For example, the correlation between length of residence and the presence of a sewer system in the home is $r = .457$.

Our data indicate that *colonias* in the study areas have a relatively high spatial density per dwelling. Although the dwellings tend to be small, Areas 1 and 3 average 4.7 residents per dwelling, while Area 2 reports an average of 5.2 residents per dwelling.

Renting or borrowing housing is relatively rare in this area. Eighty-six percent of Area 1 residents owned their house, 6% rented, and 8% were borrowing their homes. Seventy-eight percent of Area 2 residents owned their house, 17% rented and 5% reported borrowing their houses. Eighty-six percent of Area 3 residents owned their homes, 9% rented and 5% borrowed their homes.

*Infrastructure characteristics of dwellings and neighborhoods*
Marginalized communities are defined primarily by the absence of adequate infrastructure. Part of the present survey was designed to document the quality of housing stocks, the physical characteristics of dwellings, and the presence of infrastructure elements in and around the dwelling. Details of the data are displayed in Appendix A.

1. Dwellings. The houses in the study area had the following characteristics: Fifty-seven percent of the houses were composed primarily of wood, 32% of brick block or cement, and

3.3% of paper carton. The rest were comprised of amalgamations of materials. Data indicated that approximately 60% of the floors in the three study areas were made of cement. All areas also had considerable numbers of dwellings with dirt floors – Area 1 reported 36.7%, Area 2 reported 32.6%, and Area 3 reported 40%. We observed a great deal of variation in the quality of housing in the communities surveyed. Some residents lived in relatively large dwellings that were well constructed and equipped with electricity and piped-in water. Other families lived in small, minimal shelters built out of scavenged scrap materials. These latter dwellings provided only minimal shelter and no real amenities.

Very few of the residents sampled reported that they live on streets that are paved. Area 1 had 1.7% of streets paved, Area 2 had 18.2% of streets paved, and Area 3 had 3.8% of streets paved.

Residents also reported that dwellings were infested with insects and rodents. In Area 1, 44% of the dwellings contained insects and 62% contained rodents. In Area 2, 68% of the dwellings contained insects and 65% contained rodents. In Area 3, 72% of the dwellings were reported to have insects, and 70% were reported to have rodents.

2. Electricity. The majority of residents in this area have electricity in their homes. Overall, 80.8% of the sample reported some type of electrical connection. However, the percentage of houses with electricity varied widely by locale. Among Area 1 residents, only 56.7% had electrical service, while 89.2% of Area 2, and 94.7% of Area 3 residents had electricity. In one of the most marginalized *colonias*, only 6.1% of residents sampled had electrical service. Figure 3 depicts the spatial distribution of homes with electricity.

3. Sewers. The majority of dwellings in the surveyed *colonias* do not have a sewer connection to the dwelling. Thirty-one percent of the residents reported a sewer connection, while 69% reported no sewer connection. The presence of this infrastructure element also varied dramatically between locales. The majority of residents in Area 2 (64.8%) lived in homes connected to a sewer, while only 16.7% of the residents in Area 1 and 21.1% of the residents in Area 2 reported sewer connections. Figure 4 depicts the spatial distribution of homes connected to a sewer system.

Residents who are not connected to a sewer system use latrines for the disposal of human waste. Like the dwellings themselves, the latrines vary considerably in terms construction quality. Virtually all are situated in dense, rocky soil with poor drainage characteristics.

The widespread use of latrines constitutes one of the most significant environmental hazards in the region. The best estimate of population in marginalized communities in Nogales is 130,000 residents. Our data suggests that 69%, or 89,700 people, are using latrines for human waste disposal. If it is assumed that the average amount of human waste generated per capita per day is 1.13 kilograms, then the data suggest that approximately 101,361 kilograms of human waste are deposited in the latrines of Nogales *colonias* each day.

4. Water. Survey data indicate that houses with a sewer connection typically have piped-in water, while houses without a sewer connection rarely have piped in water. Overall, 30.8% of

the sample reported piped-in water, while 69.3% reported that they did not have piped-in water.

*Behavior related to water use and storage*
Of the people who receive piped-in water, 54% consider the water quality to be good, 30% consider it to be of medium quality, and 15.5% consider it to be bad quality water. Seventy-five percent of these residents report that the water looks clear, while 24% report that the water looks cloudy or contains sediments.

Fifty-three percent of the residents who received piped in water reported that they used it directly for drinking or cooking. Residents who treated the water before consumption commonly boiled it, although 16% reported using chlorine as a disinfectant.

The majority (93%) of *colonia* residents that do not have piped-in water buy water from private trucks that service the area. The most common storage method – used by 82% of the residents who buy water from trucks – is to store water in portable containers outside the residence. Of the residents who buy water from trucks, 47% reported consuming it directly without treating it, 37% reported boiling it before consumption, and 16% reported adding a disinfectant such as chlorine before consuming the water.

*Behavior related to air quality*
The methods that *colonia* residents use to heat their homes, cook their food, and dispose of trash may have a direct effect on air quality in the region. The data from this survey indicate that 23% of interviewed households burn wood to heat their homes. If we assume a total *colonia* population of 130,000 residents, with 4.9 residents per household, we estimate approximately 26,500 households. Extrapolating our data on residential burning to the total population, this result implies that during the colder months of the year, approximately 6,100 *colonia* households burn wood for daily heating. The data further indicate that 17% use gas, 6.5% use electricity, 5.3% use oil, 1.8% use coal, and 1% burn tires for heating. It is noteworthy that although only 1% of respondents reported burning tires, 13.3% reported that others in their area burned tires for heating. It should also be noted that even this small proportion of the population could substantially contribute to air pollution in the region.

A significant percentage of residential burns are related to trash disposal. Although 92% of the residents report that there is some trash collection service in their neighborhood, less than half think trash collection occurs often enough. Twenty-six percent of respondents reported that they burned trash on a regular basis. Of the residents who burned trash, 37% just burned paper, while 63% reported burning all of their garbage. Extrapolating to the total *colonia* population, this data implies that approximately 7,000 households burn the trash from 33,800 *colonia* residents on a weekly basis.

*Perception of Risk*
There exists substantial variation in the degree to which residents are aware of the environmental hazards present in their environment. Some residents are quite cautious about water quality and take many precautions in storing water and sterilizing it before use. Other residents tend to assume that if the water looks clear and has no odor, it is safe for

consumption. Similar results emerge from the questions concerning air pollution. While some residents are concerned about the effect of air quality on their health, the majority assume that their own behavior is not hazardous.

This research project is based on the presumption that perception of risk mediates self-protective behaviors. Residents who are concerned about hazards to their health from water should be more likely to clean water storage containers, disinfect water before using it, and buy bottled water. Residents who perceive risk from air pollution should be less likely to burn trash. If this relationship between risk perception and behavior is confirmed by data, then educational interventions designed to heighten awareness of environmental hazards could have positive effects on both human health and the environment.

In order to test the relationship between risk perception and relevant environmental and self-protective behaviors, we subjected our data to structural equation modeling (SEM). Our theoretical model is depicted in Figure 5. The purpose of SEM is to allow us to evaluate the hypothesis that the perception of risk is more important than actual environmental conditions in predicting environmentally protective and self-protective behavior.

*Risk perception and water purification*

*Colonia* residents are exposed to health risks from the water they consume. The water delivered to the residences either by truck or by pipe has known contaminants. The city government of Nogales has warned residents about contaminants in water and has recommended water purification before consumption. Further, residents who obtain water from trucks store it in containers that are rarely clean and that, on occasion, had been used to store toxic substances. Given the health hazards present in water, it is important to assess the degree to which residents are cognizant of risks and the degree to which they engage in self-protective behaviors.

Data from questions 18, 19, 20, 23, and 37 (presented in Appendix A) indicate that the majority of residents believe their water to be of "good quality," "not dangerous" to their health, and do not purify it. Among those who did receive a message from the city government warning of dangers in the water, the majority did not change their behavior.

A structural equation model of the relationship between water characteristics, perceived risk and self-protective behavior is presented in Figure 6.

Figure 6 indicates that the strongest path is between water clarity, perceived water quality, and water purification. When the water received at the residence is clear, it is generally regarded as being of good quality and is not purified. When the water is not clear, it is regarded as being of poor quality and is purified. There is a significant direct pathway from water clarity to water purification (when water is not clear, it is more likely to be purified), but this linkage is much weaker than the path that runs through the variable of perceived quality. The model also indicates that residents that receive piped-in water are more likely to purify water. This result is in accord with the general tendency – which was observed in this study – for residents who have better living conditions to perceive greater risks to their health than do residents who have very poor living conditions.

One alternative to water purification involves the purchase and consumption of bottled water. Figure 7 displays an SEM that evaluates the relationship between quality of water storage methods, risk perception and the use of bottled water.

Water storage methods were ranked from least dangerous to most dangerous. Our data indicate that residents who use poor-quality methods of water storage tend to perceive greater risk from their water, and tend to consume more bottled water. There is a significant direct link between quality of water storage and use of bottled water, but this path is much weaker than the one that runs through "perceived risk." It should also be noted that in separate SEMs for each of the three study areas, a direct link between quality of water storage and use of bottled water only appeared in the model of Area 3. In Areas 1 and 2, the only significant path ran through "perceived risk."

In overview, the majority of residents in this study are not concerned about hazards present in their water, or in their method of water storage. However, those residents who do perceive risk are more likely to purify water and are more likely to use bottled water. This result suggests that educational programs about the relationship between water quality and good health could have a significant impact on the health of residents of *colonias marginales* in Nogales, Sonora

*Risk Perception and Residential Burns*

Because of a relative lack of infrastructure for trash disposal and household heating, *colonia* residents significantly impact air quality by burning trash and by burning materials for heating the home. The magnitude of this impact is displayed in the data from questions 44 through58 in Appendix A. The data indicate that the average household burns trash approximately twice per week, for about 15 minutes each time. If we assume a *colonia* population of approximately 6,900 households that burn trash, our data indicates approximately 3,500 hours of residential burns occur each week solely for trash disposal. Using SEM, we evaluate the hypothesis that the amount of burning and the precautions taken during residential burns are related to the perception of risk.

Figure 8 indicates that the perceived risk to health from burning trash significantly influences whether residents actually burn trash. Two variables account for variation in perceived risk. If neighbors burn trash, the perceived risk of burning trash is greater. If trash is collected frequently, the perceived risk from burning trash is lower. There are no significant direct links between environmental variables and trash burning. All significant paths run through "perceived risk."

A similar relationship between perceived risk and self-protective behavior is found in an SEM of the variables surrounding home heating systems. Figure 9 displays the model.

Figure 9 indicates that perceived risks to health govern whether safety precautions are taken with respect to home heating systems. No direct links were found between environmental variables and the employment of safety precautions. All three variables depicted significantly influence the perception of risk.

*Implications of Structural Equation Modeling of Risk Perception*
Structural equation modeling of a subset of the data from the present study confirm our initial hypothesis that risk perception significantly influences both self-protective behavior and behavior that has environmental impacts. Rarely are direct linkages between environmental conditions and behavior observed, and when they are, they are weaker than the paths that run through perceived risk.

Data on risk perception also show that longer-established residents of marginalized communities are more concerned about environmental hazards than are newer residents. They are more concerned about water quality, more likely to treat their water before consuming it, and more worried about smoke from burning garbage than low status residents. Longer-established residents, who are likely to be connected to a sewer system, are more worried about the danger to their health from a neighbor's latrine than are newer residents, who are likely to use a latrine themselves.

These results suggest that educational intervention should be designed to increase residents' awareness of environmental hazards and risky behavior. Increases in perceived risk were found to be significantly related to environmentally protective and self-protective behavior. Such interventions should be directed primarily at lower status residents who are living in the most substandard conditions. Educational interventions can not be regarded as a substitute for adequate infrastructure, but they can be instituted immediately and at a much lower cost than the cost of adequate infrastructure.

*Guidelines for Educational Interventions*
Research that evaluates the impact of environmental education programs on behavior has described a pattern of mixed results. Some evidence suggests that simply raising awareness of the magnitude of the threat rarely leads to action to remedy that threat (Sims and Baumann 1983). Recent studies specifically directed at residents of *colonias*, however, have shown that people are willing to make changes in their accustomed pattern of behavior when provided with instructions on how to do so (Leonard et al. 1995; Liebman et al. 1995). One cautionary note from the present research is that a message from the Nogales city government concerning hazards present in water had little impact on the behavior of residents who received the message.

As part of this research project we conducted focus groups that discussed issues involving environmental education in Nogales *colonias*. A diverse group of individuals participated in these focus groups, including *colonia* residents, employees of government service agencies, management of *maquiladoras*, and members of non-profit community agencies and service organizations. As a result of these focus groups, we developed the following guidelines for educational interventions.

First, a series of training modules should be developed to educate residents about environmental hazards and provide specific information for their mitigation. Such training modules should concern topics displayed in Figure 10.

The training modules should be directed at an audience that would be most receptive to the information and would most likely influence other family members. It was the consensus of focus group participants that the individuals displayed in Figure 11 would be the most appropriate target audience for environmental and behavioral education.

The location of training sites was also deemed to be of primary importance by focus group participants, who thought of the location as related to the credibility of the information, and more importantly, to the ease of access to the information. The sites displayed in Figure 12 were recommended. Focus group members also indicated that long standing conflicts between different organizations that might support environmental education should be taken into account when designing an educational outreach program. Organizations that have had conflicts in the past are displayed in Figure 13.

## CONCLUSIONS

The data gathered in this survey confirm that infrastructure inadequacies lead to residential behaviors that are both hazardous to the health of *colonia* residents and result in environmental pollution. The most salient problems involve behaviors related to the disposal of human waste, the negative impact on air quality resulting from residential burning, and the potential for disease produced by inadequate water sanitation and storage. Also noteworthy is the potential for disease caused by the presence of insects and rodents in the home.

Available data indicate that residents of *colonias* have few economic resources available to pay for improvements in housing and infrastructure. In an analysis of survival strategies of poor families along the U.S.- Mexican border, Anderson and de la Rosa (1991) found that food accounted for the largest proportion of the household budget. In contrast to middle class families, in which housing is a relatively large expenditure, poor families spend virtually nothing on housing. In this study, housing expenditures averaged slightly under one percent of the household budget. Utilities and water represented about nine percent.

The results of this study, specifically the relationship between risk perception and behavior, indicate that educational interventions are likely to be useful in reducing environmental hazards in Nogales, Sonora, communities. Prior research that evaluates the impact of environmental education programs in the border region has described a pattern of mixed results. Some evidence suggests that simply raising awareness of the magnitude of the threat rarely leads to action to remedy the threat (Sims and Baumann 1983). Recent studies specifically directed at residents of *colonias*, however, have shown that people are willing to make changes in their accustomed pattern of behavior when provided with instructions on how to do so (Leonard et al. 1995; Liebman et al. 1995). Information from focus groups, gathered in the present research, suggested guidelines for the development of educational interventions in Nogales, Sonora.

## RECOMMENDATIONS FOR FURTHER RESEARCH

This project explored the environmental contamination and health risks produced by the living conditions and residential behavior in the *colonias marginales* in Nogales, Sonora. The data gathered led to the following recommendations for future research:

1. A more fine-grained analysis should be conducted of the amount and chemical composition of the toxic substances used by residents. It would be advantageous to have something equivalent to a Toxic Release Inventory that displayed quantitative data showing the amount of hazardous chemicals that are released by each community into water, air, and soil.

2. This type of research should be expanded to other *colonias* along the entire U.S.-Mexican border, with emphasis on showing regional variation in the types of environmental pollution produced by *colonias*. Different environmental conditions, including subsoil drainage, atmospheric inversions, temperature variation, and the availability of toxic substances, will presumably lead to a different sort of environmental hazards produced by *colonias*. The research should be designed to identify problems that could be mitigated through education or through low-tech, appropriate technology.

3. Research should be focused on developing effective educational interventions. Such research might address which organizations could conduct an educational outreach and the type of information that should be presented. Information concerning latrine construction, water storage and treatment, and type of material that should not be burned is particularly important.

4. Research should be designed to identify low-cost, environmentally sound designs for housing in the *colonias*.

5. Research should be designed to identify prototypes for latrine and septic systems. Workshops and outreach programs should be developed that would educate residents about appropriate construction.

The environmental impact of the *maquila* industry is due to the output of factories, and due to the presence and activities of workers in those factories. More research needs to be directed at the problems faced by, and created by, the human population that has migrated to the border.

## RESEARCH BENEFITS

This research project was designed to assess the degree of environmental hazards produced in residential communities by workers in the *maquila* industry. Findings indicate that substantial environmental pollution and health risks are associated with living conditions in these communities. The present research can provide the basis for intervention programs

designed to:

- Reduce environmental pollution
- Reduce health risks to residents of *colonias*
- Reduce health risks to residents of communities proximate to *colonias*

**ACKNOWLEDGMENTS**

This project was designed in response to explicit goals in the *Border XXI Program* and an interest in the problem area that was emphasized by the Arizona Department of Environmental Quality Border Team during a visit to Arizona State University. The Arizona Department of Environmental Quality Border Team helped to define project goals and was instrumental in the construction of the survey instrument.

This project also benefited from discussions with the President and Secretary of the Nogales, Mexico, city government (*Ayuntamiento de Nogales*), with the State Commission of Public Service for Water and Sewage (*Commision Estatal de Servicios Publicos de Agua y Acanterillado*), and with the Nogales, Mexico, Department of Ecology (*Departamiento de Ecologia del Ayuntamiento de Nogales*). Each of these agencies supported this project and reviewed the design of questionnaire.

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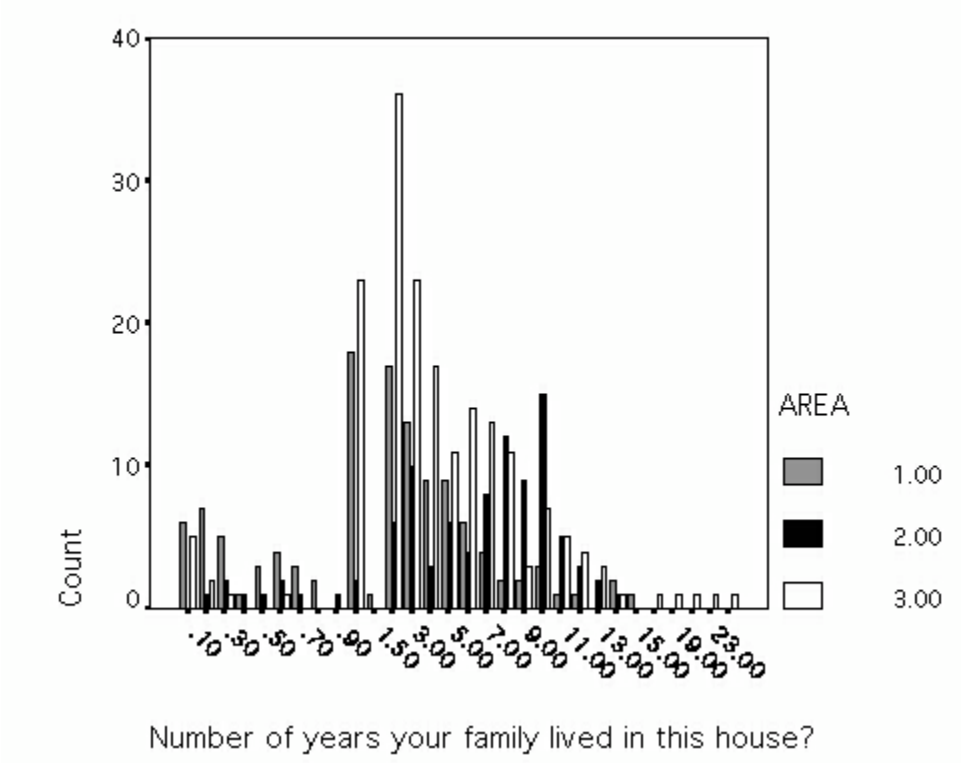
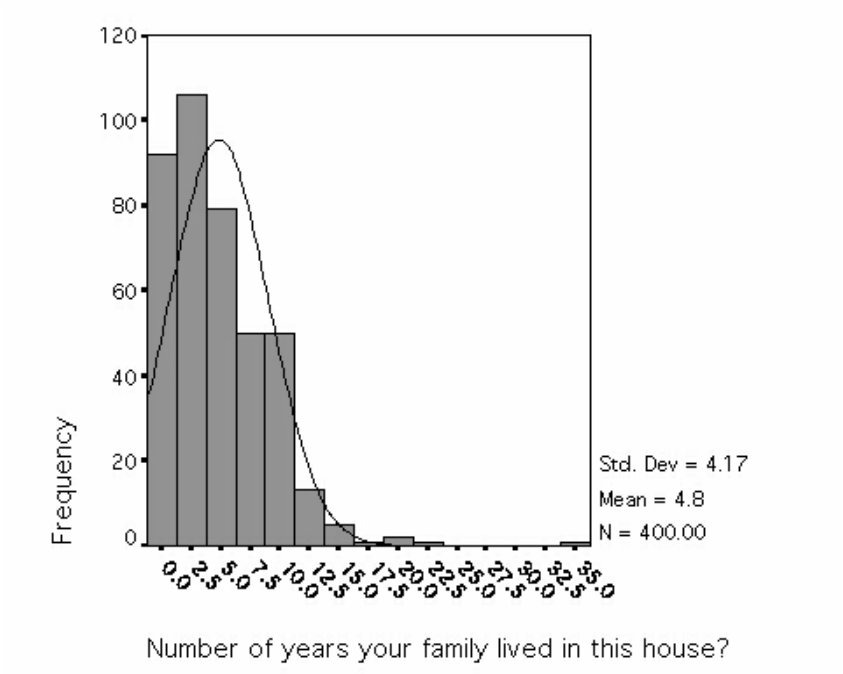
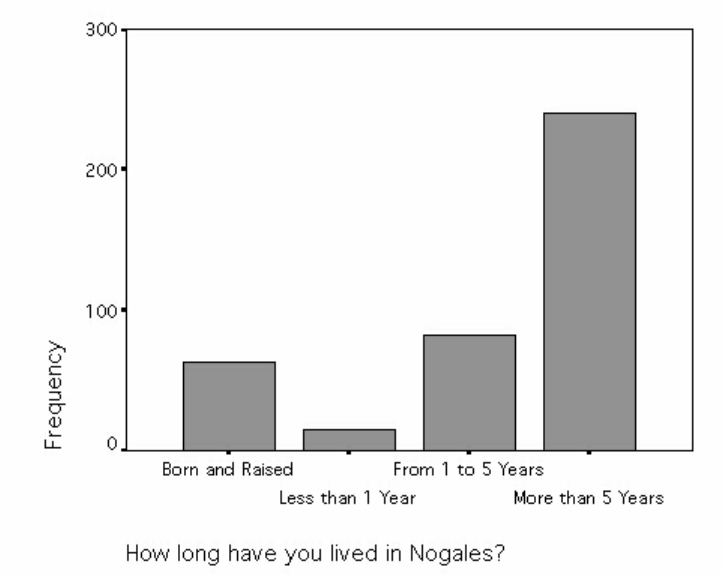
## APPENDIX A: SURVEY QUESTIONNAIRE AND RESULTS

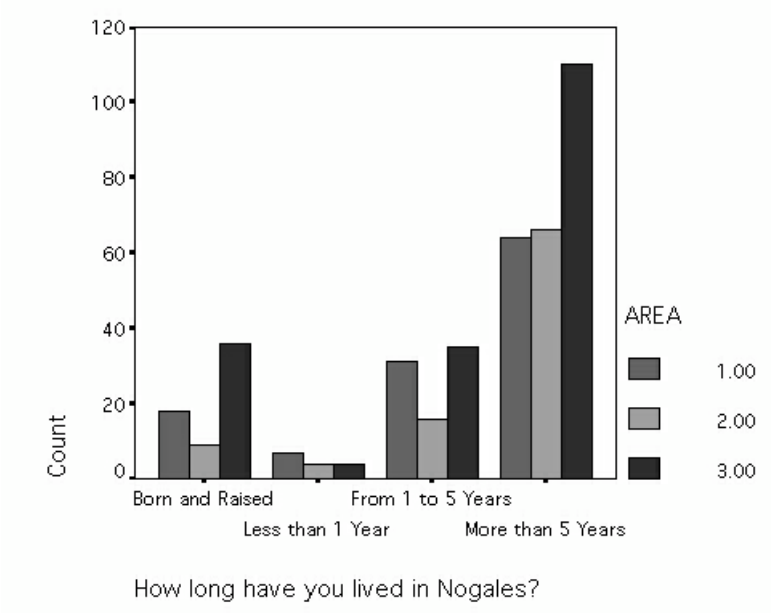
1. How long has your family lived in this house?



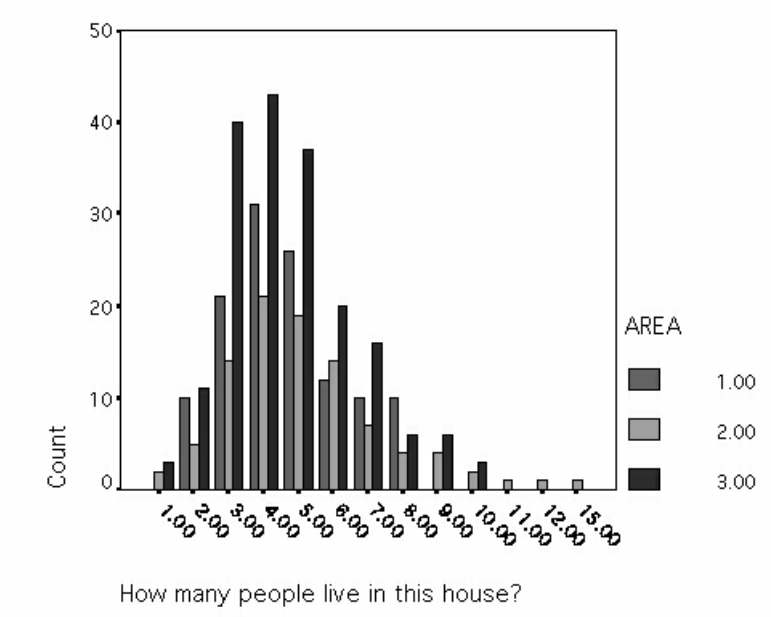



2. How long have you been living in Nogales?
   01 – Born and raised in Nogales
   02 – Less than one year
   03 – From 1 to 5 years
   04 – More than 5 years

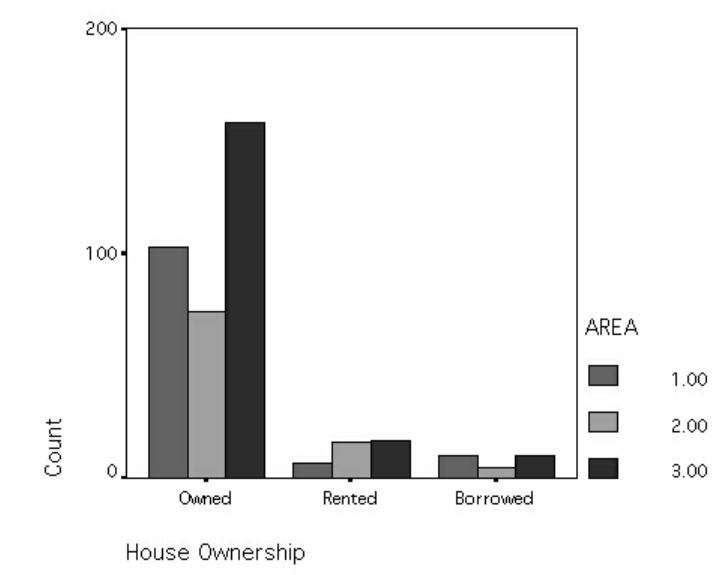


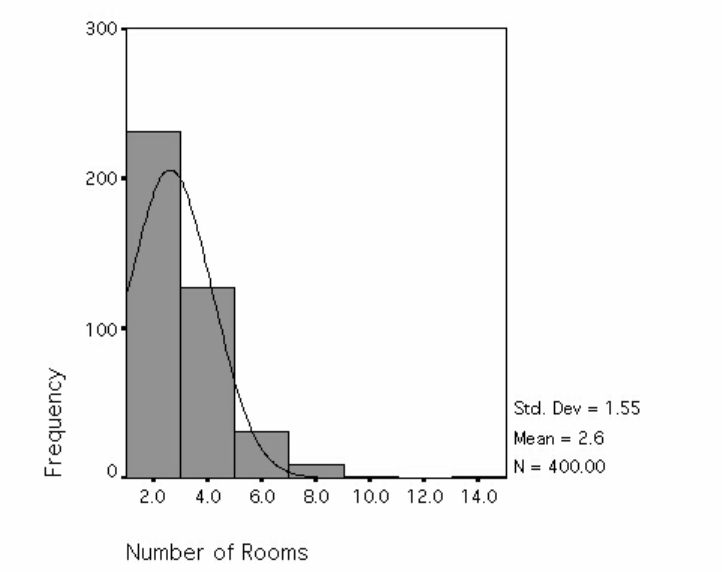
3. How many people live in this house?

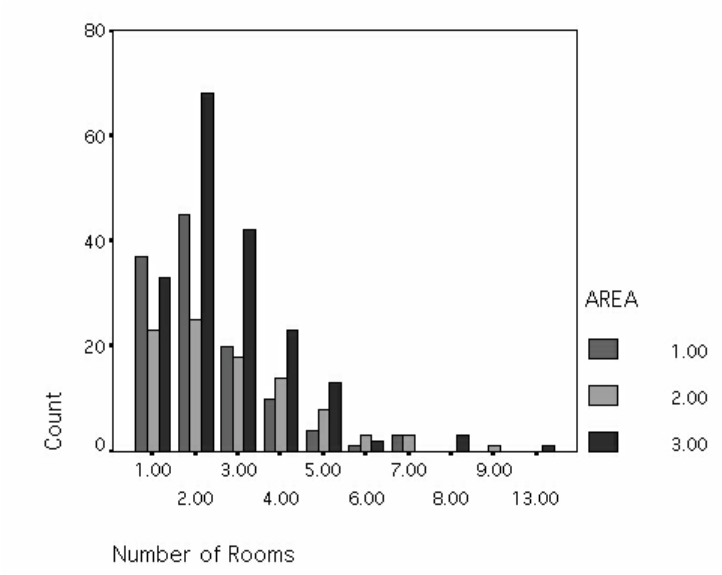



4. This house is:
   1. owned
   2. rented
   3. borrowed

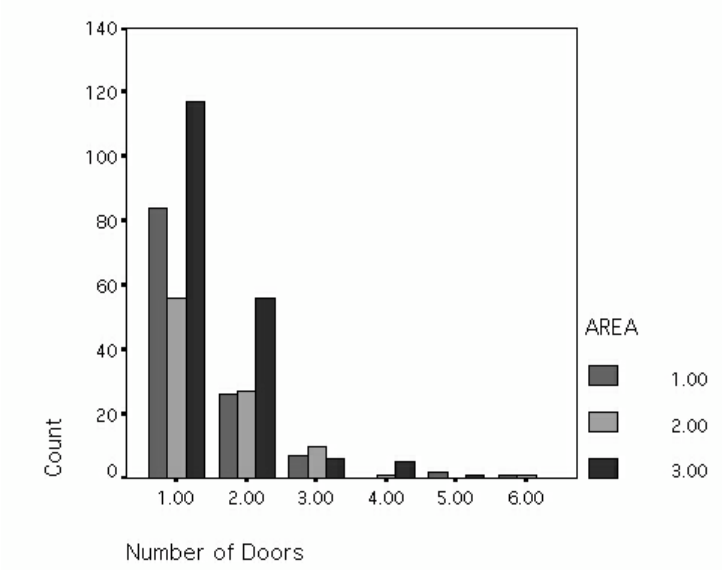


5. How many rooms does this house have?

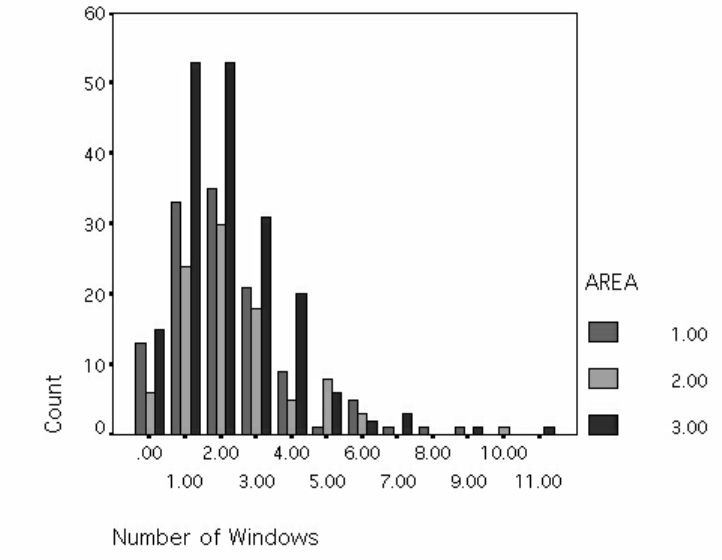


6. How many doors that can be used as outside exits does this house have?

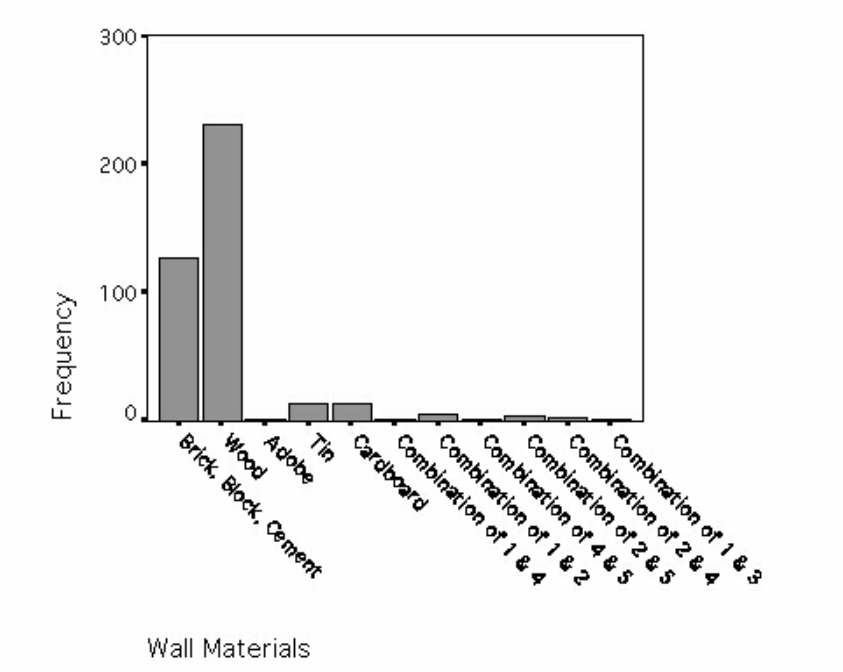


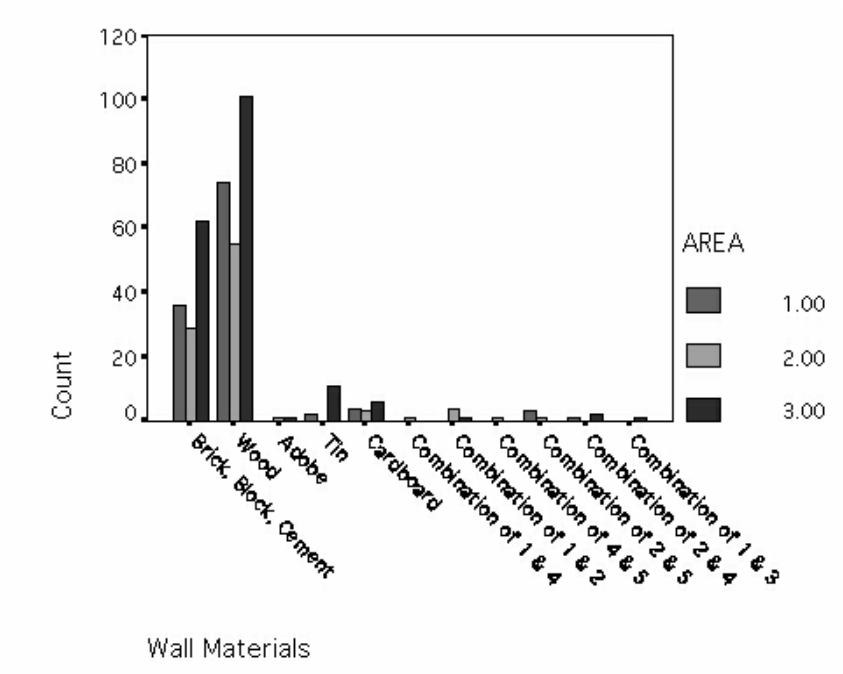

7. How many windows does this house have?



8. With what materials are the major part of the walls constructed?

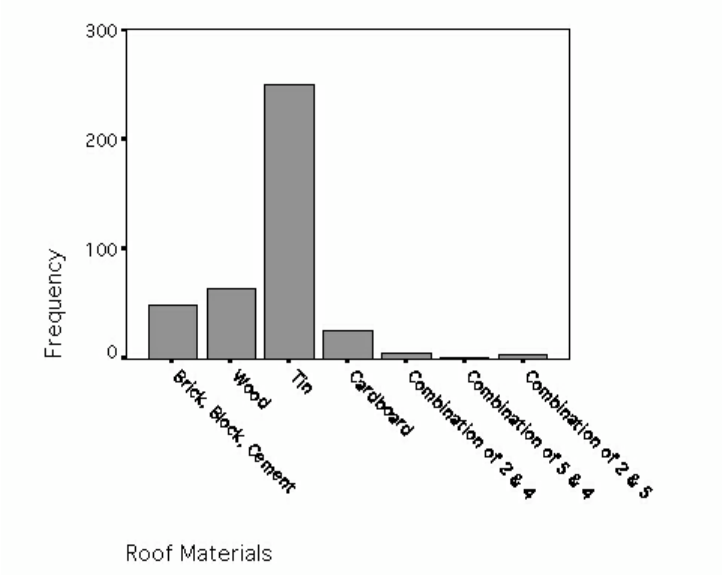
1. Brick, block, cement
2. Wood
3. Adobe
4. Tin
5. Cardboard
6. Other ( specify)
7. Combination of 1 & 2
8. Combination of 4 & 5
9. Combination of 2 & 5
10.. Combination of 2 & 4
11. Combination of 1 & 3



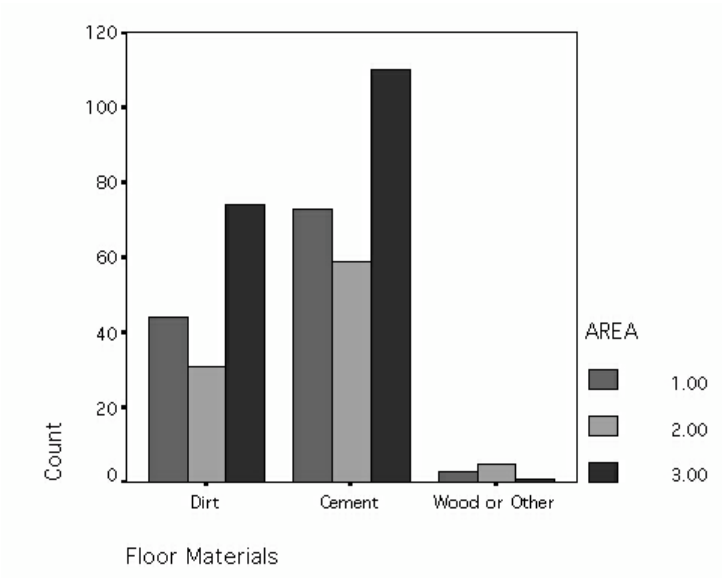



9. With what material is the major part of the roof of this house constructed?

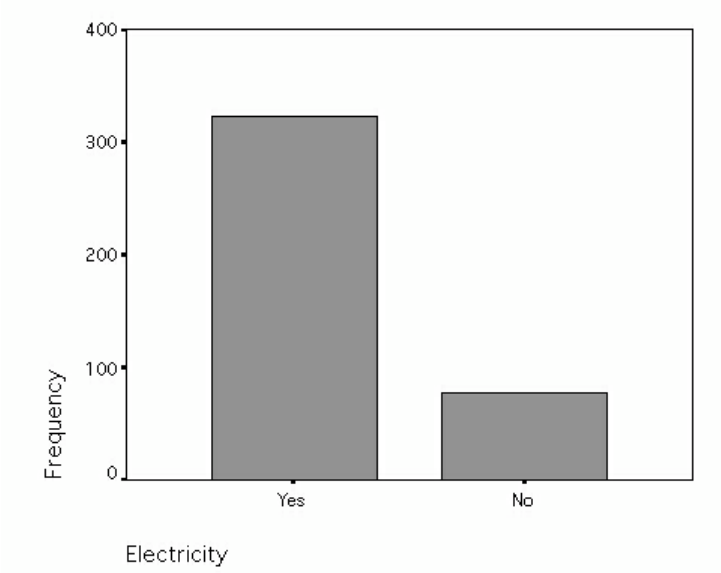
| | | | |
|---|---|---|---|
| 1. | Brick, block, cement | 5. | Cardboard |
| 2. | Wood | 6. | Other (specify) |
| 3. | Adobe | 7. | Combination of 2 & 4 |
| 4. | Tin | 8. | Combination of 5 & 4 |
| 9. | Combination of 2 & 5 | | |

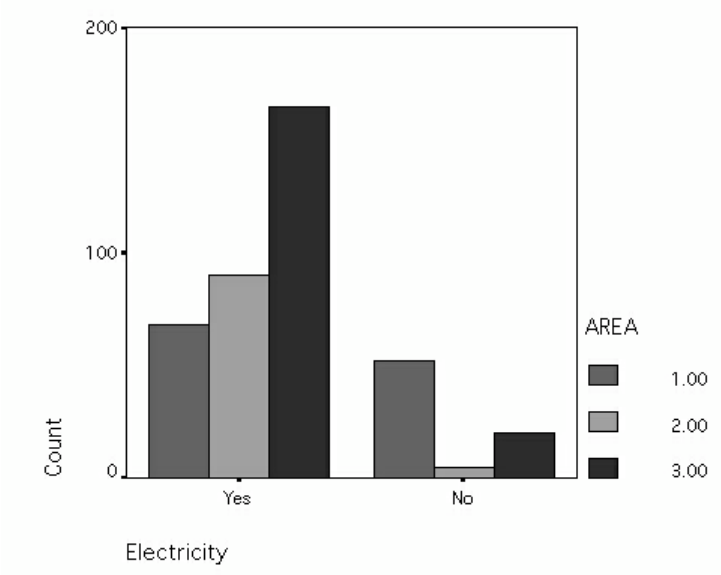



10. With what materials are the major part of the floors of this house made?
    1. Dirt
    2. Cement
    3. Wood or other material

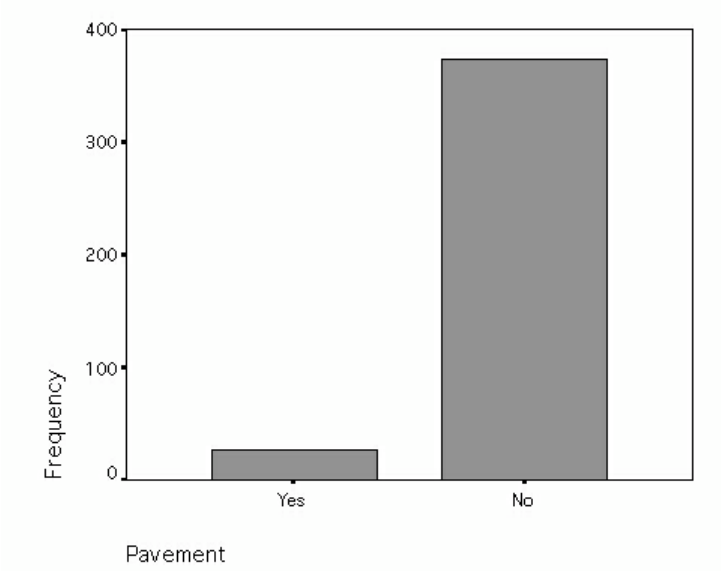


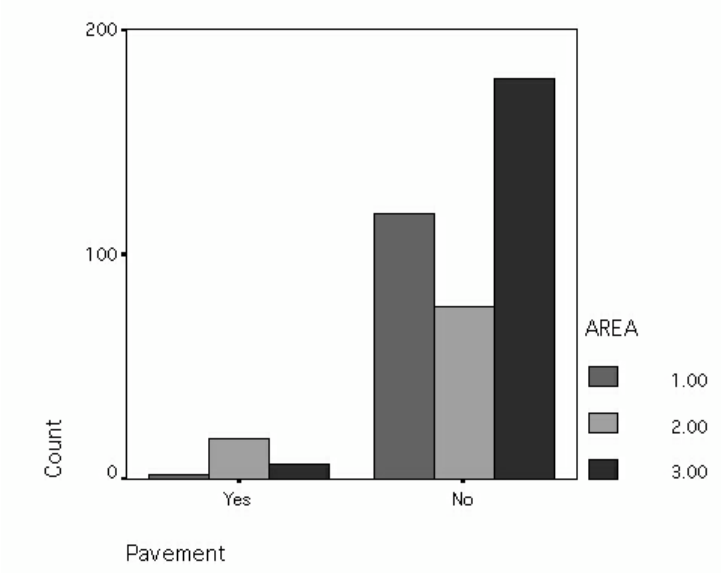
11. Do you have electricity in the house?
    1. Yes
    2. No



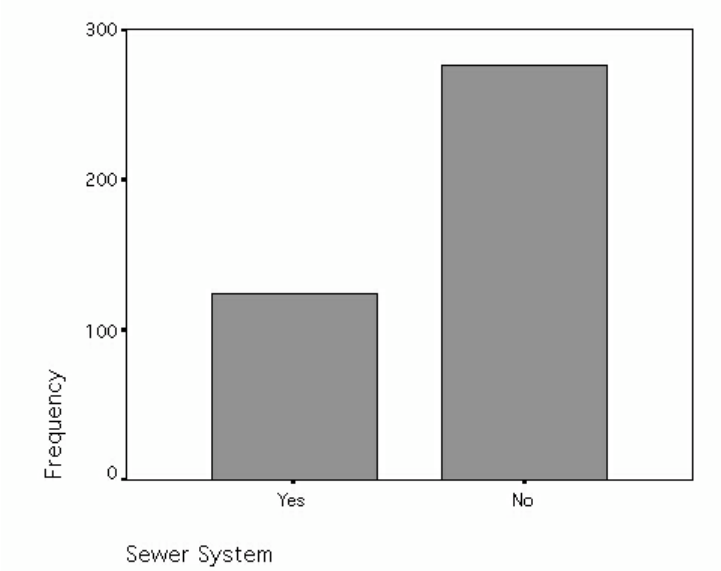



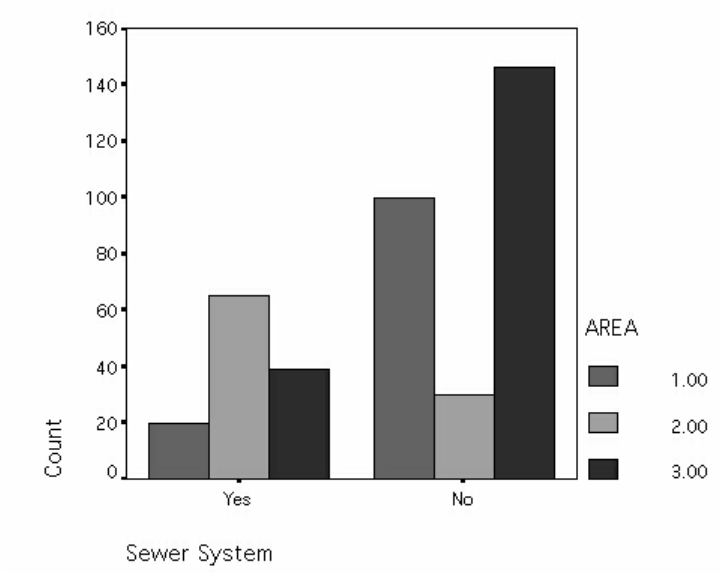
12. Is the street where this house is located paved?
    1. Yes
    2. No



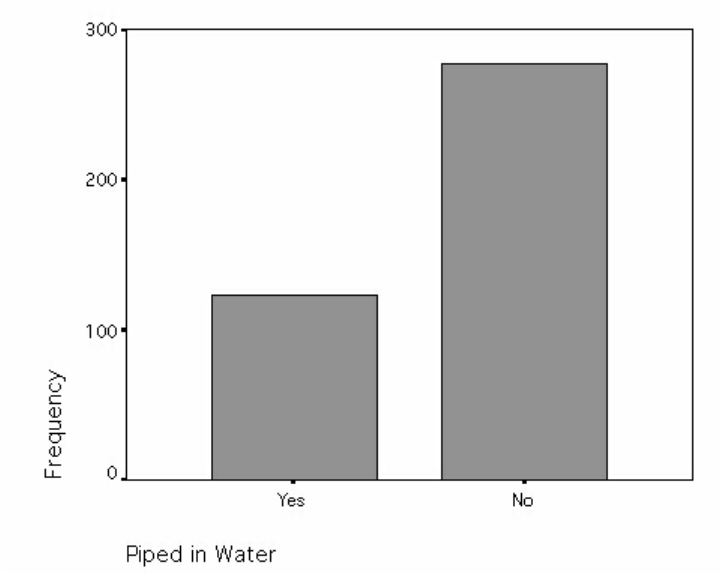



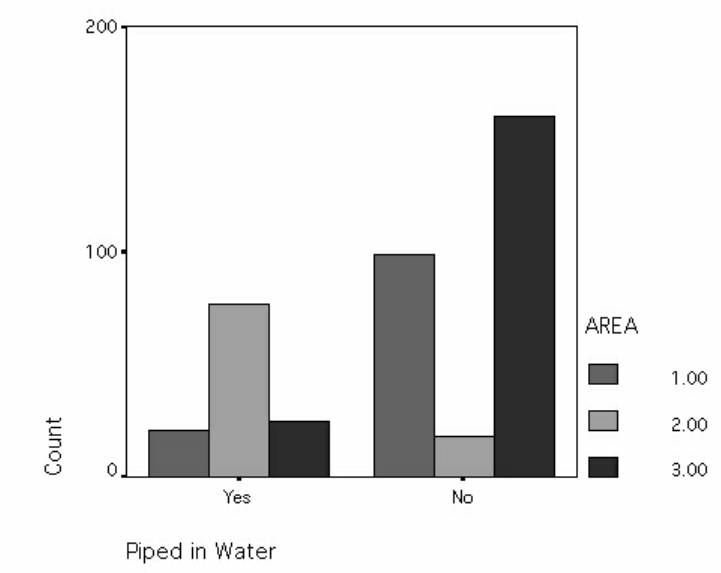
13. Does this house have drainage (sewer) connected to the street tubes?
    1. Yes
    2. No



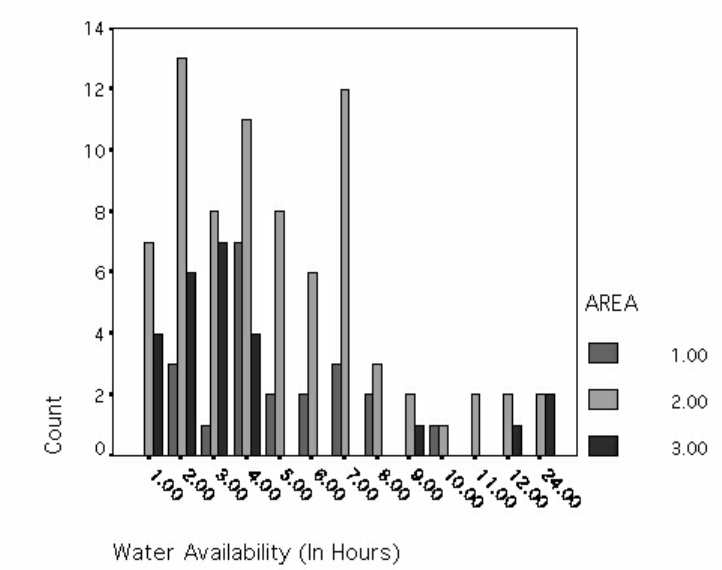



14. Do you have water faucets in your house? (piped-in water)
    1. Yes
    2. No

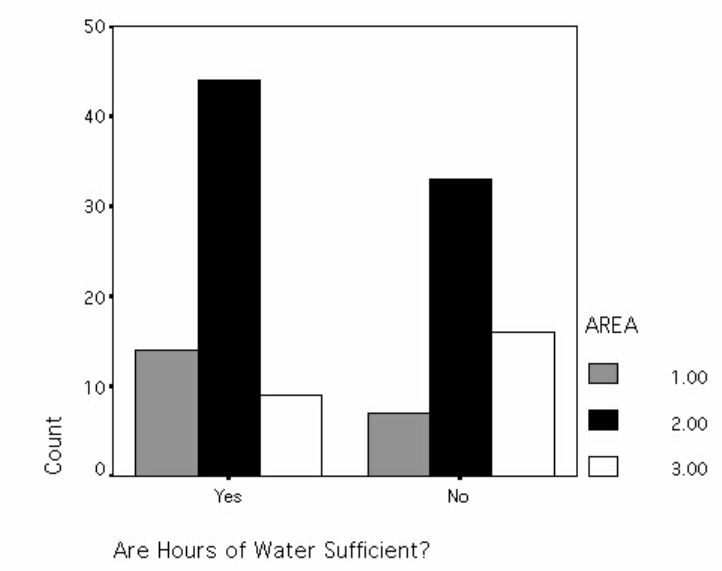


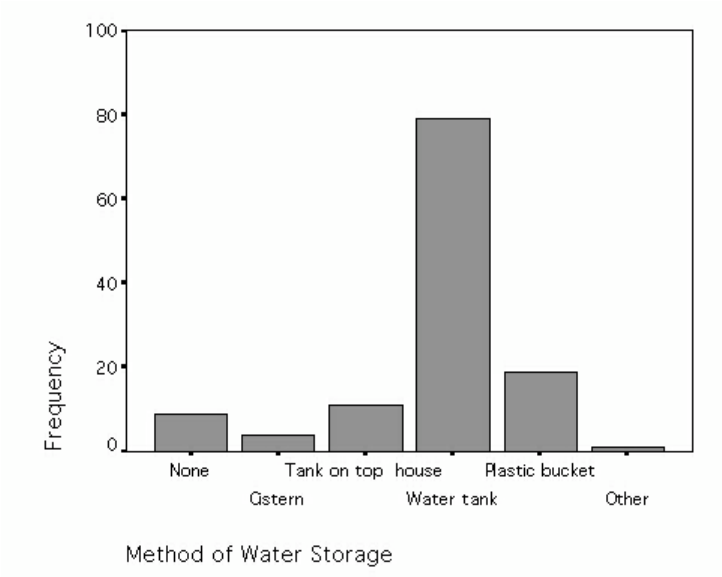
15. How many hours per day can you count on this water from the faucet?

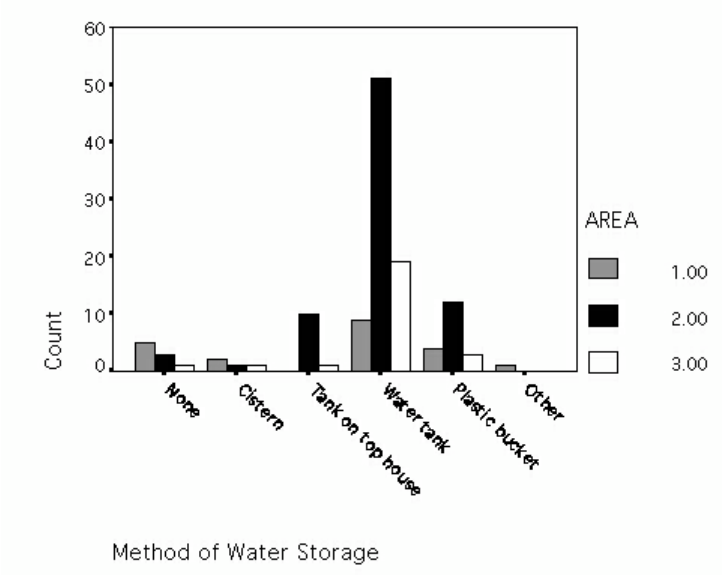



16. Do you think that the hours of your water service are sufficient to cover your needs?
    1. Yes
    2. No

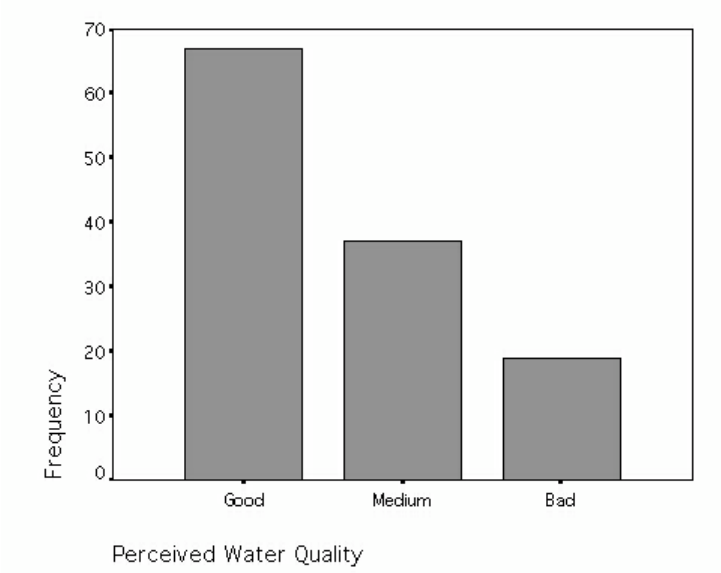


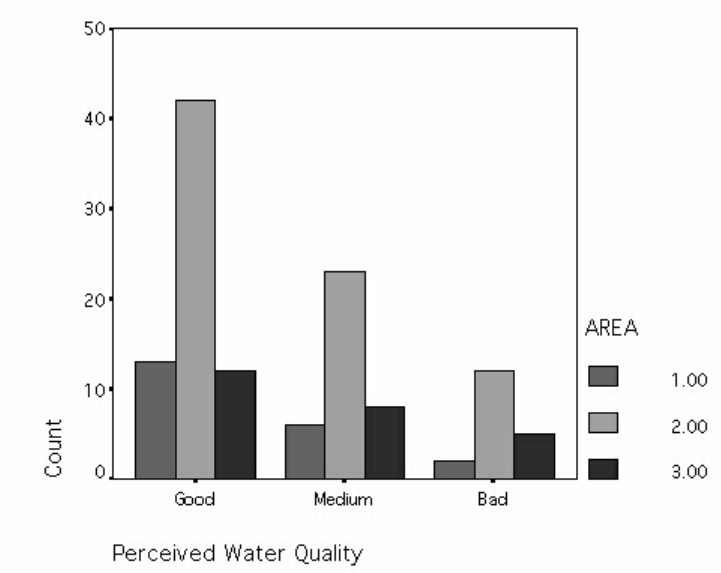
17. Do you utilize one of the following ways to store water?
    1. None
    2. Cistern
    3. Tank on top of the house
    4. Water tank or portable container
    5. Plastic gallon or plastic bucket?
    6. Others (specify)



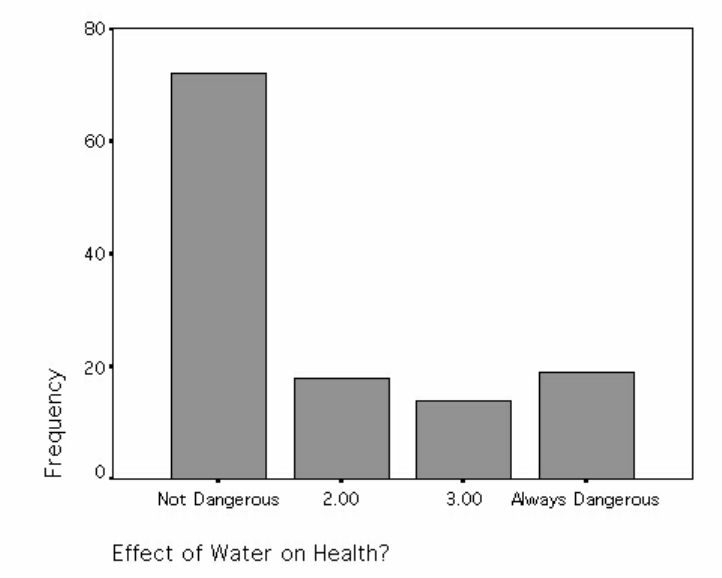



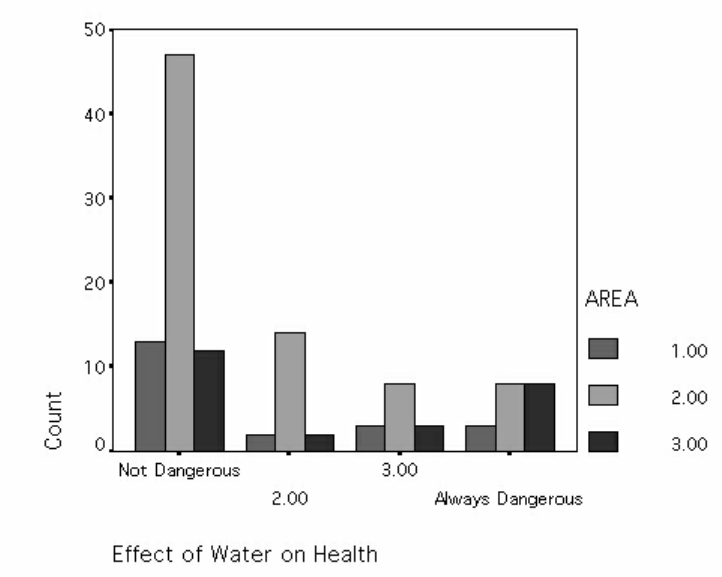
18. Do you consider the quality of your water:
    1. Good
    2. Medium
    3. Bad



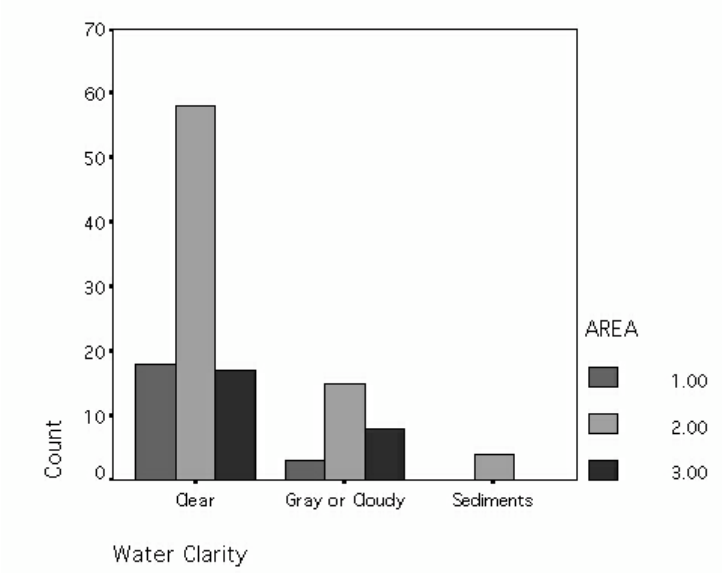



19. Is the water that reaches your house dangerous to the health of your family?
    1. It is not dangerous
    2. It is a little dangerous
    3. Sometimes dangerous
    4. Always dangerous

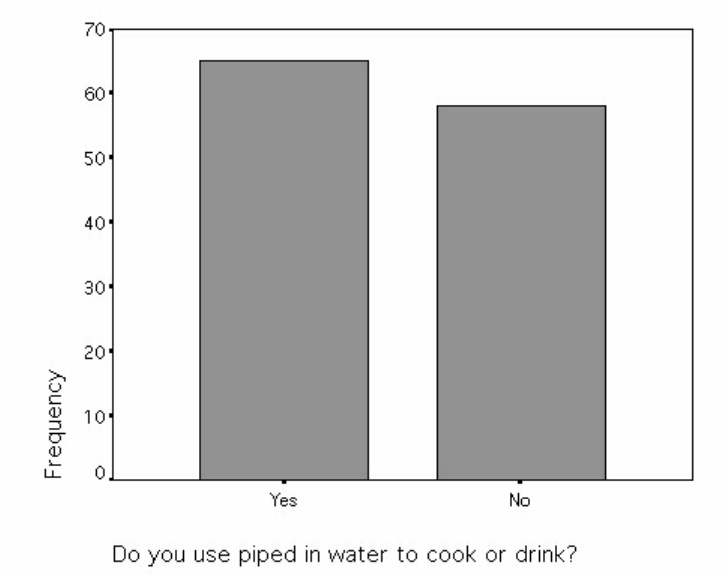


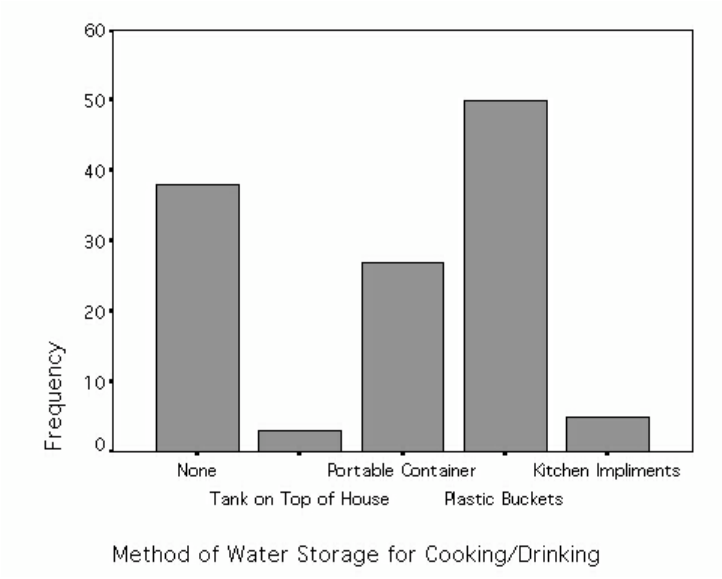
20. Normally, how does the water that reaches your house look?
    1. Clear
    2. Gray or cloudy
    3. With sediments



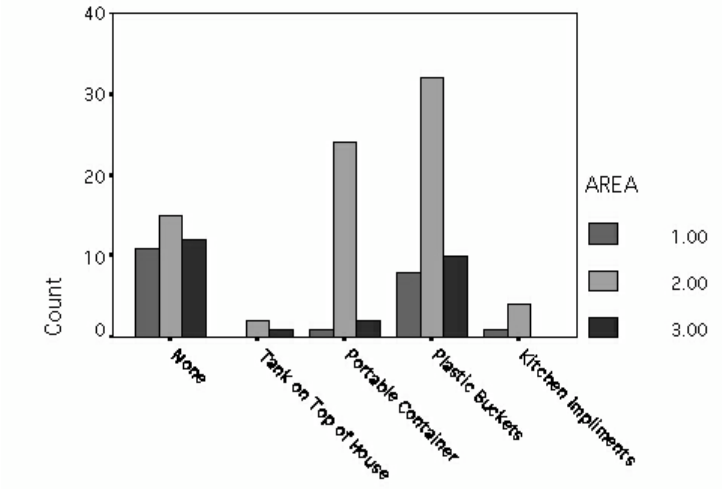

21. Do you utilize tubed-in water to cook or drink?
    1. Yes
    2. No



22. Do you utilize any of the following ways to store water that you use to cook or drink?
    1. None
    2. Cistern
    3. Underground tank
    4. Tank on top of the house
    5. Tank or portable container
    6. Plastic gallon containers or plastic buckets
    7. Kitchen implements (pots, etc.)
    8. Others (specify)

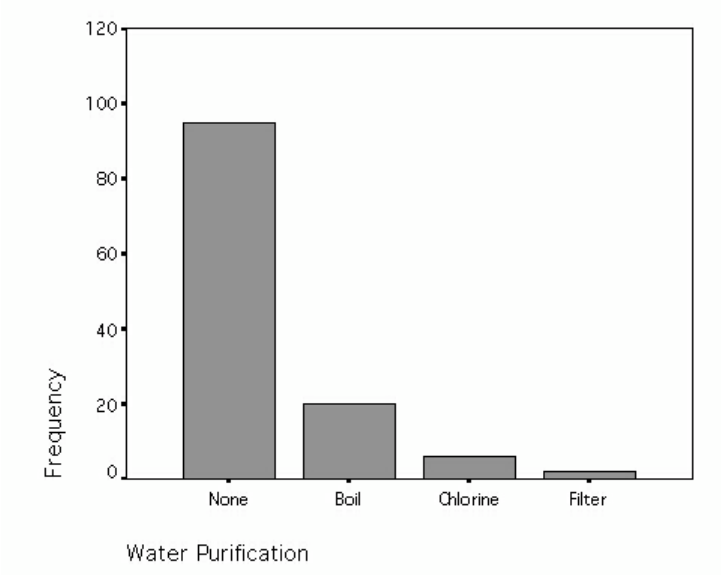


Method of Water Storage for Cooking/Drinking

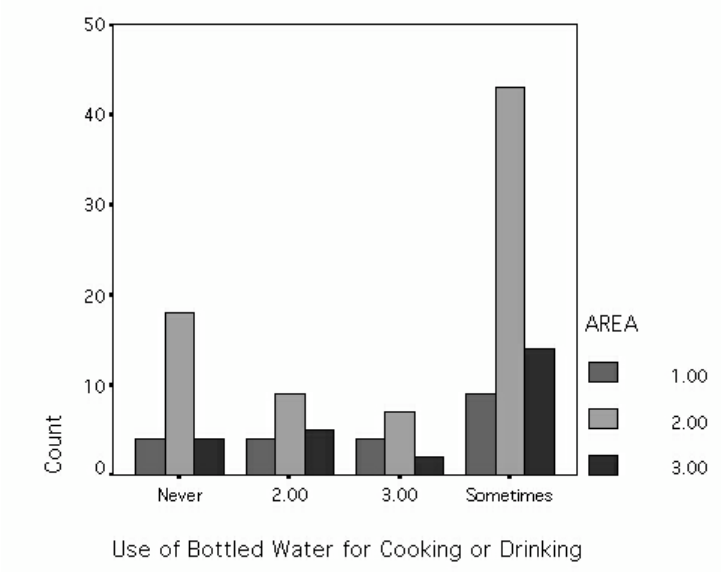


Method of Water Storage for Cooking/Drinking

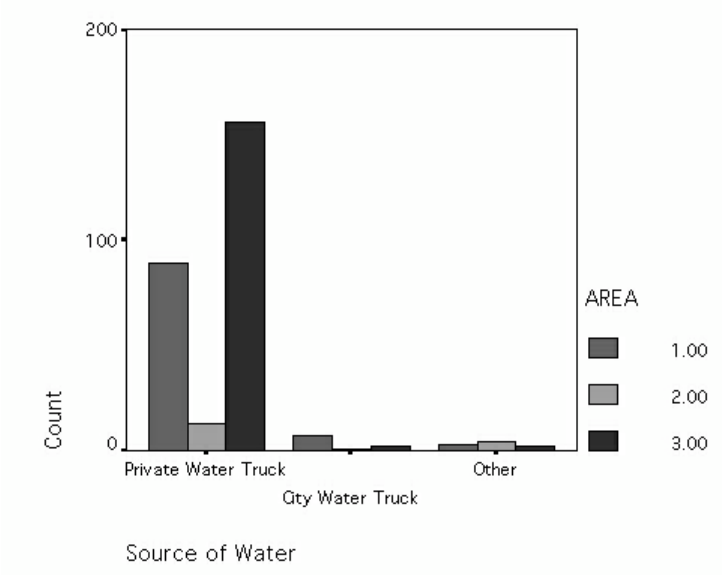
23. Do you give this water any type of treatment prior to consuming?
    1. None
    2. Boil it
    3. Enter chlorine
    4. Filter it



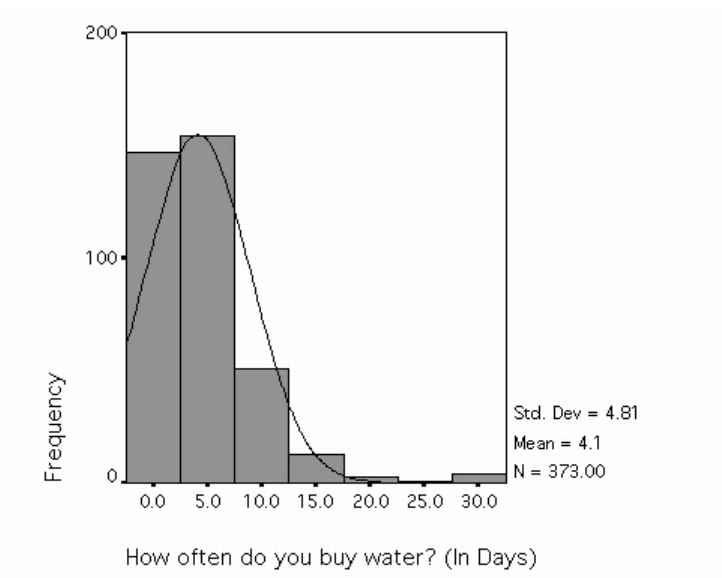

24. With what frequency do you use bottled water to cook or drink?
    1. None
    2. Sometimes
    3. Regularly
    4. Always



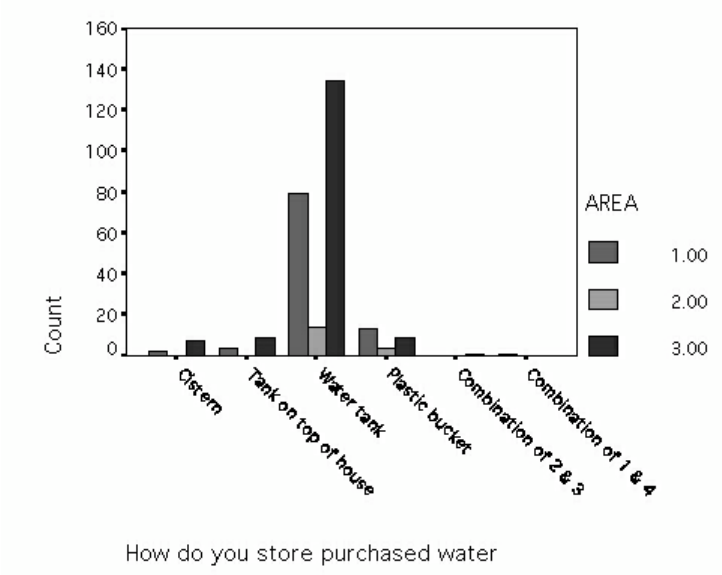
25. How do you obtain water that you utilize for domestic use (baths, personal hygiene, washing, etc.)?
    1. Private water truck
    2. City water truck
    3. Other (specify)



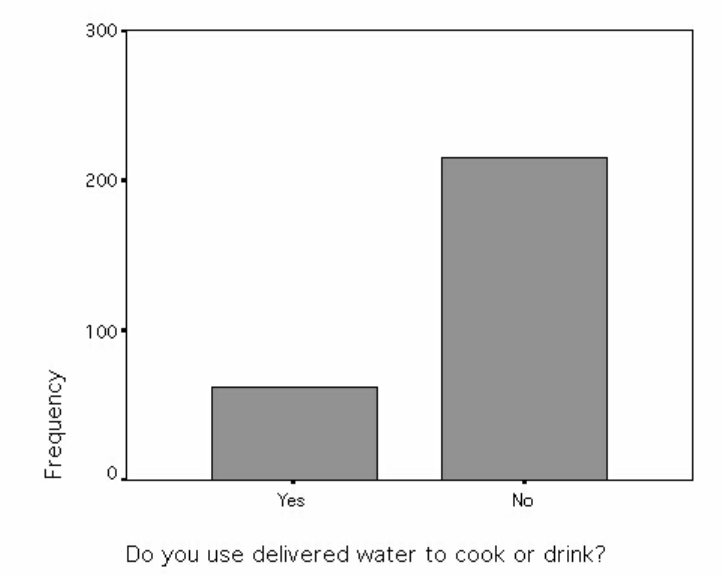

26. Normally, with what frequency do you buy water or is water delivered?



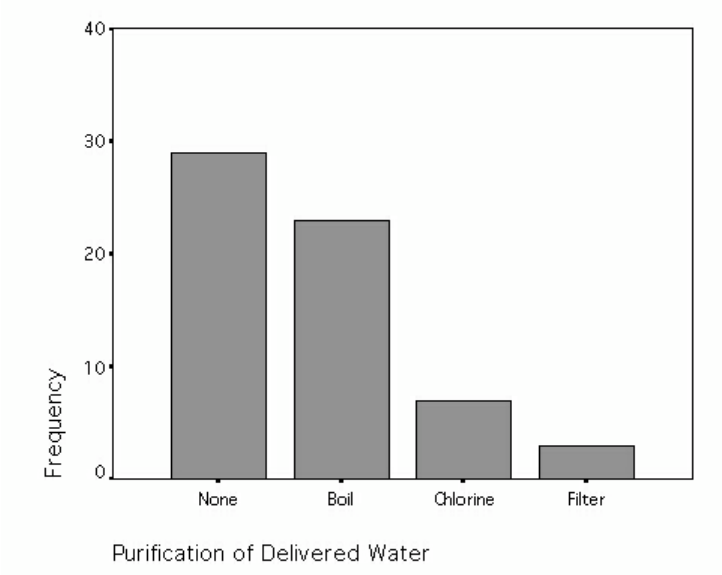
27. Which of the following do you use to store the water?
    1. Cistern
    2. Tank on top of the house
    3. Tank or portable container
    4. Plastic gallon containers or plastic buckets
    5. Others (specify)
    6. Combination of 2 & 3
    7. Combination of 1 & 4



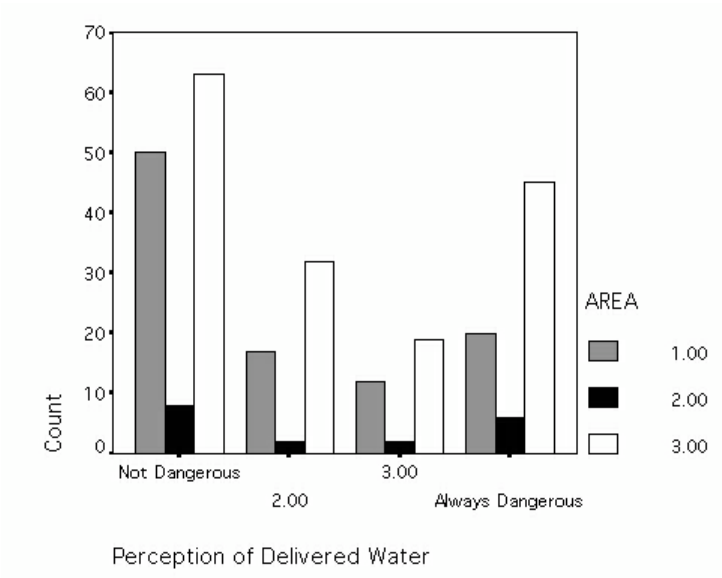

29. Do you use the water that is delivered by truck to cook or drink?
    1. Yes
    2. No



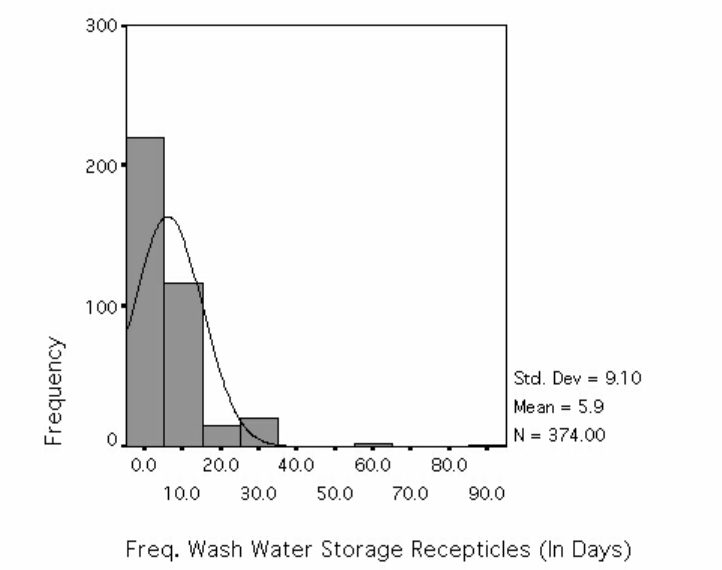
30. Do you treat this water in some way before you consume it?
    1. None
    2. Boil it
    3. Enter chlorine
    4. Filter it



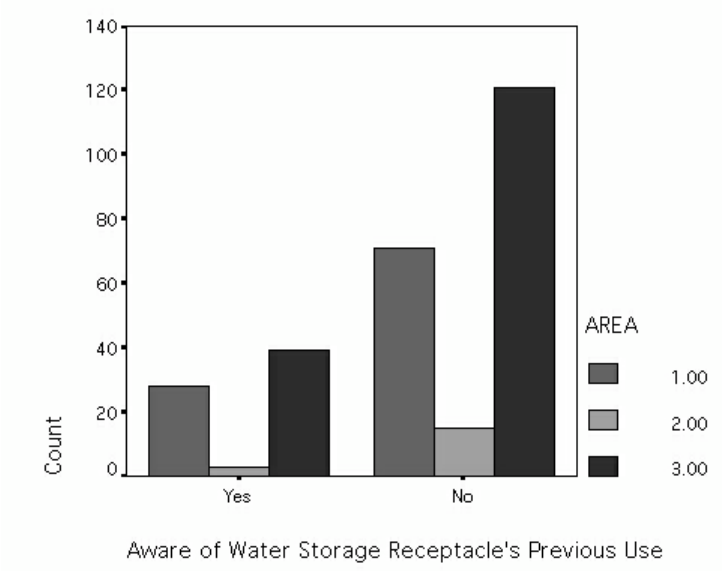

31. How do you regard the water that is delivered by truck on the health of your family?
    1. It is not dangerous
    2. A little dangerous
    3. Sometimes it's dangerous
    4. It is always dangerous



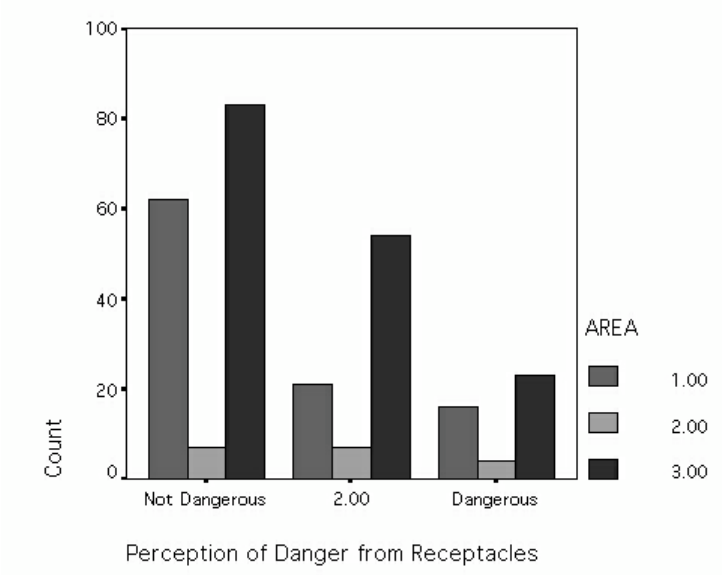
32. How often do you wash the receptacles or the cistern used to store the water?



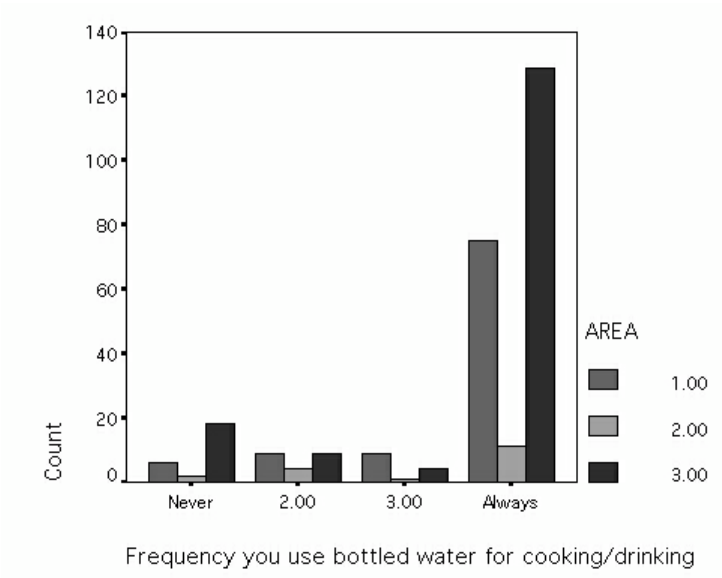

33. Do you know what was the previous use of your receptacles?
    1. Yes
    2. No



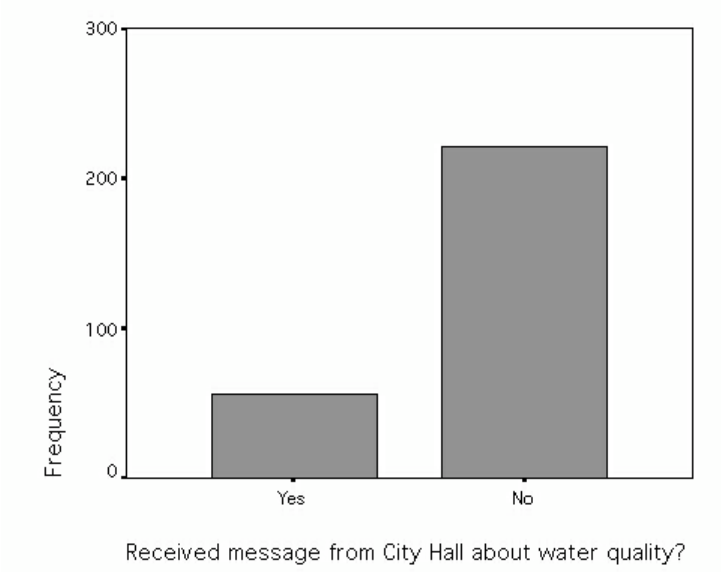
34. Who do you consider the effects on the health of your family to be from those water receptacles?
    1. They are not dangerous
    2. They are a little dangerous
    3. They are dangerous



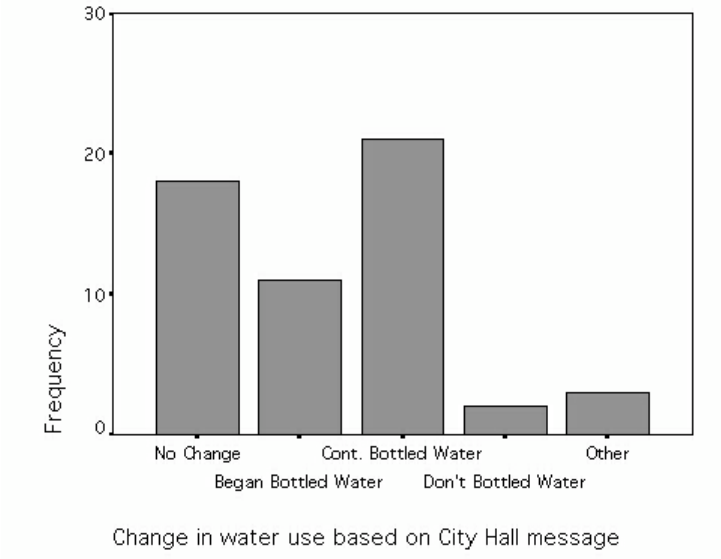

35. With what frequency do you utilize bottled water for cooking or drinking?
    1. Never
    2. Sometimes
    3. Regularly
    4. Always



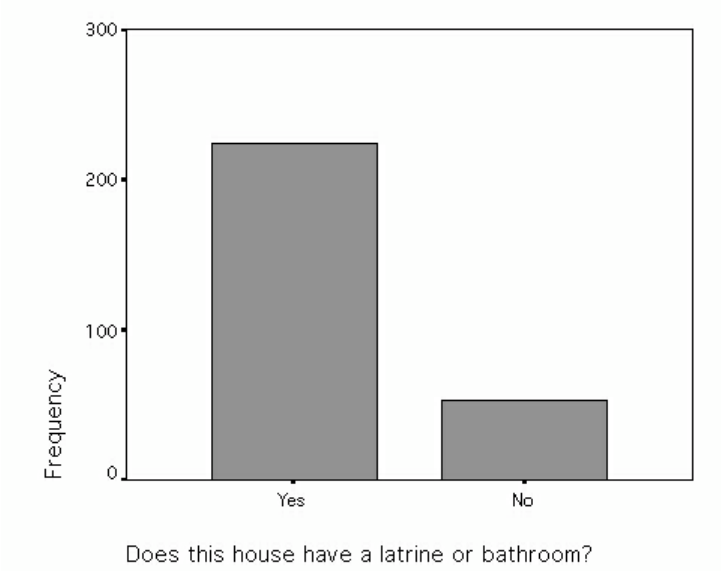
36. Did you know that that City Hall is notifying residents regarding the quality of the water that they consume?
    1. Yes
    2. No

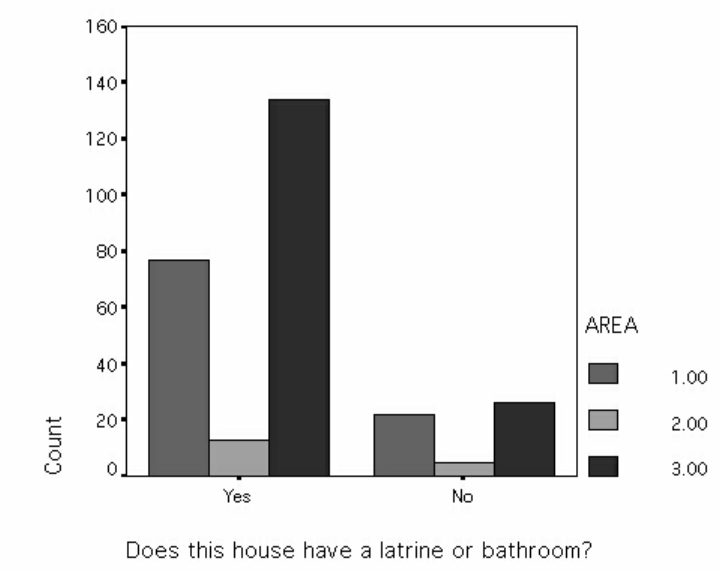



37. Based on that notification, did that spark a change in how water is consumed in your family?
    1. There was no change
    2. Began drinking bottled water
    3. They drank bottled water before and continue to do so
    4. They did not drink bottled water and have not started
    5. Others (specify)



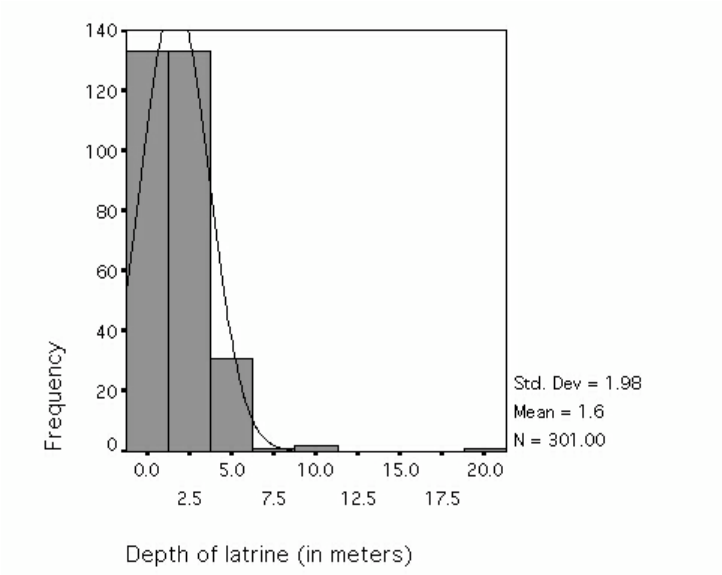
38. Does this house have a latrine or bathroom?
    1. Yes
    2. No



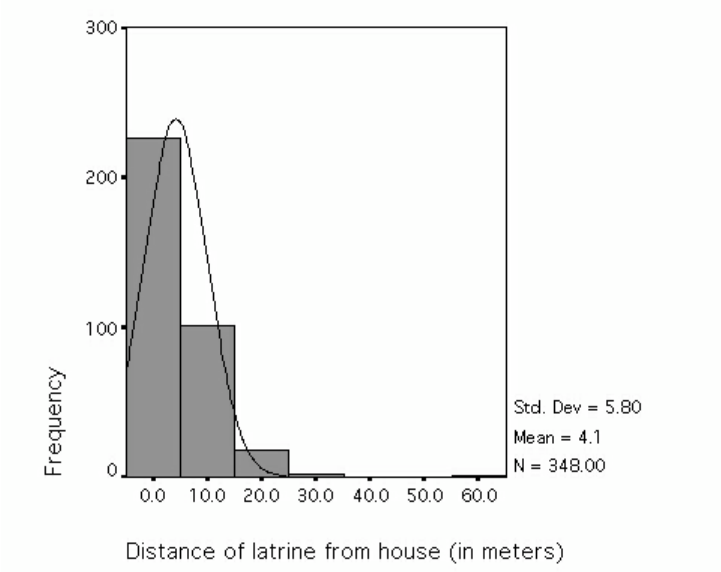



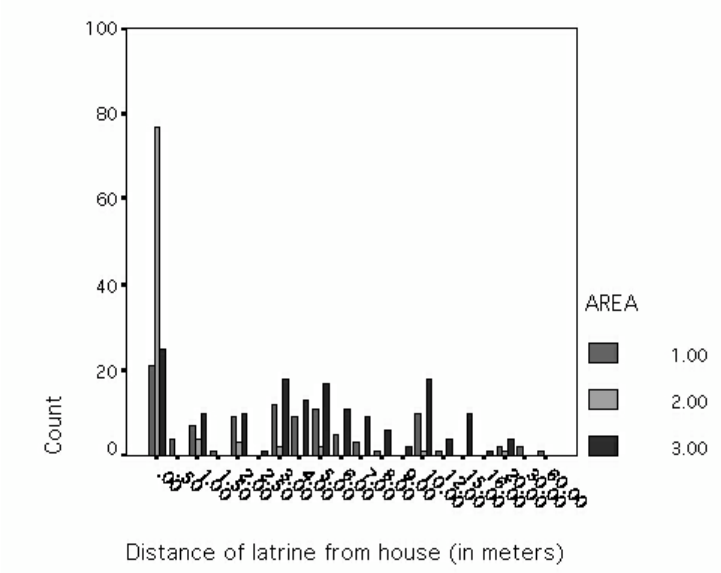
39. What is the primary construction material of the latrine or bathroom?
    1. Brick, block, cement
    2. Wood
    3. Adobe
    4. Tin
    5. Cardboard
    6. Other ( specify)
    7. Combination of 5 & 4
    8. Combination of 2 & 4


40. What is the depth of your latrine?

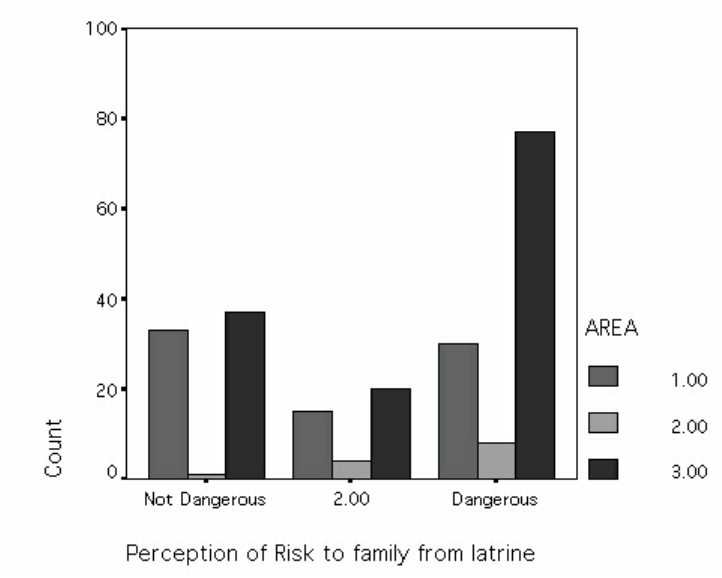


41. How far from the house is the latrine located?

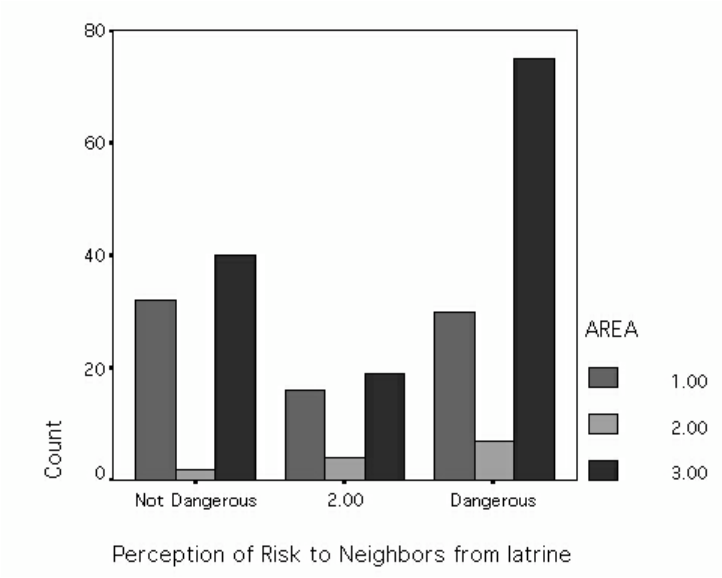


42. Are the characteristics of the latrine or bathroom dangerous to the health of your family?
    1. Not dangerous
    2. A little dangerous
    3. Dangerous

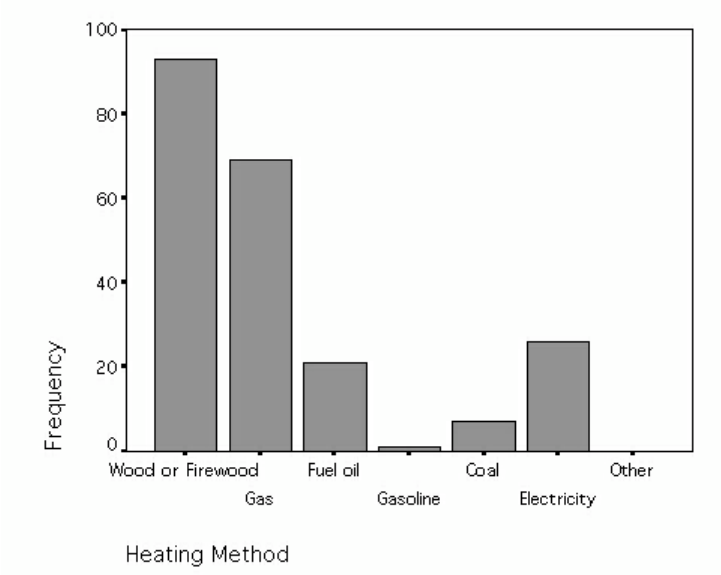



43. Are the characteristics of the latrine or bathroom dangerous to the health of your neighbors?
    1. Not dangerous
    2. A little dangerous
    3. Dangerous



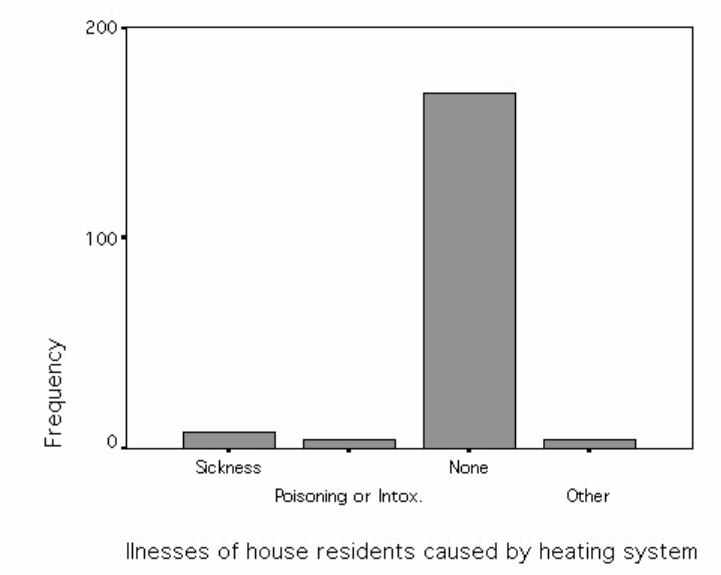
44. Of the following heating systems I will be mentioning, could you tell me which ones are utilized in this house?

a. Wood or firewood b. Gas c. Fuel oil
d…Gasoline e. Coal f. Electricity
g. Others

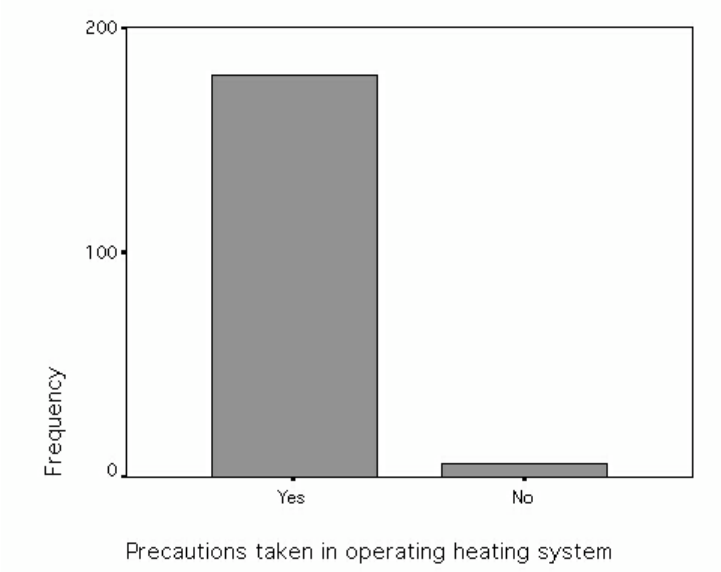



45. Among the people residing in this house, have any of the following cases presented themselves due to problems with the type of heating systems utilized?

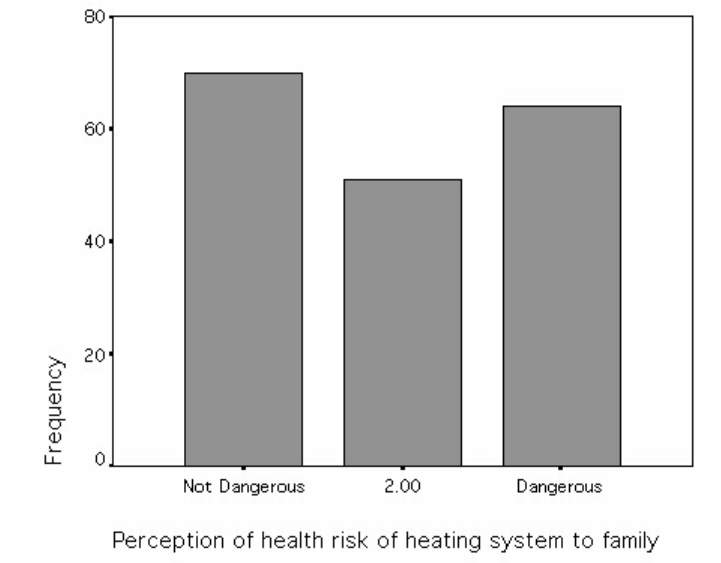
1. Sickness
2. Poisoning or intoxication
3. Death
4. None
5. Other (specify)



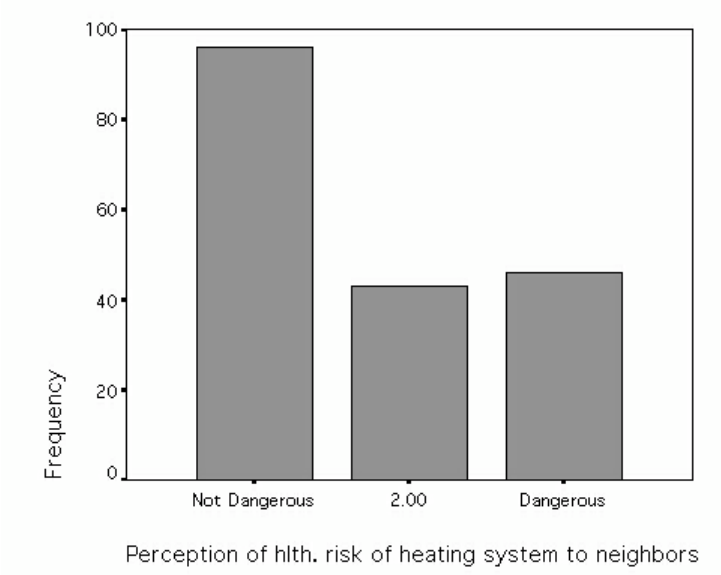
46. Are precautions taken in the operation of the heating system?
    1. Yes
    2. No



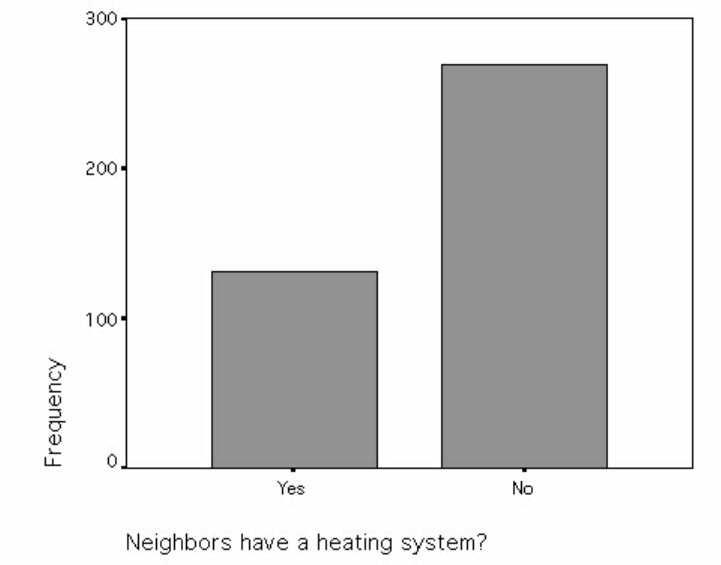

47. How do you consider the impact of the heating system that you use on the health of your family?
    1. Not dangerous
    2. A little dangerous
    3. Dangerous



48. Is the heating system you use dangerous to the health of your neighbors?
    1. Not dangerous
    2. A little dangerous
    3. Dangerous

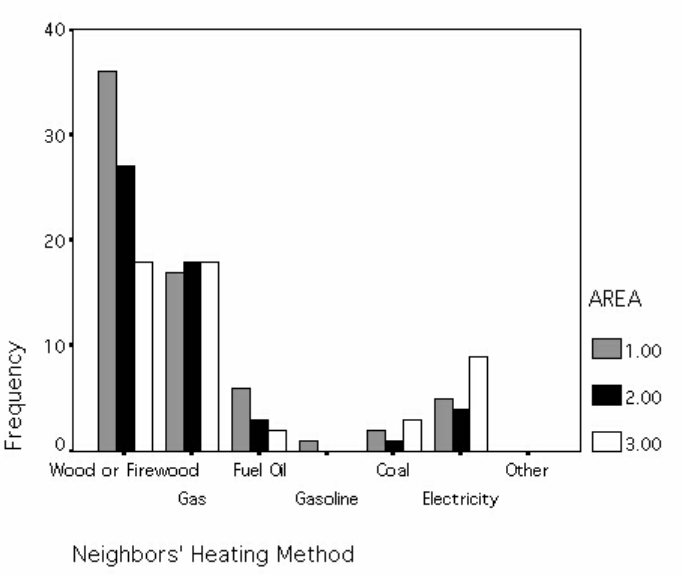



49. Do your neighbors use some heating system?
    1. Yes
    2. No



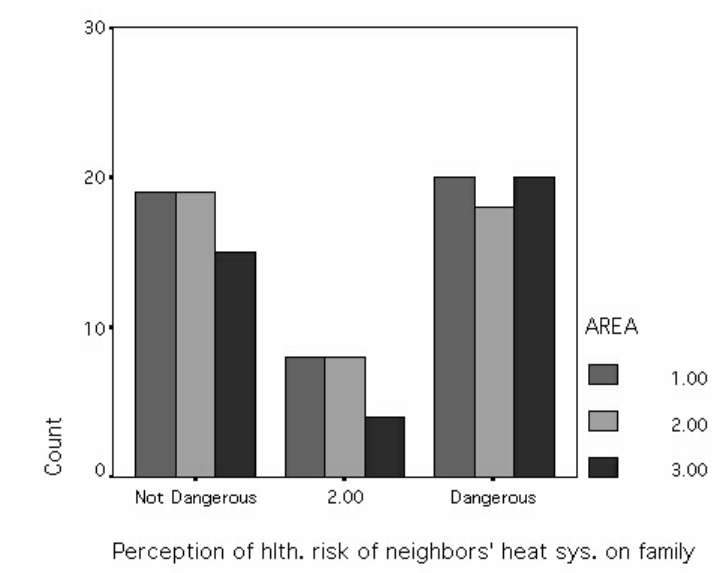
50. Do you know what kind of heating system your neighbors use?

a. Wood or firewood
b. Gas
c. Fuel oil
d. Gasoline
e. Coal
f. Electricity
g. Others

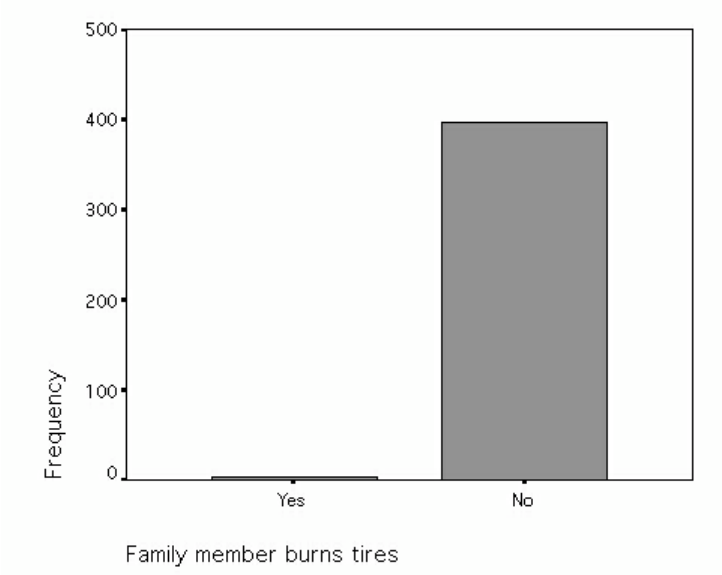


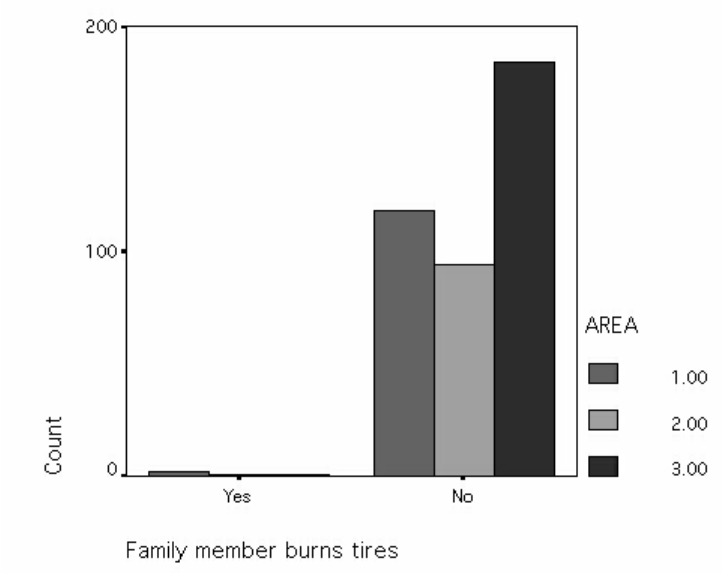

51. Is your neighbor's heating system dangerous to the health of your family?

1. Not dangerous
2. A little dangerous
3. Dangerous

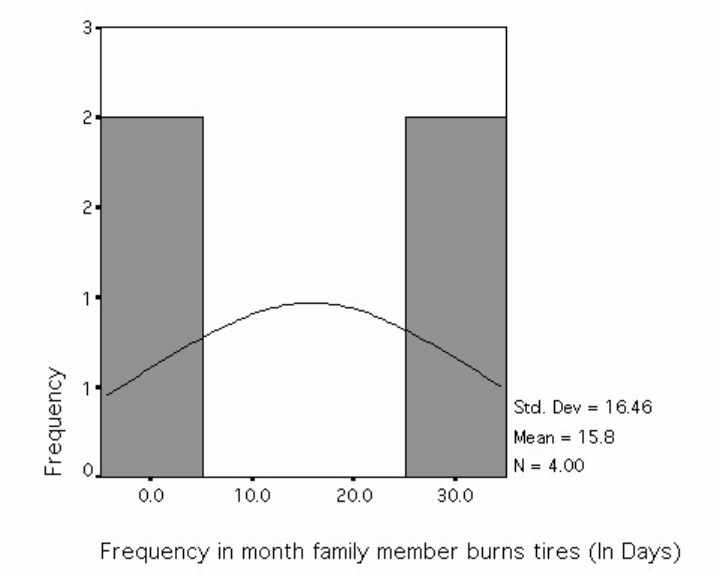


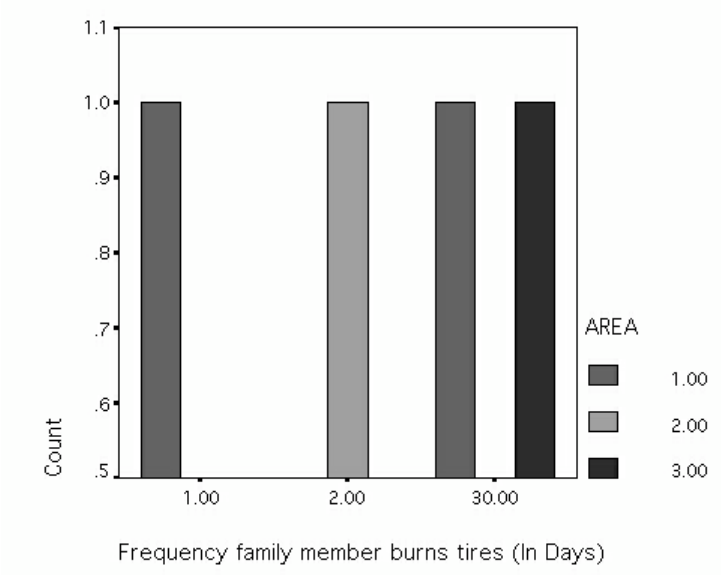
52. Does a member of your family burn tires regularly?
    1. Yes
    2. No



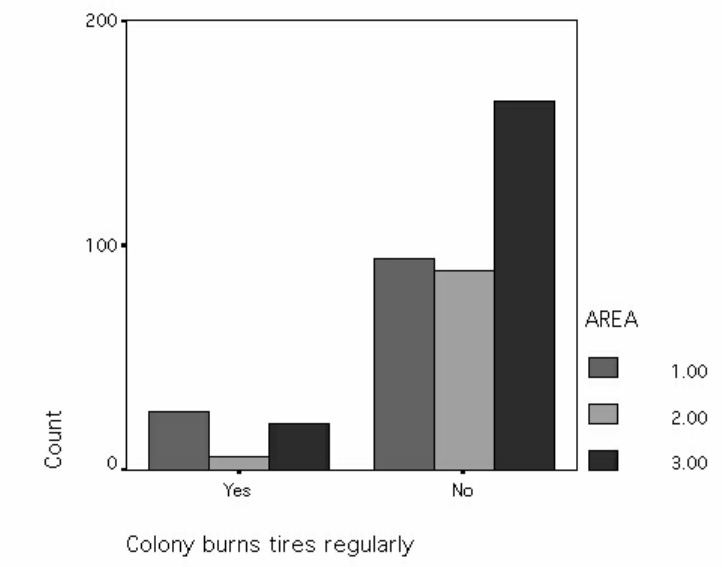



53. With what frequency is it done?

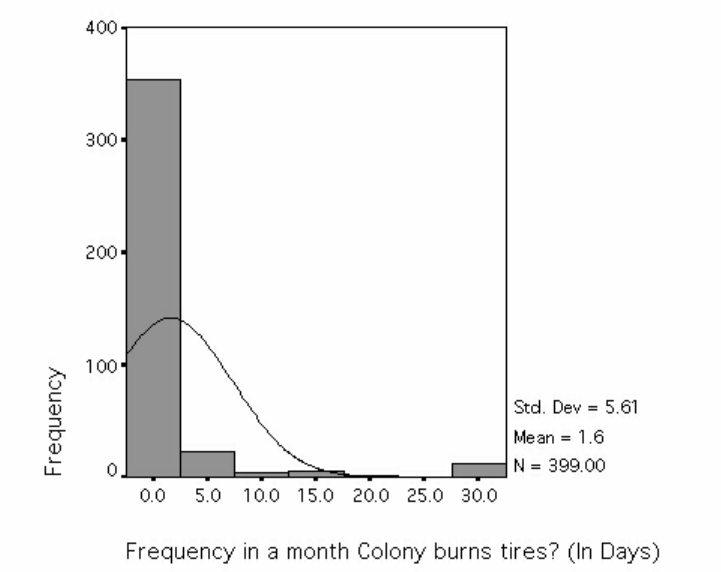


54. Do people in this *colonia* burn tires regularly?
    1. Yes
    2. No

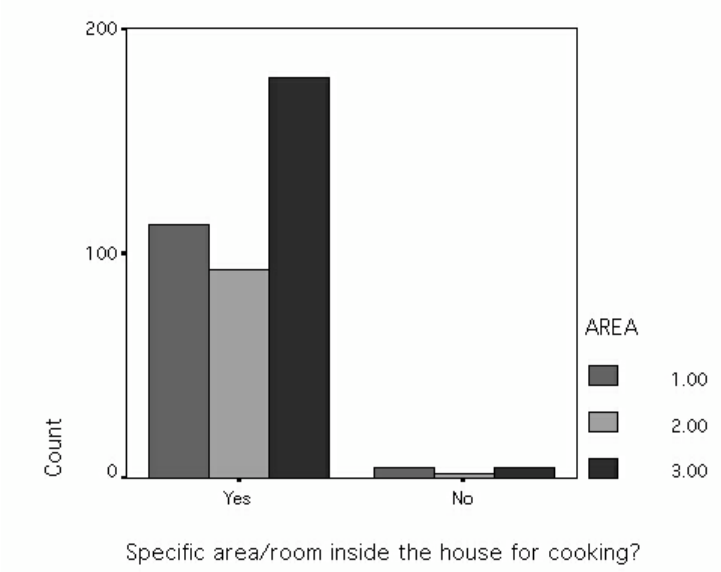



55. With what frequency?

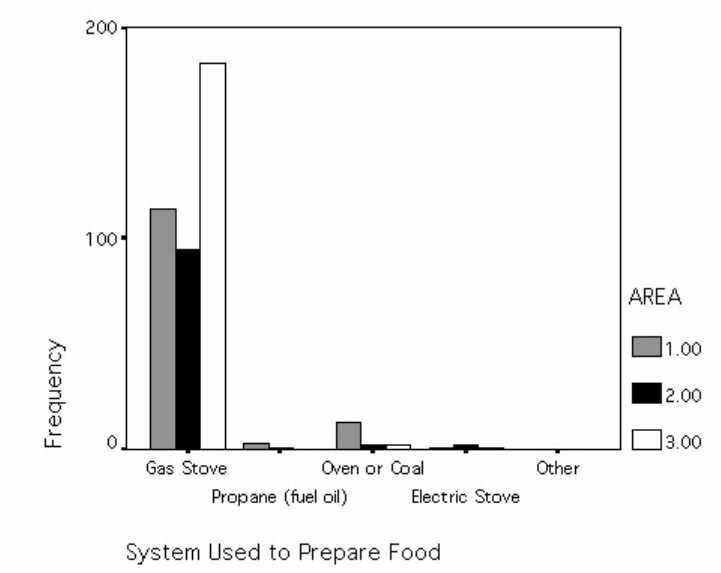



56. In which of the following places are meals normally prepared?
    1. Inside the house
    2. Outside the house
    3. Inside and outside the house

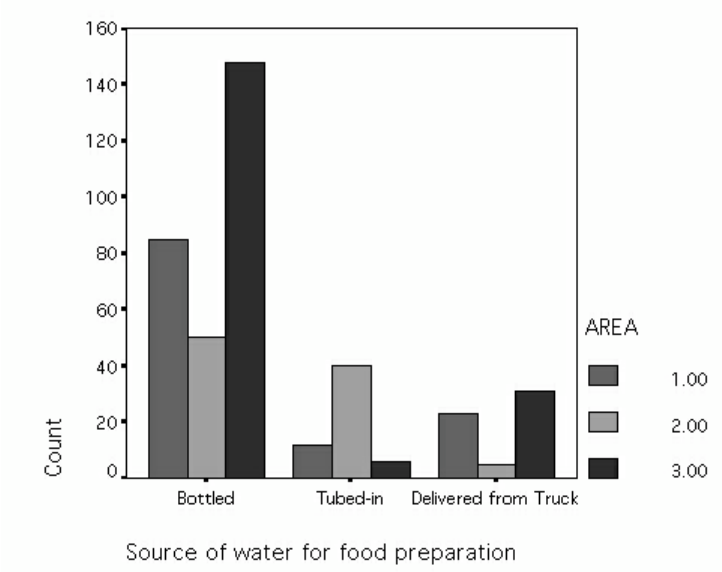
57. Is there a specific area or room inside the house used for cooking?
    1. Yes
    2. No



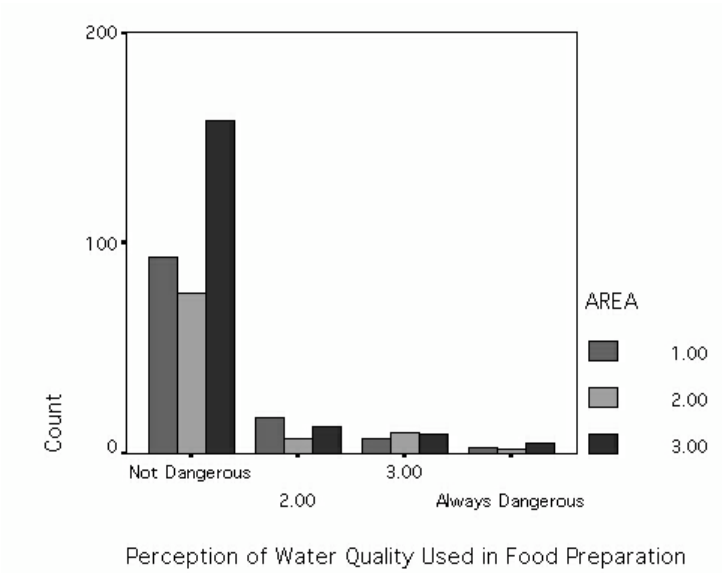

58. To prepare meals, which of the following systems are utilized?
    a) Gas stove
    b) Propane (fuel oil) stove
    c) Oven or coal/firewood device
    d) Electric stove or grill
    e) Other (specify)



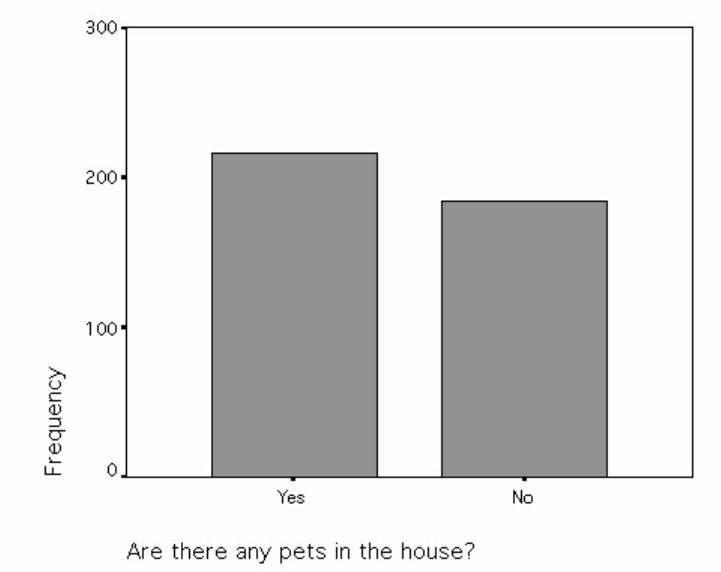
59. From where does the water utilized to prepare meals come?
    1. Bottled water
    2. Tubed-in water
    3. Water delivered from trucks



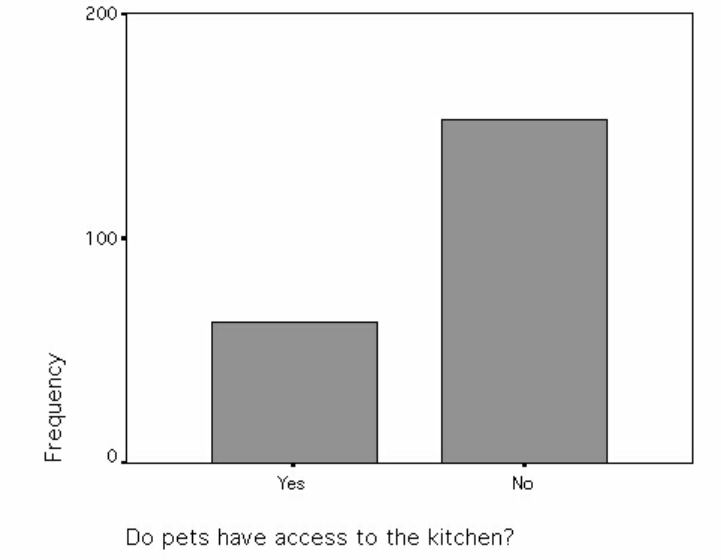

60. How do you consider the quality of the water utilized for cooking?
    1. Not dangerous
    2. A little dangerous
    3. Sometimes dangerous
    4. Always dangerous



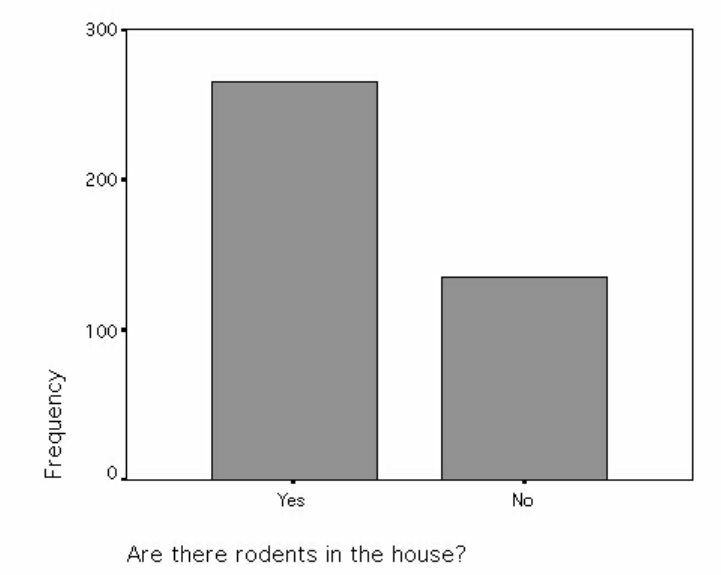
61. Are there any pets in this house?
    1. Yes
    2. No



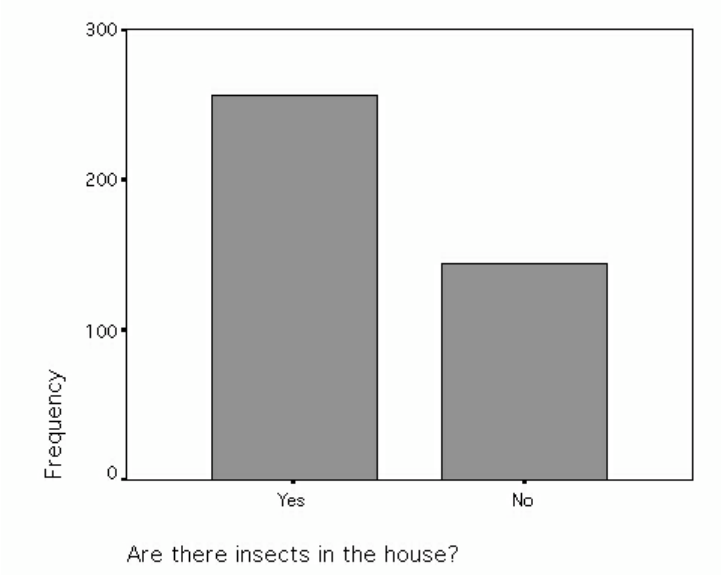

62. Do these animals have access to the kitchen?
    1. Yes
    2. No



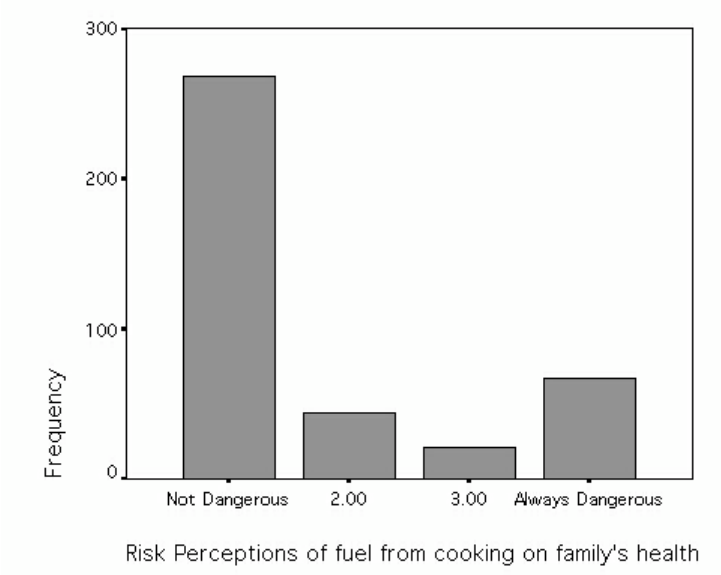
63. Have you detected the presence of rodents in this house?
    1. Yes
    2. No



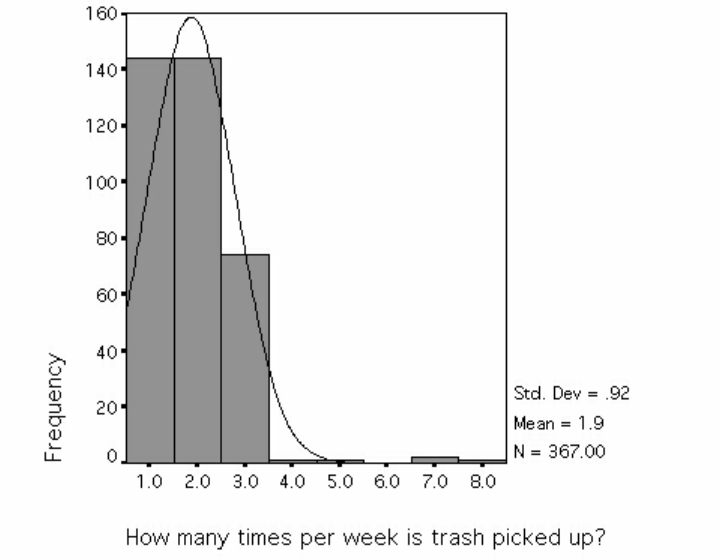

64. Have you detected the presence of insects in this house?
    1. Yes
    2. No



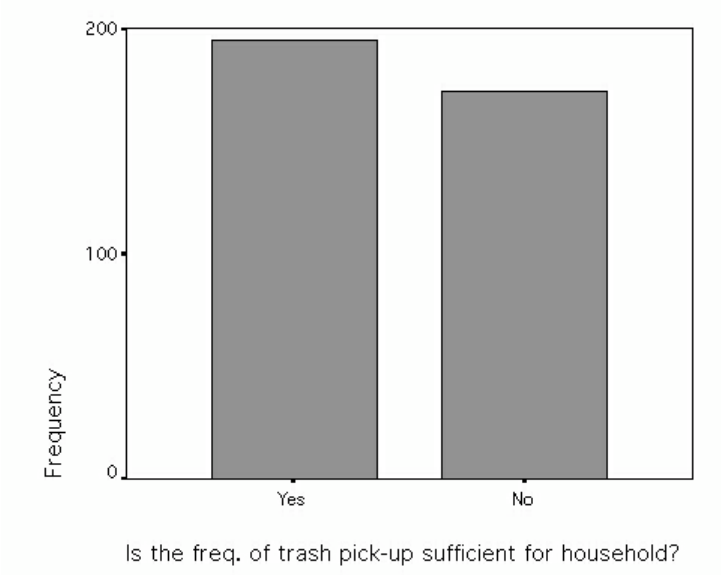
65. Are the vapors or smoke from the fuel utilized for cooking dangerous to the health of your family?
    1. Not dangerous
    2. A little dangerous
    3. Sometimes dangerous
    4. Always dangerous



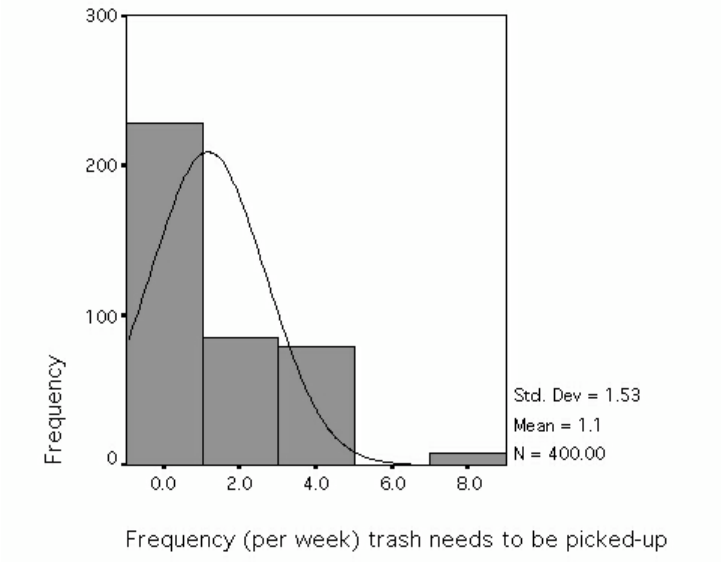

66. Generally, how many times per week is the trash picked up?



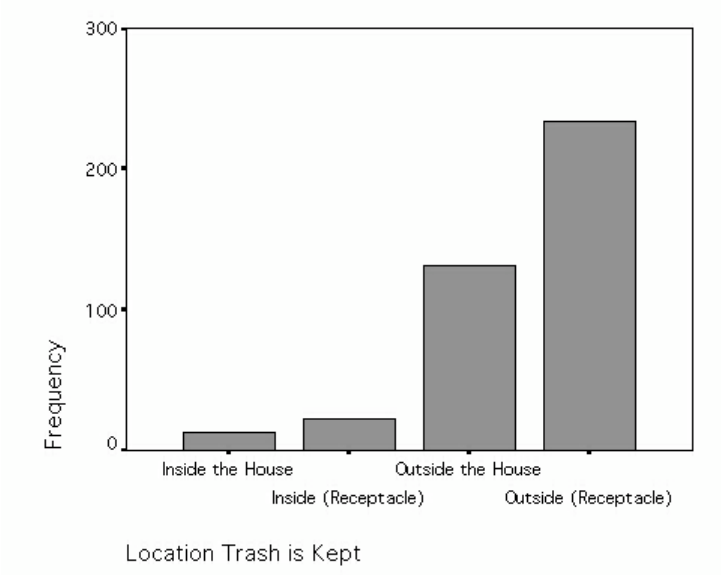
67. Do you consider the frequency with which the trash is picked up sufficient bearing in mind the quantity of trash produced in this household?
    1. Yes
    2. No




68. How many times a week do you should trash be collected?

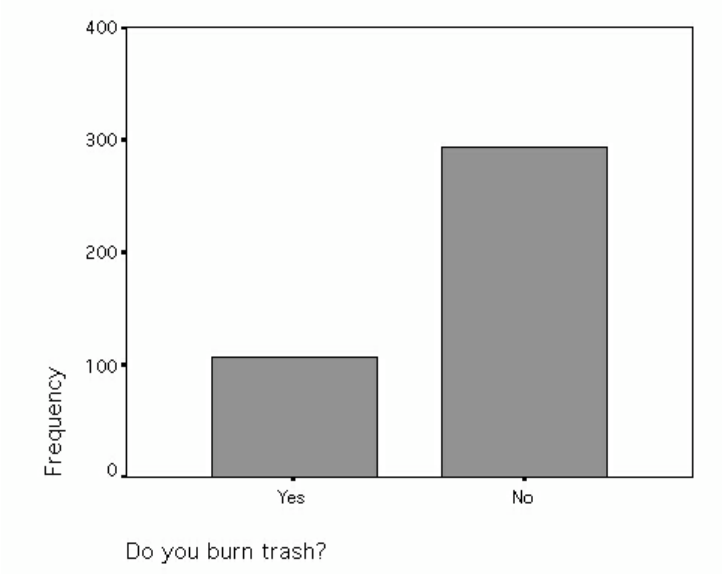


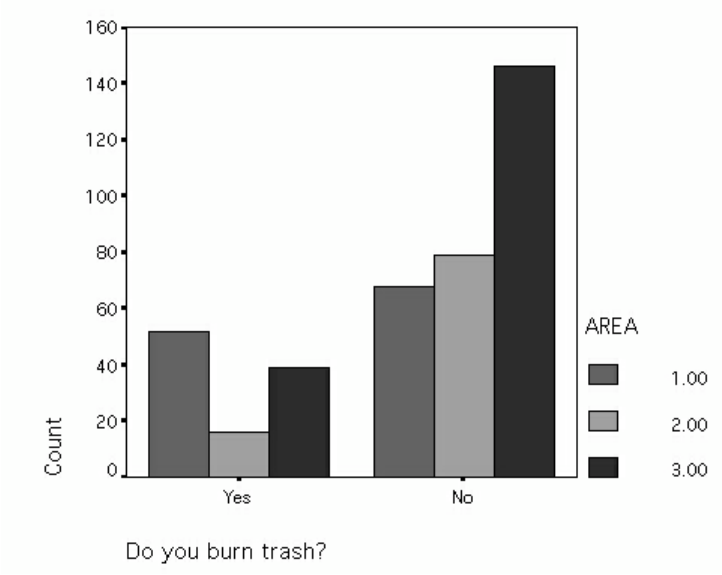
69. Do you keep the trash in a special place?
1. Inside the house
2. Inside the house in a receptacle
3. Outside the house
4. Outside the house in a receptacle



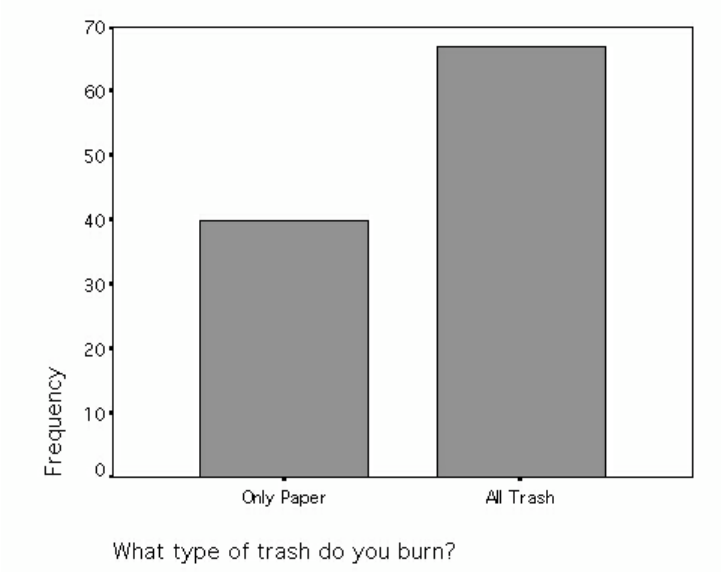

70. Do you throw the trash in any of the following places:
a) In the street
b) Around the colonia
c) Outside in common dumpsite
d) In a trash receptacle
e) Collective trash receptacle
f) Other (Specify)_____

71. Do you sometimes burn the trash?
    1. Yes
    2. No

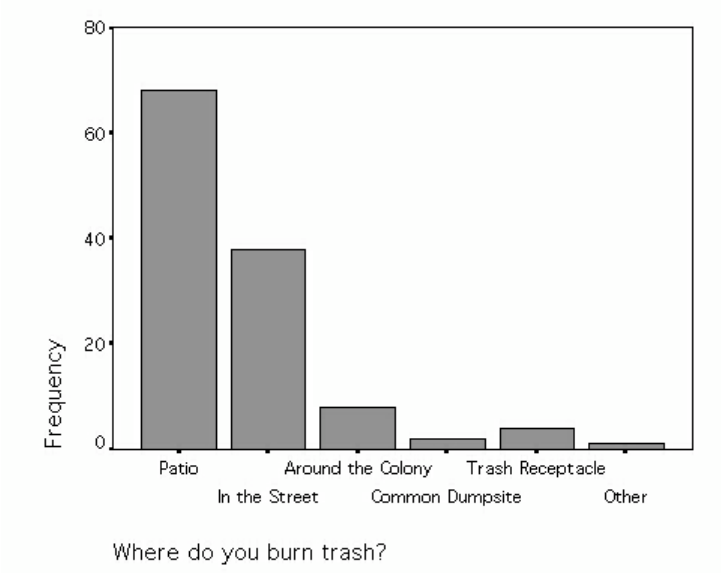


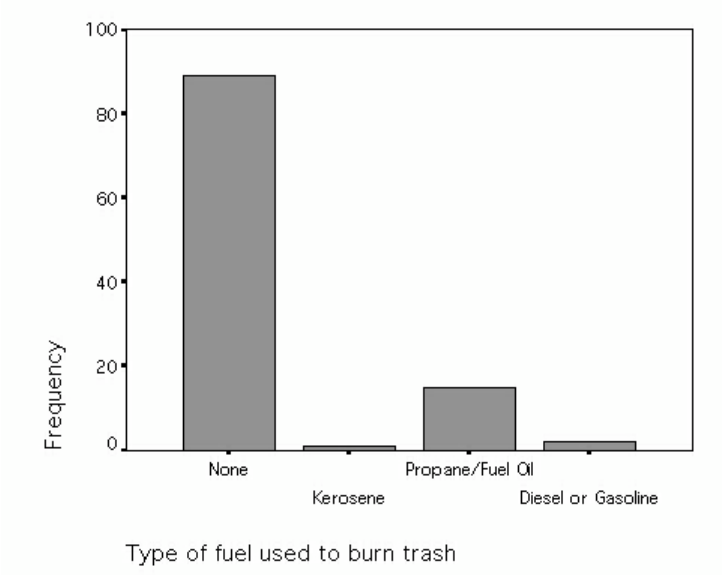
72. What type of trash do you burn?
    1. Only paper
    2. All the generated trash



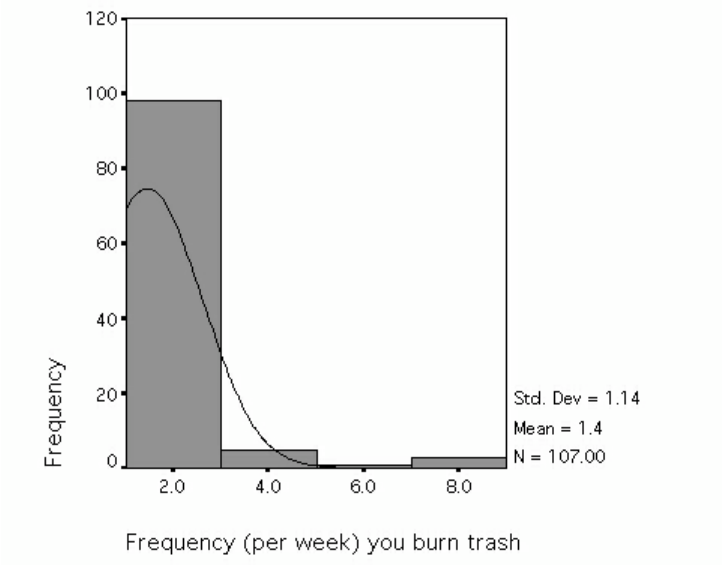

73. Of the places I will mention, where do you burn the trash?
    a) In the patio area of the house
    b) In the street
    c) In the area around the colonia
    d) Common dumpsite.
    e) In some trash receptacle
    f) Other (specify)



74. What type of fuel do you use to burn the trash?
    1. None
    2. Kerosene
    3. Propane/fuel oil
    4. Diesel or gasoline
    5. Other (specify)

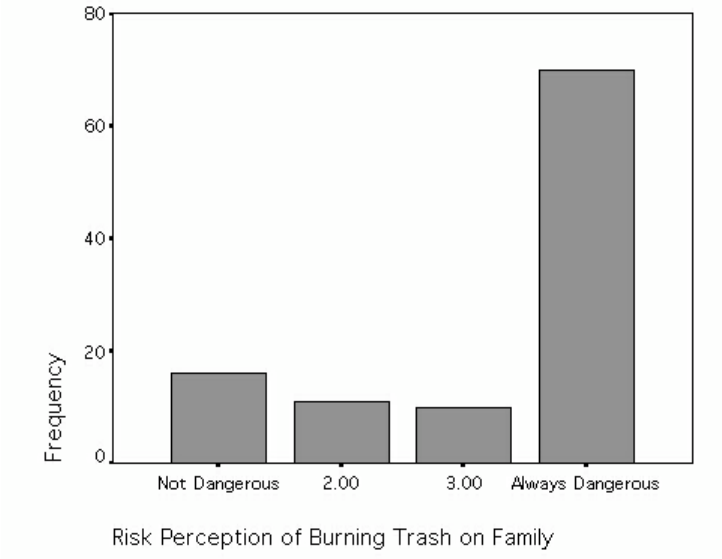



75. How many times a week do you burn the trash?

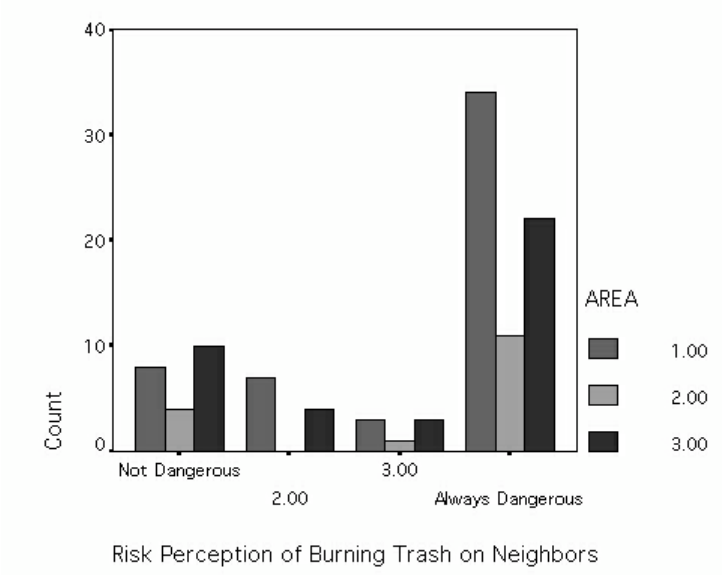


76. Approximately how long does it take you to burn the trash?
    1. Less than 15 minutes
    2. From 15 to 30 minutes
    3. From 30 to 45 minutes
    4. From 45 min to an hour
    5. More than an hour

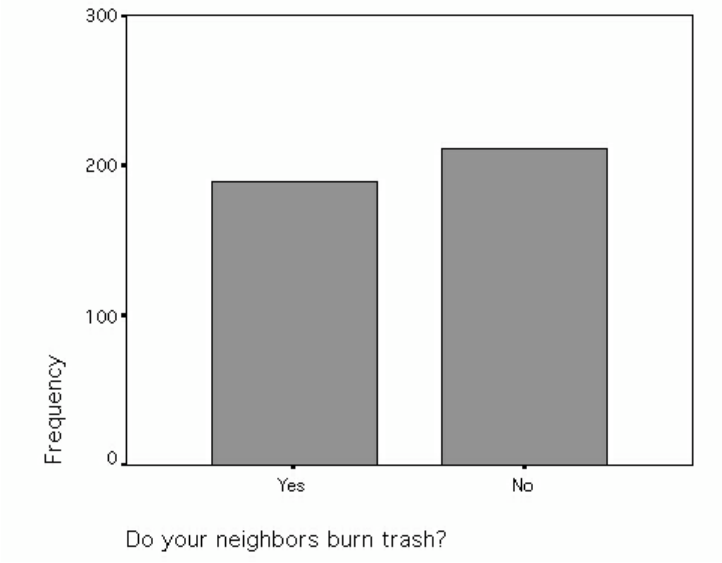

77. Is the smoke from the trash you burn dangerous to the health of your family?
    1. Not dangerous
    2. A little dangerous
    3. Sometimes dangerous
    4. Always dangerous



78. Is the smoke from the trash you burn dangerous to the health of your neighbors?
    1. Not dangerous
    2. A little dangerous
    3. Sometimes dangerous
    4. Always dangerous

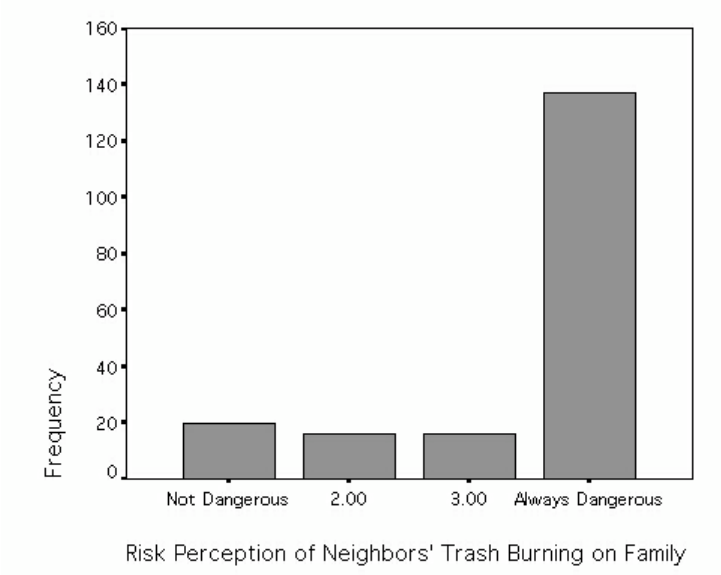



79. Do your neighbors burn trash?
    1. Yes
    2. No



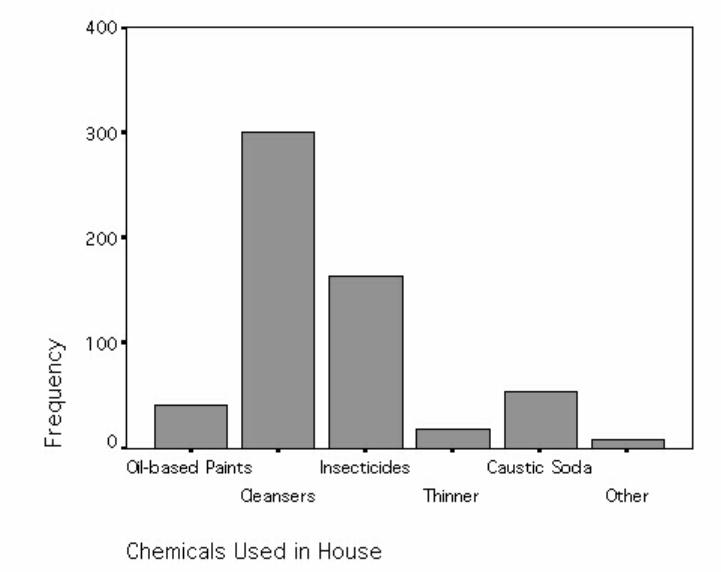
80. Is the smoke from the trash your neighbors burn dangerous to the health of your family?

1. Not dangerous
2. A little dangerous
3. Sometimes dangerous
4. Always dangerous




81. Of the following chemical products I am going to mention, which ones are frequently utilized in this house?

a) Oil-based paints
b) Cleansers
c) Insecticides
d) Thinner
e) Caustic soda



82. Do you use products considered toxic?
    1. Yes
    2. No