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Risk perception and awareness of oil and natural gas safety among local populations in the eastern province of Jubail, Saudi Arabia

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**RISK PERCEPTION AND AWARENESS OF OIL AND NATURAL GAS SAFETY
AMONG LOCAL POPULATIONS IN THE EASTERN PROVINCE
OF JUBAIL, SAUDI ARABIA**

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**Dissertation Submitted to the
Davis College of Agriculture, Natural Resources and Design
at West Virginia University
in Partial Fulfillment of Requirements
for the Degree of
Doctor of Philosophy
in
Resource Management and Sustainable Development**

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Keywords: awareness, risk perception, risk recognition, risk understanding, safety

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ABSTRACT

Risk Perception and Awareness of Oil and Natural Gas Safety Among Local Populations in the Eastern Province of Jubail, Saudi Arabia

The main goal of this research was to examine the residents' and Saudi Aramco employees' awareness of risks to public health and the environment as a result of their close proximity to oil and natural gas production facilities in Jubail Industrial City, Saudi Arabia. The research objective was to characterize social representations of industrial activities by different social actors in order to enhance public participation in the region's risk management plan. Social representation theory was adopted to understand the risk perception of members of the community, both residents and oil plus natural gas employees. Residents were represented by faculty and students at Jubail Technical College (n=42) and employees were selected from Saudi Aramco (SA) Oil Company Environmental Protection Department (EPD) (n=11). An original survey was used to determine factors associated with their risk perceptions with respect to environmental air, water, soil, and community well-being. Quantitative categorical data analysis and ordinal logistic regression were used to find relationships between measures of demographics, health, communication, oil and gas industry-related emergency situations, past experiences and risk perception.

Statistical analyses revealed several significant relationships between characteristics of the survey participants and their opinions about environmental and community impacts of the oil and gas industry. Communication from non-governmental sources was found to be a key source of statistical significance, as residents' opinions about environmental air, water, soil as well as community well-being were found to have a significant ($p < 0.05$) or near-significant ($0.05 < p < 0.10$) relationships with their level of information. In addition, employment with SA was another factor; the probability of negative awareness was lower for those employed by the oil and gas industry (among both current and past employees) than people who have never been employed with the oil and gas industry ($p < 0.05$).

While many questions in the survey were asked to all of the respondents, several questions were asked only to Saudi Aramco employees to gauge the effects of their working environment on their opinions about the industry's impact. Among the factors investigated, only the training and environmental safety practices delivered from Saudi Aramco to field workers and the production knowledge of Saudi Aramco workers were found to be near-significant in relation to workers' opinions about the impact of the industry. This may indicate that workers' on-the-job experiences and insider knowledge of the industry do little to affect their opinions on the environmental and social impacts of the industry. However, only very small proportion of oil and gas employee representatives (n=11) answered the survey so caution was used to interpret these results.

Due to an overall lower than desired survey response rate of 55%, it was decided to combine the two groups (residents and SA representatives) in order to meet the requirements for the sample size in logistic regression and provide more statistically meaningful conclusions. When looking at both respondent groups combined (n=53), it was found that the number of

modes of communication from non-governmental sources was the driving factor behind their opinion on the nature of the industry's impact ($p < 0.05$ for air, water and community well-being). The level of information from a governmental source only had a nearly significant impact ($p=0.09$) on opinion about impact of the industry on community well-being.

Another factor significantly related to opinion of the industry's impact on air and community well-being was cancer ($p < 0.05$ for both). As expected, people who experienced any type of cancer had a higher prevalence of negative opinions about industrial impact on the environment. In addition, the speed of the emergency response in cases of fires, explosions, spills or transportation accidents was related to the responders' (residents and employees combined) opinion about environmental soil ($p < 0.05$). In general, people whose characterization of the emergency response by Saudi Aramco was described as slow were more likely to have negative opinions of the industry's impact on the environment than those who thought the emergency response was fast.

To conclude, four main characteristics of Jubail City's residents and Saudi Aramco employees' related to their awareness about the industry's impact on environmental and community elements were 1) the employment with oil and gas company as a demographic information; 2) health issues, especially cancer; 3) communication of residents with non-governmental sources and Saudi Aramco and 4) the speed of emergency response of Saudi Aramco.

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Key terms: awareness, risk perception, risk recognition, risk understanding, safety

Awareness: refers to a consciousness of internal or external events or experiences (“Awareness,” 2015)

Risk Perception: Risk as it is assessed through individual judgment as correlated with specific dangers. Past experiences, age, gender, and culture all have an impact on an individual's risk perception (“Risk Perception,” 2015)

Risk Recognition: A sense of familiarity when encountering people, events (including risk) or objects that have previously been encountered (“Recognition,” 2015)

Risk Understanding: The procedure of attaining knowledge about the meaning or significance of a particular risk (“Understanding,” 2015)

Safety: One of the basic psychological needs, safety includes the sense of personal security, financial security, health and well-being, and safety against illness and accidents (“Safety,” 2015).

CHAPTER 1

INTRODUCTION

With each passing year, it is increasingly clear that there is a need to find better ways to use energy as a catalyst for industry, a means to effectively sustain man's existence, and to find new sources of power so oil and natural gas can be put to better use. According to the United Nations' population division of the Department of Economic and Social Affairs, "the world's population is likely to grow from 7.2 billion now to 9.6 billion in 2050 and to 10.9 billion in 2100" (Gerland et al., 2014). This expected rise in population will cause a corresponding increase in the already high demand for energy—oil, natural gas and alternative forms of energy—that already exists. The process of harvesting oil and gas resources, or hydraulic fracturing, plays a major role in the rapid development of many local economies. However, there exists controversy about resource extraction activities because of perceived impacts on the environment and public health (Harrison 2007; Chindo 2015), as well as the reverse economic growth scenario also called the "resource curse."

The term resource curse refers to a situation in which a country or region is endowed with valuable natural resources (especially oil, natural gas, extractable minerals or timber) experiences less economic growth than those countries or regions that are not equally resource rich (Schiffman, 2011). For example Venezuela, a country with a population of 30 million, received 64% of its export revenue from oil in 1998; in 2009, those revenues amounted to 92%. Official statistics now show that the country's poverty rate is rising rapidly, with the number of Venezuelans classified as poor rising in the last year by 1.8 million (Nagel, 2014). The main question is: why are areas where mineral wealth is concentrated experiencing lower economic

growth than non-resource rich areas, and are even being harmed by the extraction of these minerals?

To address the public health and environmental concerns that exist in oil-rich regions, it is important to study and understand the level of awareness and risk perception of oil and gas activities that take place, especially pertaining to the local residents who depend on the land for their livelihood.

The Kingdom of Saudi Arabia (Figure 1) has two major industrial cities: Jubail on the Gulf Coast and Yanbu on the Red Sea, which together boast more than 170,000 inhabitants and 200 plants, including petrochemical and refining complexes (Energy Intelligence Group, 2005). The Jubail region is home to most of Saudi Arabia's oil production, and Jubail Industrial City is a global hub for chemical industries. The top petrochemical company in the region is Saudi Aramco, a state-owned oil company and a fully-integrated global petroleum and chemicals enterprise. Throughout the company's 80-year history, Saudi Aramco has become the largest oil company in the world, with a total oil production in 2014 of 3.4 billion barrels, about one in every eight barrels of the world's crude oil production (Saudi Aramco Website, 2014). Since 1938, Saudi Aramco has been the leading petrochemical company in the harvesting of oil and natural gas deposits in Saudi Arabia's Eastern Province.

Over the course of the last 30 years, the Saudi government has employed massive amounts of oil resources to enhance the country's urban and industrial development. A set of planning objectives was put forth by the Saudi government to provide a means to control and manage the industrial development and the physical growth of the surrounding communities. These planning objectives are implemented by the Royal Commission for Jubail and Yanbu (RCJY), two independent planning commissions, which were established as autonomous

organizations in 1975. The Jubail region has remained economically viable, attracting international investments to support the economic and industrial growth and development of the region.

Figure 1- Map of Saudi Arabia, with Jubail Industrial City circled in red. Source: Wikimedia, 2016.

A consultant for corporate planning at Saudi Aramco, Afzhal Chowdhry, said in a presentation that "We expect to attract over \$25 billion in investments to the industrial hub with two objectives: firstly to attract business opportunities, and secondly to promote economic growth" (Al-But'he, and Saleh, 2002). The Jubail province has since expanded its exploitation of large oil and natural gas reserves to include bauxite, and the world's largest known deposits of ammonium-rich material. In addition to its mineral wealth, the province is rich in fertile soil and well-known for producing dates for local consumption and export.

Saudi Aramco is by far the biggest energy company in the world, generating more than \$1 billion a day in revenues with over 12 million barrels per day in production (2010), followed by Russia's Gazprom with 9.7 million barrels per day (Helman, 2012). It owns the rights to approximately one-quarter of the world's proven conventional oil reserves and is the world's top producer and exporter of natural gas liquids (Saudi Aramco, 2005a).

With such high levels of oil and gas production, there is heightened concern for major environmental challenges, including air quality deterioration in urban areas, safe drinking water supplies, industrial pollution, waste management, pollution in coastal areas and subsequent stress on marine ecosystems (Tahir and Abdulwahab, 2013). These challenges call for an increase in the environmental policy awareness of the Saudi government, as well as the people living in the region. For instance, with industrial development and urban construction on the rise—coupled with the arid climate and corresponding limited water resources—the Saudi government has fully subscribed to reclaiming drilling wastewater from gas exploration operations (Al-A'ama1 and Nakhla, 1995). Fresh water is utilized in all phases of gas well development: drilling, completion and stimulation. On average, a single well can consume 5-8 million gallons of fresh water per day that may never find its way back to the fresh water cycle (HTI, 2010).

The importance of an adequate supply of clean, fresh water cannot be overemphasized, especially when considering the potential rise of the population as industrial development and urbanization continue in the region. The use of wastewater in agriculture is limited by the presence of certain toxic elements such as lead (Pb), nickel (Ni), cadmium (Cd), cobalt (Co), copper (Cu), molybdenum (Mo), mercury (Hg), etc. Therefore, wastewater needs to be evaluated prior to its use in agriculture (Hussain and Al-Saati, 1999). Another concern is reported cases of over- or under-irrigation of crops due to inadequate information and a lack of education in the farming community about the use of wastewater, which has caused soil degradation. Research in Saudi Arabia (Powell, 2001) shows that rural populations are especially affected by environmental problems, mainly because of their lack of formal schooling and the functional illiteracy of farmers. In addition, Saudi Arabia lacks a sufficient number of skilled employees as a direct result of the country's educational and economic policy during the oil boom years in the 1970s (Delwin, 1994).

Religious schools have been the primary teaching institutions throughout the Islamic world for more than a thousand years, providing many students who might have had no educational opportunity with the skills to read and write. However, there seems to be a gap between the abilities of the students and the skills required to survive in the modern economy. The impetus for educational reform is driven by demographic pressures and economic difficulties, such as the expenditure on education, as the percentage of Gross National Income has grown from 2.59% to 7.19% (1970 to 2010), while the literacy rate stands at 86% (Prokop, 1994). It is important to mention the level of progress within the educational system in Jubail Industrial City. The Institute of the Royal Commission for the Development of Human Research provides training for students based on skills that fulfill the needs of its industries. Enrolling 650 students

annually, the Institute aims to reinforce the syllabi prepared by the Royal Commission, and to provide fully equipped educational facilities for graduate students who can cope with the special nature of the industrial cities (The Saudi Network, 2014).

As the education level rises in this region, so too will the level of awareness of the risks that living in close proximity to oil and gas extraction sites entail. Previous studies have shown that the perceptions of local residents regarding the risks and benefits of mining activities differ significantly from those of company representatives, policy makers and government officials (Hadden, 1991). One of the goals of this study is to assess how, and to what extent (if at all), these perceived risks are actually harmful to the environment and to humans residing in the area, as well as how effective risk communication and management can be employed to alleviate the identified hazards.

Kreienberg and Kopp (2013) established that in order to reduce the risk of bias while conducting research in the medical community, it is pertinent to understand the role of conflicts of interest for all stakeholders involved. In a similar vein, in order to understand the risk perceptions of social actors in a community, there needs to be a more streamlined understanding of the interests of all stakeholders. This will reduce misunderstandings about how oil and gas extraction and production activities affect the environment and human safety. Understanding the risk perception of industrial activities helps realign policy guidelines and implement protective factors that will benefit all stakeholders, including underlining a systematic evidence base, advocating for multiple interests and avoiding undue influence by individual interests.

In the case of Jubail Industrial City, also referred to as Jubail Province, misunderstanding of oil and natural gas safety activities is an outcome of the demarcation of conflict of interest of the major stakeholders. Stakeholders include local residents who wish to live in clean, fresh

environments, oil and gas companies with the primary goal of maximizing profits and oil and gas production, and the Saudi government that serves as a regulator of all parties involved. This ensures that sustainable business activities are upheld and environmental sustainability enhanced.

The above mentioned stakeholders perceive risk differently, and this research seeks to investigate to what extent. Public opinion on the risk involved in oil/gas production safety can fundamentally compel or constrain political, economic and social action to address environmental and public health risk perception in the Jubail Province. Leiserowitz (2005) explained that experts tend to narrowly define risk using two dimensions: probabilities and severity of consequences. However, the general public's risk perception is comprised of a more multidimensional and complex set of assessments beyond scientific and technical descriptions of danger, including personal experience, affect and emotion, imagery, trust, values and worldviews.

Wright, Pearman, and Yardley (2000) investigated potential differences in risk perception of potential hazardous events between experts (loss-prevention managers in the U.K. oil and gas production industry) and non-experts (managers and students). In contrast to many of the earlier studies of expert versus non-expert perceptions of risk, the study concluded that experts did not judge the overall riskiness of the portrayed hazardous events as less risky than the non-experts. Miller and Sinclair (2012) used a qualitative design method to assess the risk perception of the resource community of West Virginia of coal mining activities in the region. They reasoned that although technical risk analyses often attempt to quantify acceptability of a particular risk or decision, risk acceptability can only be understood in relation to the subjective definition of risk held by the affected stakeholders.

CHAPTER 2

LITERATURE REVIEW

Before delving into specific aspects of this study, it is necessary to define key terms and concepts related to risk and establish the theoretical framework based on previous studies pertaining to human perception of risk. The roles of governments, both central and sub-central, in regulating the activities of key stakeholders, will also be studied. Finally, relevant models and cases of socioeconomic effects of oil and gas extraction on people and the environment are identified.

2.1 What is Risk?

Crowe and Horn (1967) define risk as the possibility that a sentient entity will incur loss. Their paper aimed to develop and agree upon a logical, consistent structure of concepts with which to explain the meaning of risk. The incurring of loss is significant to their definition of risk and loss—as used in their definition—means the involuntary reduction in the capacity of an entity to satisfy its wants. Risk is subjective in this context because the definition of one’s wants is based on financial ability and is interpreted differently from one person to the next. Another word that is more pertinent than others in Crowe’s and Horn’s (1967) definition of risk is to “incur”. The authors explain that a risk can be present independent of a person’s awareness of it.

Greene (1962) defines risk as uncertainty of loss. As such, it is a psychological phenomenon that is meaningful only in terms of human reactions and experiences. This definition supports Crowe’s and Horne’s (1967) conceptualization that highlights the dimensions of the concept of an entity by using the word “sentient”. The party or parties involved in

incurring the risk must hold a human element, as in the case of a fetus or a person in a coma, to be considered a risk.

Risk also refers to the possibility that human actions or events lead to outcomes that affect what humans' value, possibility of occurrence (uncertainty), and a formula to combine both elements (Renn et al., 1992; Renn, 1998). Risk research examines the nature and probability of a hazard, how risk is perceived, and safety goals. Since the probabilities of risk rarely can be lowered to zero, the affected parties and the public should have enough information for rational decision-making. For example, decisions concerning where to locate oil and gas development sites should be inherently social in nature since communities and individuals living nearby will have to accept as well as deal with the risk.

Other definitions of risk include Williams Jr. and Heins's (1964), who characterize risk as an "objective doubt concerning the outcome of a given situation." It is the doubt a person would have concerning the future outcome even if he knew all the possible outcomes and their probability, or chance of occurrence. Riegel and Miller (1966) define risk as the possibility of an unfortunate occurrence, referencing the likelihood of potential harm and exposure.

The above definitions of risk have been used within the framework of insurance and legal interpretations. However, more recently risk has been viewed in more abstract terms relating to business and economics. Risk has been defined by the World Health Organization's (WHO) International Program on Chemical Safety (IPCS) as "the probability of an adverse effect in an organism, system or (sub) population caused under specified circumstances by exposure to an agent" (Benford, 2008). Benford's paper states that determining risk is dependent on expert judgment in assessing adverse effects or hazards. "Expert judgment" here refers to the use of science (experimental and observational studies and reports) from an epidemiological point of

view, to ascribe a disease to a causal chemical agent. Although animals are used for experimental research to mimic effects on humans, the closest experts can really get to assessing exact risk values are through probability and mathematical-statistical computations to compare point estimates of exposure.

Attempts to quantify point estimates of risk exposure bring to light the question of how much risk is involved within a given context. To fully analyze the level of risk, one must simultaneously consider safety, the reciprocal of risk. Safety is defined by the IPCS as the “practical certainty that adverse effects will not result from exposure to an agent under defined circumstances” (WHO, 2004). Such deterministic studies focus on exact risk assessments that base their results on ballpark exposure or safety levels above or below a specific percentile. Benford (2008) says that it is easier to conclude that some individuals might be at risk, but more difficult to determine the exact amount of risk. Providing estimates of risks is more realistic when working at the population level and cannot be directly extrapolated to individual risk, which is determined by a number of factors related to individual susceptibility and exposure. This sequence of research requires copious amounts of data, which may not always be readily available. Even when data is available, this method does not address the proper way in which to communicate the understanding of such risk research across cultural differences and educational echelons. How do we effectively communicate risk findings in a way that accurately reflects individual susceptibility and exposure? The following section explains risk perception and how to overcome this barrier in risk analysis.

2.2. Risk Perceptions

Nielsen et al. (2013, p. 369) use Short’s (1984) definition of risk perception as “the likelihood that an individual will experience the effect of danger” in their investigation of the

relative impact of workplace bullying and risk perception on the mental health of employees in safety critical organizations. Their results show that workplace bullying is a stronger predictor of mental health problems than is risk perception. However, public perceptions of risks might not coincide with objective risk levels. Events pertaining to hazards interact with psychological, social, institutional and cultural processes in ways that can heighten or attenuate individual and social perceptions of risk and shape risk behavior (Renn, 1998).

Risk perceptions of people (social groups and the public) expresses an individual's level of understanding of technical and economic risk assessments, as well as psychological, social and cultural responses to risk. Cultural and sociological analyses imply that the definition of desirability or undesirability of outcomes, the generation and estimation of possibilities as well as the formulas to combine both aspects depend on the social context and the cultural affiliation of the respective social group (Shubik, 1991). Therefore, risk perception is highly subjective and based on the social context and a group's assessment of risky events and situations.

The importance of cultural belief in society's perception of risk is highlighted because of claims that the depth of social and cultural traits cannot be overestimated (Ingram 2012, p. 30). For example, in analyzing whether climate change is dangerous or not, Ingram writes "No matter how open-minded, rational and well-considered you think your opinions are, you cannot be immune to social pressures." Hence, people who share similar values perceive risk in similar ways. Social responses to risks are influenced by individual or social interests and values, as well as cultural belief patterns, i.e., clusters of related convictions and perceptions of reality (Renn, 1998; Thompson et al., 1990).

Cultural patterns structure the mindset of individuals and social organizations to adopt certain knowledge structures and value systems, and to reject others. As such, different groups

cope with the universal experience of potential outcomes of actions and events differently. Physical harm is the only consequence that (almost) all social groups and cultures agree is undesirable (Thompson et al., 1990). Therefore, society is concerned with avoiding physical harm; modern societies are strongly concerned about health impacts and ecological damage. However, the selection of physical harm as the basic indicator for risk may be irrelevant for a culture in which violations of religious beliefs are perceived as the main risks in society. In this case, Lave (1987) wrote that there is a basic social choice about the extent to which individuals should be allowed to make their own decisions, to understand the information provided and the consequences of their choices. Social responses to risks are also influenced by social consequences that matter to most people, such as inequities, unfairness and perceived organizational incompetence (Dietz et al., 1996).

Society is not necessarily trying to minimize risk (Schwarz and Thompson, 1990), as people are willing to suffer harm if they feel it is justified by the benefits that come with a given activity or situation. At the same time, these same individuals may reject even the slightest chance of being hurt if they feel the risk is imposed on them by others (Renn, 1998). Aven and Renn (2010, p. 38) further explain that “In democratic societies, people demand procedural fairness and expect risk management institutions to demonstrate that fair procedures have been used.” The psychological perspective on risk includes all undesirable or desirable effects that people associate with a specific cause, whether or not these cause-effect relationships reflect real dangers or gains. That is subjective satisfaction or dissatisfaction with effects that are deemed undesirable or desirable.

Risk research, because of its multidisciplinary nature, is itself a beneficial force for overcoming structural weaknesses in the risk management system (Bacon, 1997; Fortune and

Peters, 1995). Risk assessment of social groups and public perceptions is important for these perceptions to reflect the actual concerns of people and include the undesirable effects that the technical and economic analyses of risk often miss. It is important to point out that technical risks are risks that a proposed machine or system, such as an aircraft or computer, will not operate to its required performance specifications when developed (Klein, 1998, p. 345). In essence, an inherent characteristic of technical risk analyses confines undesired effects of physical harm to humans and the ecosystems, thus excluding social and cultural impacts.

The economic risk concept integrates risk analysis as part of a larger cost-benefit consideration that expresses risk in terms of utilities. This approach excludes social groups and the public, as it constitutes a consistent and coherent logical framework for situations in which decisions are being made by individuals, and in which decision consequences are confined to the decision maker (Renn, 1998).

Assessment of public perceptions of risk reveals public concerns and values, serves to establish public preferences, documents desired lifestyles and helps to design risk communication strategies (Renn, 1998). It contributes valuable information for understanding risk responses and for designing risk policies by widening the understanding of the mental processing of risk information and unique coping mechanisms that people use in dealing with uncertain outcomes. Social group and public risk assessment provides a multi-dimensional approach to risk assessment, which helps to create a more comprehensive set of decision options. In almost all countries in which perception studies have been performed, most people perceive risk as a multi-dimensional phenomenon and integrate their beliefs with respect to the nature of the risk, the cause of the risk, the associated benefits and the circumstances of risk-taking into one consistent belief system (Renn, 1998). The strength of belief that people have about the likelihood of any

undesirable effect occurring depends on properties such as the degree of perceived personal control, the perception of a social rather than an individual risk or the familiarity of the risk situation (Gould et al., 1988).

Assessment of social groups and public perceptions of risk can help risk management with several tasks: designing procedures or policies to incorporate cultural values into the decision making process; designing programs for participation and joint decision making and designing programs for evaluating risk management performance and organizational structures for identifying, monitoring and controlling risks.

2.3. Attitudes toward Risk

Mearns and Flin (1995) studied offshore workers on United Kingdom (U.K.) and Norwegian oil and gas installations and discussed how the working environment and socio-organizational factors can affect risk perception and attitudes toward safety, and ultimately risk-taking behavior and accident involvement. They assert that attitudes to safety in the workplace will be constrained by the values, norms, rules and regulations that the system has in place. They also mention that perceived risk partly explains the safety culture of an organization, although it may not necessarily be the prime influence in determining the level of safety in the workplace.

Weber and Milliman (1997) also support the above claim that subjective perceptions of risk form the basis for risk acceptance, regardless of objective or quantified risk, and are important for understanding feelings of safety, risk-taking behavior and accident involvement within the workforce. They assess attitudes toward risk on the basis of personality traits, as defined on a continuum, from risk avoidance to risk seeking. They also found support for their view that risk preference may be a stable personality trait, and that the effect of situational variables on choices like perception, estimation and introspection may be the result of changes in

risk perception. Attitudes to risk in a working environment are also likely to be influenced by social and cultural factors, such as the commitment of management and co-workers to safety and job satisfaction.

Risk attitudes at the societal level involve making decisions in an uncertain environment. This is true in oil and natural gas production locations, where people's attitude toward risk are influenced by risk management agencies and officials affiliated with oil and gas development companies or the government. The most critical roles of risk management agencies are to make the decision process transparent. This obligation/expectation is reflected in the definition of risk management as the process of reducing risks to a level deemed tolerable by society and to assure control, monitoring and public communication (Renn, 1998). Information on technical and economic risk assessments should be disseminated to the public, since such risk assessments influence individual responses to risk only to the degree that they are integrated in individual perceptions.

It is not unusual for government agencies or independent research companies to carry out economic risk assessments to examine the level of risk that could be tolerated by a society relative to the benefits gained from such activities. Physical and non-physical aspects of risk are investigated to balance out overall gains and losses resulting from an event or an activity, which are projected or documented. The ultimate goal is to allocate resources in a way that maximizes utility for society (Shrader-Frechette, 1991).

Such assessments influence the social perception of risk for people who are risk averse, if the potential losses are high, and risk prone, if the potential gains are high (Renn, 1998). Economic risk assessments also take the cost-effectiveness of control measures for the company into account. Technical risk analysis is focused on potential physical harm to human beings,

cultural artifacts or ecosystems (health effects or ecological damage), such as the possibility of environmental and human risks from carcinogens, benzene or radioactive particles that are byproducts of oil and gas development. They also examine the possibility of the failure of complex technological systems (technical malfunctions or human errors in handling machines, e.g., oil and gas development machines).

2.4. Socio-Economic Issues and Risks

It is imperative to analyze the social and economic issues surrounding the risk perceptions of oil and gas production by the local population in the Eastern Province of Jubail in Saudi Arabia. History shows that the discovery of oil and gas in different regions of the world has led to a multidimensional array of effects on the region's Gross Domestic Product (GDP), life expectancy, literacy, levels of employment etc. For example, Da Coasta (2009) reported on the tragic effects of "black gold" (crude oil). Local villagers had incessant complaints, stating that the discovery of oil and gas in the Niger Delta region of Nigeria brought about drastic negative socio-economic and political effects on the region's local community. Orogun remarked "Nigeria, Africa's largest oil producer, has pumped more than \$400 billion worth of crude oil from the southern delta states, since the 1970's. But high unemployment in the delta, environmental degradation due to oil and gas extraction and a lack of basic resources, such as fresh water and electricity, have angered some of the region's youths and incited them to take up arms (2010, pp. 469).

In essence, despite the positive effects of resource mining on economic activities in Nigeria—increased employment, foreign investment and better infrastructure for local communities—there still exists a very poor living standard reported in this region. Ozughalu and Ogwumike (2013) investigated the extent of vulnerability to food poverty in Nigeria, and their

results show that 61.68% of Nigerians were vulnerable to food poverty. The incidence of vulnerability to food poverty varied significantly across zones, and between the urban and rural sectors. It was highest in the South West zone at 68.32% and lowest in North East zone at 50.19% percent, while it was more in the urban sector at 64.61% than in the rural sector at 59.37%. It is evident that the magnitude of vulnerability to food poverty is very high. This speaks volumes about the socio-economic state of the country as a whole, despite the presence of copious amounts of resource capital.

Catalan-Vazquez, Riojas-Rodriguez and Pelcastre-Villafuerte (2014) conducted a risk analysis using interviews to assess how risks were perceived by three different groups of stakeholders: residents, public officials and mining companies in Mexico. They concluded that “Residents viewed mining activities as synonymous with contamination and, therefore, as having affected all areas of their environment, health, and daily life. These activities were seen as a collective risk. On the other hand, the public officials and the mining company held that there was no evidence of harm and saw mining activities as a generator of regional development” (p. 28). The truth about how much real risk is involved in the mining process is somewhere between the extreme viewpoints of the local residents and the mining company.

In order to effectively arrive at a risk management plan that promotes social participation, it is pertinent to outline the risk factors, the mitigating factors and minimize irrational heuristic effects. Slovic et al. (2004) distinguish between three fundamental ways in which risk is dealt with: risk as feelings (intuitive), risk as analysis (logic) and risk as politics (modern era). However, risk as feelings is still the predominant method by which humans assess risks, and this effect was called heuristic. The feelings that become salient in a judgment or decision-making process depends on characteristics of the individual and the task, as well as the interaction

between them. In fact, humans are hard-wired to have a strongly passionate resolve toward a stance that they have some sort of stake in. Regardless of scientific data or hard facts, individuals still have a high propensity of going with their gut. This fact was kept in mind as the survey to assess effective risk management activities in eastern province Saudi Arabia was carried out, as well as in the analysis of the results.

2.5. Oil and Gas Extraction and the Environment

The use of both conventional and unconventional methods of oil and gas extraction, particularly in agricultural or residential areas, has raised concerns for human and animal health as well as for the safety of the food supply (Bambergera and Oswald, 2014). Today's best practices reflect what the industry and regulators have learned over time. Ideally, companies in the extractive industry monitor their activities so as to minimize impacts on nearby populations and the environment. Sethi et al. (2011) explain that: "More recently, the industry has had to contend with another set of challenges that involved treatment of indigenous people and their traditional land rights, fair treatment of workers, human rights abuses, and bribery and corruption involving local officials and political leaders" (p.1).

Generally, it is good public policy for companies to publicly alert local populations to the impact of their waste disposal activities on the environment. Such communities should be well-informed of known negative externalities and possible consequences on the environment and health, as well as other consequences of activities in the area such as dust production. The population near company waste disposal sites needs to know the exact location of long-term waste disposal sites so that they will not be disturbed or otherwise made unsafe in the future. According to Halfacre, Matheny and Rosenbaum (2000), "Regulating the hazards produced by the siting of factories or waste facilities, or by cleaning up the toxic remains of a defense

operation, is all part of the new social regulation” (p. 649). The following sections shed light on the common adverse effects of oil and gas production on the environment and best practice remediation techniques.

2.6. Most Common Adverse Effects

A common industrial waste product that accumulates at various locations along the oil and gas production process is called “naturally occurring radioactive material” (NORM). The presence of NORM in pipelines, plants and machinery may restrict operability and cause potential radiological health hazards to workers and the environment (Cowie et al., 2012; Underhill, 1996). Workers who work at a plant or use equipment contaminated with NORM may be exposed to external radiation from closed systems during normal operation, and internal radiation if no controls are established during shutdowns and periods of time when systems are opened (NRPB, 1999). Such adverse effects of industrial activity do not only affect the workers on site, but also the local community that is mostly living in rural areas where agriculture and farming are major sources of income.

Bambergera and Oswald (2014) raised significant questions about the safety of shale gas development that need to be explored in much greater detail, preferably in the absence of a politically-charged environment, as in the celebrated case of Erin Brockovich and Edward Masry, who exposed the release of hexavalent chromium from the Hinkley Compressor Station near San Francisco. This is an example where multiple wells that are present in close proximity, networked with pipelines, compressor stations and processing plants in the area, were potential sources of danger. The main cause for alarm is that neither the identities of potential toxicants, nor the routes of exposure (air, water, soil, food etc.) are well-defined. Humans and animals need to be protected from such exposure to multiple toxicants from multiple routes, and concentrations

which vary over time.

Carcinogens such as benzene and radioactive particles, which are byproducts of oil and gas development, are usually perceived by the public as slow killers (Renn, 1998). Institutions that provide information about risks associated with them to the general public must establish a high degree of trustworthiness. Renn notes “If trust is lost, people demand immediate action and assign blame to these institutions even if risks are very small which may be one of the underlying causes for the observed public response” (1998, p. 49). The importance of trust in monitoring and managing such risks demands that risk managers put forth serious effort into building and maintaining trustworthiness and credibility within the community.

Anugwom and Anugwom (2009) suggested that to mitigate the adverse effects of mining activities in the Niger-Delta area of Nigeria, “intervention efforts should target women and their organizations as crucial modes of mediation in both socio-economic spheres and in the elusive peace building efforts in the region” (p. 334). They argue that women’s groups play a critical role in the socio-economic development of the local communities and the region at large. Other vocal subsets of the community can be sought to act as mediators, creating more awareness on how to minimize mining risks and channeling concerns of the local community to government officials.

2.7. Remediation Techniques

Environmental assessment and remediation during oil and gas production may seem like daunting tasks, but the importance to humans and the environment cannot be overemphasized. Getchell, Yalcin and Prokopchak (2011) provide an outline for managing such a project. Their paper discusses selecting qualified consultants, characteristics and safety and health considerations associated with different contamination, managing generated waste streams and reviewing and approving final deliverables. These environmental assessment and remediation

projects will likely generate waste streams that must be managed. Laboratory analysis of waste streams identifies potential hazards in soil, groundwater and decontamination water (e.g. chemicals, color, odor, percent solids, free liquids, flash point and pH).

The final deliverable, which could be in report form, of such remediation analysis summarizes the activities performed at the facility or property, and recommends risk-based closure of identified contamination issues in a way that emphasizes adherence to the company's corporate culture. Such recommendations may or may not be consistent with risk-based closure due to risk tolerances, and other outstanding environmental liabilities at other facilities or properties.

Quantification of risk data simplifies risk information for people who would regard risk probability as small in comparison with other dangers. It helps identify significant hazards, stimulates basic research, and spotlights the need to agree on health goals and priorities. The public needs to be aware of what is at stake and the probabilities for (un)wanted consequences, health and safety issues and how these issues will affect the health of their children and themselves. Lave (1987) noted that people feel strongly about health and safety issues but become deeply uncomfortable when thinking about situations that involve danger to their children or to themselves. This lack of comfort is important for it pushes people to action or to make difficult decisions. In addition, those affected by risk decisions should be involved in the risk decision-making process. Risk managers can initiate a discourse among the major parties involved in the decision-making process, or those affected by the decision.

A dialogue with the public can be organized in the form of surveys, through the actions of elected representatives, advisory committees, citizen panels, formal hearings and others. Participation is a requirement for rational decision making in situations in which risks need to be

evaluated. Risk managers should be aware that risk reduction is at the heart of the process by which decisions on risks are made. It is thus essential to provide semantic and organizational tools for creating a common language base among and between different groups and to find new means of mediation and conflict resolution among different stakeholders (Webler, 1995).

Finally, information dissemination to local populations should be part of a company's baseline survey (pre-test) prior to the start of industrial activity and formative assessment throughout the process. It should be demanded and spelled out in company contracts, and its implementation monitored and assessed by government regulators and non-governmental not-for-profit consumer advocacy and human rights groups. When the population is well-informed, they become an asset to government regulators and companies regarding harmful waste management and monitoring officers. They are better suited to monitor environmental and crop changes in their fields/farmlands and to inform relevant authorities rather than the oil companies themselves. In the long-run, the company ends up saving money because the local population (not on the company's payroll) is working in tandem with oil companies to conduct baseline monitoring/surveying. Such collaboration is in the best interests of all stakeholders involved, as local residents become a much more valuable backup monitor of industrial waste management for the company and the government. Theoretical approaches, such as ecological modernization theory and theories examining the privatization of environmental governance, continue to underscore the importance of non-state actors in environmental improvements (Mackendrick, 2005, p. 38). Consistent feedback from the local community and public officials creates better waste management incentives for the companies in the extraction industry.

Waste management treatment and disposal methods ought to be implemented by oil and gas companies and monitored by public agencies. However, a difficult problem associated with

cleaning a contaminated site is determining when cleanup is complete. As Reis notes, “Complete removal may not be practical or economically feasible in all cases, particularly if the risks associated with the remaining waste are small. Proper sampling and analysis procedures must be used to ensure accurate and reliable estimates of contaminant concentrations and locations” (Reis, 1992, p. 64).

A commendable example of a major oil and gas producing nation that highly values commitment to environmental sustainability is Norway. The country is the third-largest exporter of energy in the world, and the Norwegian government takes climate policy very seriously (International Energy Agency, 2011). Norway also manages its petroleum resources and revenue in a commendable way, providing a model for other countries to follow.

2.8. Norwegian Regulations on Hazardous and Radioactive Waste

In Norway, all hazardous and/or radioactive waste must be declared and handled by companies licensed by the Norwegian Radiation Protection Authority. The companies must report annually to the authorities on the quantities and activities of waste handled and the management options chosen. A purpose-built repository for waste from the Norwegian oil and gas sector, run by a private company, is legally required to maintain a fund for closure and post-closure remediation. There is a state guarantee from the Ministry of Petroleum and Energy in case the company is no longer able to run the repository. The costs for depositing waste are covered by the industry.

There are also different repositories for hazardous waste¹, also classified as radioactive waste, but with activity concentrations below the threshold for final disposal. Environmental monitoring is performed around repositories annually “and the results are reported to the authorities according to the licensing requirements” (Liland et al., 2012, p. 327). The industry already cleans the contaminated water of oil and is looking into the possibility of implementing purification technologies for NORM in the waste stream before it discharges to the sea.

The Norwegian government’s policy and regulatory system makes it easier for the industry to use best practices to handle waste and provides a better inventory and better statistics for authorities. Because Norwegian law prohibits pollution unless it is explicitly permitted, practices that may lead to pollution must obtain a license for discharges. Procedures for the handling of NORM waste in Norway also eliminate the need to create awareness for the population affected by NORM waste. However, individuals can easily obtain information from the government controlled inventory and statistical data. Referencing Saudi Aramco’s (2005a) description of its waste handling practices, Cowie et al. (2012) shed light on a country with hazardous waste treatment that is not up to par with that of Norway. Contrary to Norway’s oil and gas companies, Saudi Aramco does not mention or specify the availability of inventory or statistical data on radioactive waste, pollution repositories or environmental monitoring of those repositories. Records are also not made public on the volume of Saudi Aramco NORM waste in the past, present and that anticipated in the future, or planned areas of NORM waste repository.

¹ Including NORM waste classified as radioactive waste, but with total activity or activity concentrations below the level for final disposal. All repositories are licensed by the Norwegian Radiation Protection Authority (for radioactive waste) or the Climate and Pollution Agency (for hazardous and radioactive waste).

In Norway, according to Liland et al. (2012), this information is available to the public.

In Norway, radioactive waste and radioactive pollution are regulated by the Pollution Control Act of 1981, the purpose of which is to “protect the outdoor environment against pollution and to reduce existing pollution, to reduce the quantity of waste and to promote better waste management” (Pollution Control Act, 1981). The act is the legal framework for dealing with all other pollutants and hazardous wastes.

2.9 Saudi Aramco Policies and Procedures

Although Saudi Aramco first found crude oil in commercial quantities in the Kingdom of Saudi Arabia’s eastern province in 1938, the first all-inclusive Saudi Arabian national environmental legislation was enacted only on September 24, 2001 in the form of the General Environmental Regulation, Council of Ministers Resolution No. 193. This legislation was entered into force on October 31, 2002, and the Implementing Rules were published on September 30, 2003 (Saudi Legal, 2014). This legislature is overseen by the Presidency of Meteorology and Environment (the “PME”), an agency of the Ministry of Defense, which is charged with the general supervision of environmental affairs in Saudi Arabia.

Saudi Aramco had already initiated a NORM surveillance program in 2001 that established NORM management and monitoring procedures to protect workers, the public and the environment in order to comply with the International Commission on Radiological Protection (ICRP) recommendations (ICRP, 2007). The Kingdom still has “no national regulations specific to NORM” (Cowie et al., 2012, p. 320), but the present procedures are detailed in an internal process manual (Saudi Aramco, 2005b). The manual shows the importance of best practices for the general public, which set wide-ranging prohibitions on pollution and contamination of air, land and water, with particular reference to all parties involved in services

industries our or other economic activities.

In the study area, the Royal Commission for the Industrial City of Jubail has issued detailed local environmental regulations applicable to facilities located within the Royal Commission areas, and in compliance with the Jubail Industrial City Royal Commission Environmental Regulations (Saudi Legal, 2014). However, close scrutiny of the procedures raises questions concerning the absence of plans for creating awareness among local populations. There needs to be intentional and concerted efforts, reflected in budgetary allocations, to informing and educating the general public, particularly populations living in close proximity to oil and gas fields.

The identification and decontamination of NORM-contaminated equipment/waste, and the disposal of waste/equipment that could not be successfully decontaminated to required levels, seems to be largely managed by company employees. The procedures only mention the possibility of hiring contractors. One of the four main components of Saudi Aramco NORM monitoring is identifying and remediating areas of contamination, resulting from operations prior to implementation of the NORM management strategy (so-called “legacy NORM contamination”). Such areas are decommissioned and released for general purpose by the company or for agricultural use (Cowie et al., 2012). There is no mention of an intentional plan to inform locals involved in agricultural activity of the prior NORM-contaminated nature of the soil, so that they can also monitor the soil. Cowie et al. (2012) also mention that materials and waste, such as sludge/scale containing NORM at levels below stipulated points, are exempted from decontamination. In this case local populations should be informed and advised to use caution; the company or government should also monitor affected resources such as water and farm land. Cowie et al. (2012) mention that once decontaminated, NORM-contaminated equipment is

sometimes released “for sale to the public” (p. 325).

For permanent disposal of NORM waste, Saudi Aramco uses a process of underground injection known as “slurry fracture injection” (Cowie et al., 2012; Terralog Technologies Inc., 2006). Although there are researchers (e.g. Uddin et al., 2009; Schuh and Secoy, 1994) who support the slurry fracture injection as environmentally safe, others (e.g. Veil and Dusseault, 2003) have identified operational problems that lead to slurry leakage that are detrimental and create a liability to the operator. Veil and Dusseault (2003) noted that several of the largest injection sites (e.g. Grind and Inject Project at Prudhoe Bay, Alaska) had reported leakage.

Veil and Dusseault (2003) claim that slurry injection could be a safe disposal method when done the right way, but it is not the favored management option for drilling wastes in all situations. Although not always the best choice, slurry injection is often used because it is the most cost-effective option. Other consequences (induced responses) of slurry injection include the deformation of the field, micro-seismic activity or even changes in an electrical potential field measured through electrodes.

Another concern about oil and gas harvesting activity in Saudi Arabia’s eastern province is that Saudi Arabia has no national regulations specific to NORM (Cowie et al., 2012). Although there were general radiation protection regulations issued in 1997, there is no stipulated legal framework for workers and the general public to follow if, and when, affected by NORM waste.

2.10. Social Representation Theory

It is important to include public participation in the risk management plan of oil and gas extraction and production activities, promote cooperative agreements between different social actors and thereby affect progress on the country’s risk management plan. To achieve this, gathering information on each social actor’s perception of risk due to industrial activities is a

critical first step in solving social and environmental problems. According to Moscovici's (1973, 1979) social representation theory, there is system of values, ideas and practices with a two-fold function. The first is to institute an order, which enables individuals to familiarize themselves in their material and social world, and the second is to enable communication to take place among the members of the community about various aspects of their common and individual world, and history.

Social representation theory has been employed in risk research to understand risk perception. Catalan-Vazquez et al. (2014) adopted social representation theory to understand risk perception of the local risk management plan, grasping the essence of local distrust in environmental policy making, and effectively capturing disparate risk perceptions by different social actors in the Molango Manganese district of Hidalgo, Mexico. Catalan-Vazquez et al. (2014) point out that social actors find it difficult to reach cooperative agreements due to different evaluations of risks by experts versus members of exposed communities, thereby affecting progress on the risk management plan.

Jodelet (1986) defines social representation as a set of images, meanings, or reference systems involving the way in which social subjects understand events in daily life, the characteristics of their environment, the information circulating in their surroundings and persons around them. This level of analysis aims at understanding risk perceptions through the expression of individuals within a given community. The benefit of applying this theory in risk research is that it helps to resolve difficulties in incorporating different social actors into the initiatives or plans to control risk.

The theory provides a more social-scientific understanding of abstract concepts like risk awareness and perception, highlighting the process of transformation of ideas in a society. This is

because such interpretations of potential dangers are read differently when carried out by experts and by the pertinent social actors of an exposed community. Bauer and Gaskell (2008) elaborate on ways in which social representation theory can be considered a progressive research program, mainly because the theory has developed and extended beyond the range and depth of its conceptual basis.

Washer (2006) analyzed representations related to mad cow disease and methicillin-resistant *Staphylococcus aureus*. Joffe and Bettega (2004) explored social representations of the risk of contracting HIV/AIDS among adolescents in Zambia. They found that social representations reinforce different statuses and social roles, and the social order is thus perpetuated. Joffe and Lee (2004) examined social representations of risks pertaining to food in the context of the avian flu epidemic in Hong Kong, China in 2001. They described two key processes that occur as the new risk events are communicated and taken up by journalists and lay people: anchoring, or the depiction on past similar events to make sense of the unfamiliar event, and the objectification or shaping of the new events, which requires interpretation. An example of anchoring in social representation theory and community perception of environmental risk factors associated with developing oil sands can be seen in western Nigeria, where “communities’ perceptions of environmental impacts were patently negative, particularly in areas where damage to the ecosystem and economic activities is evident even before the start of production (Chindo, 2015). The communities shared the perception that damage to the quality of water sources, loss of biodiversity and destruction of both economically valuable plants and animals are the foreseen immediate impacts. Contamination of air and emission of chemical substances are expected to come with the project's full development. In this example of social representation anchoring, people drew from previous negative experiences and applied it to a new project even before it

began.

Joffe (2003) explored how lay people make meaning of risks, ranging from the dangers posed by genetically modified food to developing acquired immune deficiency syndrome (AIDS), and highlights cognitive issues such as the biases and heuristics used in the apprehension of such risks. Her study reveals how social representation theory displays the response to risk as a “highly social, emotive and symbolic entity” (p. 55). She further posits that social representation is a relatively consensual or shared understanding within a group, which is forged through communicative processes, and also facilitates these processes. Social representation theory is uniquely positioned to address Douglas’ (1994) adoption of “inter-subjective mobilizations of belief,” (p. 60) where shared understanding within a group is forged by way of communicative processes.

CHAPTER 3

RESEARCH OBJECTIVES AND HYPOTHESES

3.1 Research Objectives

This study is motivated by concerns over adverse health effects of oil and gas production and extraction on individuals living in close proximity to oil, gas and natural resource processing plants. Some negative effects of the oil and gas industry may result directly from exposure to industrial sites while others are transmitted indirectly, for example through water pollution. Such ill effects are more likely if the affected populations have an imperfect understanding of the risks they are exposed to, and if oil and gas operators and plant managers lack knowledge of the best practices that minimize, mitigate and/or treat harmful effects. This is because people who do not understand the risks they are exposed to may not take the necessary safety precautions. Most likely, local residents' risk perception differs from those of oil and gas company representatives and government officials.

The array of oil and gas activities in the Industrial City of Jubail in the Eastern Province of Saudi Arabia may be affecting the socio-economic environment. The impetus behind this research is to investigate factors explaining the risk perceptions of residents in terms of raising awareness and communication concerning the impacts of oil and gas production in the region's rural and urban communities. The primary issues considered in this study are the community members' perceptions of the effects of the oil and natural gas industry on air, water systems, farmland and community well-being.

In the present study, a goal was set to examine the social representation of health risks connected to oil-industry activities in the area, considering how the array of factors

(demographics, communication types, health history and experiences) manifest such representation. The way the danger may be perceived by lay people and the oil-company representatives may fit the social representational process of anchoring (Moscovici, 1984; Joffe and Bettega, 2003; Joffe and Lee, 2004). Using past experiences and values, the new view of danger may be evaluated in light of the past experiences. For example, people who have witnessed oil explosions or oil fires in the area are going to view the new health risks through the lenses of their past experiences. Likewise, if they experienced health issues related to the oil industry – affected environmental pollution – they may have increased risk awareness towards oil company activities. Communication among the people and the oil company would be another aspect of the social representation, as Douglas described (1994); the shared understanding within the group is affected by the way of communication.

The research methods include quantitative and qualitative design methods by means of in-depth, focus group interviews and surveys. The views of two groups of stakeholders will be analyzed: the immediate local community and Saudi Aramco representatives. Halfacre, Matheny and Rosenbaum (2000) adopted the focus group approach to assess the different risk perceptions of regulators, environmental activists and non-activists. This method captures various viewpoints and promotes social participation. It is important for Saudi Aramco oil representatives to encourage communication among various social groups to ensure that the overall societal welfare is maximized. Public awareness can encourage safer oil and gas practices, and is a stepping-stone for an improvement in the socio-economic status of any particular region.

The objective of this research is to understand environmental risk perceptions of residents in relation to awareness about oil and natural gas activities in the Industrial City of Jubail in the Eastern Province of Saudi Arabia, and if these perceptions are associated with specific social and demographic aspects of this community (both residents and oil company representatives).

Specifically, this work aims to:

- i. Explain how demographics (employment, age, education and occupation) influence risk perception and awareness;
- ii. Define the relationship between health concerns (including health issues and cancer) of residents, as well as oil and gas company representatives, and their perceptions and concerns about the environmental pollution of air, water, land and effects on community well-being;
- iii. Determine whether risk communication, specifically about the pollution of air, water, soil as well as community well-being both from industry and government raises awareness concerning the dangers of oil and gas production in the region's rural and urban communities;
- iv. Understand if past experience with the environmental hazards related to the activities of the oil and gas industry (injuries, fires, explosions and emergencies) are associated with the perception of residents of Jubail about the impact of the industry on the environmental components and community well-being;
- v. Study if the positive impact of the industry in the form of various benefits to the community relates to the residents' awareness and perception of environmental hazards;
- vi. Determine if variables pertaining to only the Saudi Aramco representatives (such

- as presence of adequate policies about the environmental safety and protection, methods of regulations by the Jubail Industrial City Royal Commission (JICRC), practices based on Saudi Occupational Safety and Health Administration (OSHA), specific risks, responsiveness of the oil company to various emergencies developed from the industries' activities, communication to public, communication with JICRC to field workers, environmental safety and health practices and training) are related to their perception about the pollution of air, water, land and effects on community well-being; and
- vii. Draw relevant policy recommendations from findings.

3.2 Research Hypotheses

Theoretical background for the hypotheses

Three major families of theoretical approaches have been identified to estimate the danger levels of risks: psychological (heuristics and cognitive), anthropological/sociological (cultural theory) and interdisciplinary (social amplification of risk framework) (Beges et al., 2010). Judgments about the severity of risk are known as “risk perception,” and are often used when making judgements about natural hazards.

Data collected in this research will test the validity of the hypothesis that risk perception bears a positive relationship with the awareness level of the residents, with other variables like experiences and knowledge bearing varying influences on the risk perception of the populace. Personal experience plays a key role in affective processing, and affective responses are essentially formed through learning and experience. It is important to note that personal experience is shaped by one's social environment, including the thoughts of others. For example,

van der Linden (2015) found that even a brief exposure to conspiratorial thoughts about a specific issue can influence perception and decision-making.

Based on my own experiences living in Jubail City, there appears to be a growing concern in this community about the increasing prevalence of chronic diseases that may be linked to environmental pollution from the oil company's activities. Fibrosis and cancer are examples of chemically-induced toxicities, according to Klaassen and Watkins (2003), and the most common carcinogens are benzene and polycyclic aromatic hydrocarbons (PAHs), mainly derived from products of oil and gas exploration. In Map Ta Phut, a heavily industrialized chemical industry hub in Thailand, the results of air monitoring for six years showed many types of organic volatile compound in the ambient air, including benzene and chloroform (Suzuki et al., 2014), while the number of cancer patients in the area was significantly higher than the national average (Khuhaprema et al., 2010). Since there may be a cancer risk associated with the exposure (Benford, 2008) of Jubail residents to volatile gases and oil in the water and soil, it is within the scope of this study to explore the occurrence of cancer in the Jubail community and see if the risk awareness is related to cancer occurrence in this area.

Historically, risk communication research has tended to most frequently involve case studies and lists of best practices. Scholars such as Harrison (2007) have focused on organizational risks in the midst of a crisis, including reputation, response, and the success or failure of the organization in moving forward after the crisis, rather than on how communication impacted the public and their behaviors. Communication as a factor has the potential to open up the eyes of a group or society, as seen in the case of the proposed Keystone XL project, promoted to carry several hundreds of thousands of crude oil from the oil fields of Canada through the USA to the refineries in the Midwest US. The communities that would have been

affected got the report, and were able to perceive the potential risk of spillages, oil contamination, fire and other hazards inherent in the project, (Indigenous Peoples Issues and Resources Journal, 2013). “Many Native Americans and Indigenous Canadians are opposed to the Keystone XL project for various reasons, including possible damage to sacred sites, pollution, and water contamination, which could lead to health risks among their communities.” In the present study, the aim is to evaluate if the amount or channels of information communicated between the Saudi Aramco oil representatives and lay people of Jubail have a relationship to the risk perception of the lay people.

Socio-demographic factors are some of the most important factors in risk perception of most oil and gas producing communities. Ojimba (2013) clearly observed that socio-demographic factors were actual determinants of perception of the locals in the Niger Delta region of Nigeria, one of the most richly endowed oil producing regions as indicated by the use of tobit regression analysis. The continuous battle over the oil rights and natural resources control and distribution in Nigeria led to oil pipelines being attacked and vandalized. That inadvertently led to oil spillage, pipeline ruptures, fires and explosions, in addition to issues with transportation and refining facilities, which all negatively affect the farmers and the landowners and are related to their poverty. In this study in Nigeria, besides income and other economic variables, demographic variables such as age and occupation status of the farmer were significant predictors of poverty perceived by the inhabitants of the oil-polluted land. Examining the conceptual relationship between personal experience and risk perception is crucial in improving our understanding of how emotional and cognitive process mechanisms, experiences like employment status, shape public perceptions of environmental pollution (Beges et al, 2010). In the present study, the aim is to evaluate whether demographic factors such as age, education and

employment status are associated with the risk perception of either the community members or the oil company representatives.

Ian Savage (2006) explains that personal exposure to a particular hazard is the most likely leading explanation of the relationship regarding how demographic factors are related to dread of that hazard through personal exposure. One possible explanation for how personal exposure could be connected to demographic variables might include socio-economic factors. For example, in some societies elderly or disabled men may experience increased poverty and thus may live in closer proximity to, or within, hazardous areas (Savage, 2006; Ojimba, 2013). According to Savage (2006), people have more fear or concern when they have a greater perceived exposure to a hazard. These examples and social representation theory, especially anchoring (Moscovici, 1973; Joffe and Bettega, 2003; Joffe and Lee, 2004) are the theoretical basis for the interest in examining the risk perception and risk awareness of residents and Saudi Aramco representatives, based on their previous personal experiences with oil extraction-related pollution of water, land and air pollution in Jubail City.

Statistical Hypotheses

Null Hypotheses

I. There is no relationship between the demographic distribution of respondents (age, education, occupation and employment with oil and gas companies) and the risk perception of local residents and their awareness about the safety of oil and gas exploration activities in their community.

II. There is no relationship between the environmental (spills, fires, explosions), or health issues (individual health problems and cancer) due to the oil and gas industry and the risk perceptions of residents about the safety of oil and gas exploration.

III. There is no relationship between environmental and health risk communication to residents (from the general public, industry and the government) and risk perceptions and awareness of residents about the safety of oil and gas exploration.

IV. The responsiveness of oil and gas companies to emergencies (including transportation) related to oil and gas activity is not related to perceptions and awareness of residents about safety of oil and gas exploration.

V. The benefits of the oil and gas industry to community (employment, economic development, infrastructure and scholarships) are unrelated to the perception and awareness of residents about safety of oil and gas explorations.

VI. The presence of adequate policies about the environmental safety and protection (methods of regulations by the Jubail Industrial City Royal Commission (JICRC), practices based on OSHA¹, specific risks, responsiveness of the oil company to various emergencies developed from the industries' activities, communication to public, communication with JICRC to field workers, environmental safety and health practices and training) are unrelated to the perception of SA representatives about the environmental pollution of air, water, land and effects on community well-being.

¹ The United States OSHA has been utilized as a model for developing the OSHA standards and policies in Saudi Arabia. OSHA in the text refers to OSHA in Saudi Arabia.

Specific Alternative Hypotheses Reflect more Details in Order to Meet the Definite Objectives of the Research

I. Demographics

- a.** The awareness and perception about risk depends upon occupation. Specifically, employed people are expected to have higher level of awareness about safety of oil and gas exploration than unemployed, retired or stay-at-home individuals.
- b.** There is a positive relationship between age and risk perception. It is expected that with increasing age individuals will have a greater awareness and concern about the safety of oil and gas explorations activity in their community.
- c.** There is a positive relationship between education and awareness about oil and gas industry. It is expected that those individuals with higher the levels of education, are more likely to have a higher understanding of the issues.
- d.** The awareness about risk depends on whether or not the individual is employed in the oil or gas industry. Specifically, those employed by the oil and gas industry (current or past employees) are expected to have higher levels of awareness about the safety of oil and gas exploration than people never employed with gas and oil industry.

II. Environmental and Health Risks

- a.** The experience of a fire disaster resulting from the activities of oil and gas industry has a positive relationship with risk perception and safety awareness of the residents. People with

experiences of such fire incidents are expected to have a higher perception of risk relating to the industry compared to individuals without experience of a fire disaster.

b. There is a positive relationship between the awareness of actual physical injuries of residents resulting from oil and oil exploration activities and the risk perception of residents. People who have experienced, or have relations who have experienced, physical injuries resulting from oil and gas exploration activities are expected to be more aware of the risk attached to the activities of the industry.

c. There is a positive direct influence of the experiencing health problems in family or community due to the pollution from oil and gas exploration activities on the risk perception of the residents about the safety of oil and gas exploration. People who know family or community residents with health problems related to pollution are more likely to have increased perceptions about the risks associated with the oil and gas activities.

d. There is a positive relationship between the experiencing any environmental disaster (fire, oil spill, water contamination or smoke in the air) resulting from the activities of the oil and gas industry and the risk perception and safety awareness of the resident. It is expected that the greater experience with any of the environmental disasters will lead to greater risk perception and safety awareness of the resident.

e. There is a dependency between the number of individual health issues possibly resulting from the effects of exploration activities and the level of risk perception and awareness of the residents in relation to the industry.

f. There is positive relationship between the diagnosis of cancer in families or the community attributed to the pollution effects of exploration activities and the risk perception of residents.

The higher prevalence of cancer of all types is expected to be related to an increased awareness and perception of risks.

III. Communication

- a.** There is a dependency between the amount of public information or communication (conversation with other community members, brochures and public meetings with Saudi Aramco's environmental protection department) and perception and awareness about the safety of residents in relation to the industry and environmental pollution. It is expected that more communication leads to better awareness and perception.
- b.** There is a dependency between the amount of information or communication from the government (conversations, brochures and public meetings with the Jubail Industrial City Royal Commission (JICRC)) and perception and awareness about the safety of the residents in relation to the industry and environmental pollution. It is expected that more communication leads to better awareness and perception.

IV. Emergencies

The responsiveness of oil and gas companies to their business-related emergencies (transportation incidents, contact with equipment, fires, explosions or exposure to harmful substances or worker injuries) is negatively related to risk perception and awareness of the residents about emergencies resulting from oil and gas exploration activities. Residents are expected to be more sensitive (higher response value) to risk and safety issues if the emergency response is inadequate or not readily available (lower values).

V. Benefits

The benefits of the oil and gas industry to the community (employment, economic development, infrastructure and scholarships) are expected to be negatively related to risk perception and safety awareness of the residents about oil and gas exploration activities. The benefits derived from the industry may play a part in desensitizing the residents to risk and safety issues about the oil and gas industries.

VI. Specific Alternative Hypotheses Related Only to Saudi Aramco Employees

a. Increased awareness of existing Saudi Aramco policies to combat negative effects of the industry on the environment and community well-being and the employees' perception of impact of the oil company on the environment (air, water, soil and community well-being) are dependent on one another. Specifically, it is expected that employees who are aware of the presence of environmental protection policies will have less negative opinions about the impact of their industry on the community environment.

b. Various methods of implementing environmental protection policies can affect the perception of the impact of the oil company on the environment (air, water, soil and community well-being). Specifically, it is expected that the more of the modes by which the regulations are implemented by Saudi Aramco, the more positive opinion about the impact on the environment will be.

c. The higher the implementation of Saudi OSHA standards in oil refining processes, the higher employees' opinions about the environmental impact of the industry are expected.

d. There is a negative relationship between actual experiences with fires and explosions on the job resulting from oil and oil exploration activities and the risk perception towards the industry's

impact on the environment (air, water, soil and community well-being) by the employees. Those employees who have experienced fires and explosions on the job resulting from oil and gas exploration activities are expected to be highly aware of the risk attached to the activities of the industry and thus have more negative opinions about the industry's impact on the environment.

e. There is a positive relationship between the awareness of actual physical injuries of employees resulting from oil and gas exploration activities and perception of the risk the industry poses to the environment (air, water, soil and community well-being) by the employees. Those employees who have experienced physical injuries resulting from oil and gas exploration activities are expected to be highly aware of the risk attached to the activities of the industry and have more negative opinions about the industry's impact on the environment.

f. There is a dependency between the amount of public information or communication (conversation with other community members, brochures, public meetings with Saudi Aramco and environmental protection department) and SA representatives' perceptions about the impact of the industry on the environment (air, water, soil and community well-being). It is expected that more communication leads to better awareness and positive perception, while less communication is expected to lead to negative opinions about the industry's impact on the environment.

g. There is a dependency between the amount of information and communication from the government to field workers and their perception about the impact of the industry on the environment (air, water, soil and community well-being). It is expected that more communication leads to better awareness and positive perceptions, while less communication is expected to lead to negative opinions of the industry's impact on the environment.

h. The more professional training and practices by Saudi Aramco to the field workers about the environmental health and safety issues provided by the company, the less negative opinions about the impact of the industry on the environment (air, water, soil and community well-being) will be detected.

i. The more professional training and practices by Saudi Aramco to the field workers about actual oil and gas extraction processes provided by the company, the less negative opinions about the impact of the industry on the environment (air, water, soil and community well-being) will be detected.

j. The degree of utilization of environmental health and safety in the field by Saudi Aramco is related to the opinion about the impact of the industry on the environment (air, water, soil and community well-being). A negative relationship is expected, as the implementation of environmental safety and health in the field should provide more security to the workers and thus lead to fewer of them having negative opinions about the industry's impact on the environment.

CHAPTER 4

METHODOLOGY

4.1. Survey Question Design

Based on the objectives, a novel survey instrument was built to answer questions related to hypotheses, as there were no similar survey instruments available in the literature.

Specifically, questions were designed determine the level of awareness about risks associated with the oil and natural gas industry-related activities in Jubail City, Saudi Arabia, as perceived by the local inhabitants. Questions were designed in a similar fashion as most of the environmental issues surveys (Katsuya, 2001; Suzuki et al, 2015; Princeton Survey Research Associates for Health-Track, 2000), to determine if the population in this specific area are aware of and concerned about air, water, and soil pollution as well as community well-being and any health risks associated with activities of the oil and gas industry. Customized questions were designed with multiple choice answers that would represent the degree of concern, for example extremely concerned, very concerned, moderately concerned, slightly concerned, not at all concerned (Cutchin et al., 2008) The survey was used to provide estimates for the targeted population (Jubail City, Saudi Arabia) and allow the researcher to rapidly focus on particular issues; however, results from this survey may be limited by self-reporting biases as found in other human health-related data (Institute of Medicine, 2010).

One set of questions was developed for the residents (lay people) of Jubail City and was designed to represent respondents' impressions of the impacts of oil and gas extraction activities on their lives as individuals, their families and the community at large. Demographic questions

also were included in the survey. These questions provided data to understand the social representation of oil and gas production contamination.

A second survey was developed for employees of Saudi Aramco (SA), specifically the employees of SA Oil Company Environmental Protection Department (EPD). These representatives reside in the same city, but not only work for the oil and gas industry, but are in charge of the environmental protection. This survey was designed to learn about their perspectives on the impact of their employing industry on health risks and the environment. In addition, questions about their knowledge of issues such as oil- and natural gas-related contamination of water systems, air and farmland, as well as methods for cleaning up such contamination were used. This resulted in two different surveys with common and unique questions that allowed for comparisons and possibly contrasts between the awareness and perception of residents and employees of SA.

Finally, a third survey was developed and given to the employees of Saudi Aramco EPD was given to the government officials, specifically to the Jubail Industrial City Royal Commission (JICRC). However, this group refused to participate in the research.

Following two sections include explanations of all survey questions, and the intended insight to be gained from survey responses. What applies to most of the questions is the desire to see if there is a relationship between the issue asked about and the perception of residents or SA representatives about the risks and impact of the industry on air, water, soil and community well-being as well as their fear of exposure to pollution.

4.2. Residents

Question 1: *Are you currently an employee or have you been employed in the past by oil and gas companies?* (Please check one box): Current employee, Past employee, Retired, Never an employee, or Others.

This question asked if the resident had, at one point in their life, been an employee at Saudi Aramco. This is to help give insight on whether or not a respondent's perceptions are being influenced by 'hands-on' industry experience or based on other factors.

Question 2: *'In your opinion, what type of impacts do oil and gas extraction activities have on your community?'* (Please check on for each impact: Environment air, Environment Water, Environment Soil and Community Well-being). Very Negative, Negative, Somewhat Negative, Neutral, Somewhat Positive, Positive, Very Positive, or Don't Know.

This question assessed the awareness of residents about the effects of the extraction of oil and natural gas on the environmental air, water, and soil as well as community well-being. These responses represent the estimated awareness of the risk and serve as the dependent variables to test the hypotheses about relationships of such awareness with other variables collected (demographics, communication, diseases, cancer, danger, speed of emergency response, etc.) listed in the hypotheses section. Based on this question and the four categories in it, the analyses and results are organized into major four areas of environmental pollution effects: air, water, soil and community well-being.

Question 3: *'What different risks associated with oil and gas extraction are you aware of?'* (Please check one for each risk: Fires and Explosions, Physical Injury Incidents):

Unaware, Aware but no personal experience, Aware and have personal experience, or Don't Know.

This question requested information about how informed the residents are about the specific risks and hazards associated with oil and gas extraction, specifically fires, explosions, and physical injuries. This helped to generate information about the different risk to different people in the region, and possibly be used to learn how the risks can be prevented in other (or proposed future) oil and gas extracting regions in Saudi Arabia.

Question 4: ***'How much do you worry about exposure to pollution related to the extraction of oil and natural gas?'*** (Please check on response for each type of pollution: Air pollution, Water pollution and Land Pollution): Very Worried, Worried, Somewhat Worried, or Not Worried.

This question addresses the different levels of worry or fear about the exposure of individuals to different types of pollution (air, water, land) involved in oil and gas extraction. It gave insight on how to rank these risks and on how the residents are being affected by each. It helped to generate the information needed about the most concerning risk, which should be given the utmost priority by the oil and gas companies involved. These responses represent the estimated fear level and serve as the response variables to test the hypotheses about relationships to this fear from the pollution with other variables collected.

Question 5: ***'What is the likelihood that pollution resulting from oil and gas activities has caused health problems for you, your family, or members of your community?'*** (Please check on response for each: You personally, Your family, Members of your community): Very Likely, Likely, Somewhat Likely, Not Likely, or Don't Know.

This question examined the awareness of the links between the health risks and the extraction of

oil and gas. The degree of the health risks of the residents and the impact of oil and gas extraction on them are be useful for assessing any negative personal experiences with the industry and their relation to the type of attitude towards the industry's impact on the environment.

Question 6: ***'How have environmental and health risks from oil and gas extraction and production been communicated to you in the past?'*** (Please check all that apply):

Conversations with other community members, Brochures, Public meetings,
Communications from Saudi Aramco's Environmental Protection Department,
Communications from Jubail Industrial City Royal Commission, No communication has
ever been made, or Other.

This question probed respondents about the amount of information they have received about the causes of health-related problems, coming from various modes of communication.

Question 7: ***'What have you learned about risks from any communications with the Saudi Aramco's Environmental Protection Department?'***

This question was an open-ended question and asked about the resident's perception of government officials and the regulatory bodies in formulating policies and standards, also creating solutions to the risk from extraction activities. It gave insight on the relationship between local residents and the oil and gas industry officials responsible for protecting the environment.

Question 8: ***'What have you learned about risks from any communications with the Jubail Industrial Royal Commission Environmental Protection Department?'***

This question inquired about the residents' awareness of the risks involved with living in close proximity to industrial activities that they learned from the government. The answers provided a measure of communication between the residents and the government.

Question 9: ***‘Have you ever experienced any environmental / health hazard resulting from oil and gas extraction and production in Eastern Province of Jubail?’*** (Please check only one): Yes or No; Please describe this experience or experiences.

This question asks about the immediate health issues of the responder related to environmental contamination from extraction activities. It gave insight into the negative experiences and sense of safety of local residents.

Question 10: ***‘Over the past year, what are some of the health symptoms that you have noticed within affected communities that might be attributed to exposure to soil, air, and/or water pollution due to Saudi Aramco Oil Company extraction and production activities?’*** (Please check all that apply): Nausea, Shortness of breath, Headaches or migraines, Eye irritation (burning or itchy eyes), Nose irritation (itchy, burning or runny nose), Throat irritation, Odor, Skin rash, Sores or blisters, Diarrhea, Disorientation, Cancer, No symptoms noticed, or Other symptoms.

This question examined a list of 12 different health issues experienced by the residents possibly related to environmental pollution from the oil and gas extraction activities. It provided information about specific health effects observed by respondents from the extraction activities.

Question 11: ***‘Within the past five years, have you ever voiced concerns to government officials regarding the negative impacts of oil and gas extraction?’*** (Please check one box): Yes or No.

This question requested information about one-way communication directed from residents to the government. It provided a measure of how frequently people followed up and expressed their concern or risk awareness to the government with a prospect of that issue being addressed accordingly.

Question 12: ***‘How satisfied are you with the response of government officials within the oil and gas regulatory bodies in reacting effectively and providing solutions to the oil and gas production and extraction impacts that you’ve voiced your concerns regarding?’***

(Please check one box): Very satisfied, Satisfied, Somewhat satisfied, Dissatisfied, Very Dissatisfied, or Not applicable.

This question provided an estimate of the resident’s satisfaction with the governmental reactions to community concerns. It gave insight into the relationship between the residents and the government.

Question 13: ***‘How comfortable are you about expressing your concerns about the impacts of oil and gas production and extraction to public officials?’*** (Please check one box): Very comfortable, Comfortable, Somewhat comfortable, Not comfortable, or Don’t know.

This question is a probing question about the levels of comfort and trust between the people of the community and public officials. If the people have issues in mind but do not voice the issues with an official, then it is unlikely that any changes or improvements will take place. The answer to this question evaluates the willingness of concerned citizens to take a risk and challenge public officials to address pollution issues.

Question 14: ***‘How responsive were oil and gas representatives in cases of emergency or any perceived risks, including transportation incidents, contact with equipment, fires, explosions, exposure to harmful substances, falls etc.?’*** (Please check one box): Very immediate, Immediate, Somewhat Immediate, Not immediate, or Don’t know.

This question represents an inquiry about the degree of satisfaction with the emergency response by gas and oil companies. It was of interest to see if there was a relationship between the

satisfaction of residents with emergency response and their perception about the risks and impact of the industry on the environment, as well as with their fear of exposure to pollution.

Question 15: *‘Based on your understanding of the risks involved in oil and gas extraction, please choose your level of agreement with each statement: Oil and gas from extraction to production is the biggest source of pollution in the Eastern Province of Jubail. Pollution from oil and gas extraction and production activities is hazardous to human health. Oil and gas extraction and production have negative impacts on agriculture. Oil and gas extraction and production have negative impacts on water quality and water resources.’* (Please check on response per statement): Strongly Agree, Agree, Neutral, Disagree, or Strongly Disagree.

Components of this question were designed to assess the attitudes of residents about the topics of this survey so that it could then be assessed if there was an association between their attitude and fear of exposure to pollution.

Question 16: *‘From your perspective, what are the benefits resulting from oil and gas production and extraction activities to the communities in the Eastern Province of Jubail?’* (Please check all that apply): A more robust economy, Employment opportunities, City development process, Attractive to other business, Infrastructure stability (roads, bridges, etc.), Scholarships to residents, Not aware, or Others.

This question inquired about advantages and positive things people experienced, or perceived as being, due to the oil and gas industry in the community. This variable was studied to find the proportion of people who thought positively about the industry and if the risk perception exceeded the benefit perception.

Question 17: *‘Year of birth:’* 19_____

Question 18: '**Gender:**' Male or Female

Question 19: '**Nationality:**' Saudi Arabian or Other

Question 20: '**Education level:**' Primary education, High school diploma, Technical school, Bachelor's degree, or Graduate school.

Question 21: '**Occupational Status:**' Employed, Unemployed, Retired, or Stay at home spouse.

These were demographic questions asked in order to be able to see if any of these variables had an association with the residents' perceptions about the risks and impact of the industry on air, water, soil and community well-being, as well as on their fear of exposure to pollution.

4.3. Saudi Aramco Representatives

Question 1: '***In your opinion, what types of impacts do oil and gas extraction activities have on your community?***' (Please check all that apply): Very Negative, Negative, Somewhat Negative, Neutral, Somewhat Positive, Positive, or Very Positive.

This question inquired about the awareness of SA representatives about the effects of extraction of oil and gas on the environmental air, water, soil and community well-being. These responses represent the estimated awareness of the risk, and serve as the response variables to test the hypotheses about relationships between this awareness and other variables collected (demographics, communication, diseases, cancer, danger, speed of emergency response), as listed in the hypotheses section.

Question 2: '***Based on the impacts listed in the previous question, are there adequate policies in place to combat any negative effects to the environment or community***

members resulting from the extraction activities of oil and gas?’ (Please check one box and explain): Yes or No.

This question asks about the availability of different policy and standards guiding oil and gas extraction activities. It gives insight into what is obtainable under the law by residents and the oil and gas companies.

Question 3: ***‘What methods are used by regulatory bodies incorporated under the Royal Commission for Jubail and Yanbu (RCJY) ensure that oil and gas companies operate or carry out the extraction activities within the confines of the laws?’*** (Please check all that apply): Inspections, Citations, Fines, Sanctions, or Other methods.

This question investigates some of the legal means employed by the regulatory bodies in ensuring that the oil and gas producing companies are in compliance. It gave information about some of the consequences or penalties for insubordination by the oil and gas company.

Question 4: ***‘Please describe the legal basis for at least one of the methods identified in question #3 above’***

This question compares the best practices that are applied in some extraction procedures utilized by Saudi Aramco compared to other oil companies. It gave insight into how seriously Saudi Aramco takes the issue of safety when compared to other oil producing companies.

Question 5: ***‘In your opinion, how would you rate the practices that are applied in retorting and refining procedures utilized by the Saudi Aramco Oil Company based on Occupational Safety and Health Administration (OSHA) standard?’*** (Please check one response for each): Maximum Practice, Below Maximum but Above Minimum Practice, Minimum Practice, or Below Minimum Practice.

This question looks at the extent of external (independent) government oversight on contamination due to oil and gas extraction in the region as perceived by public officials and the oil and gas representatives. It gives insight on the seriousness accorded to the extraction activities by the government. This intended use of this variable was to examine if there was a sense of safety among those employees who thought the Saudi OSHA standards were applied, and if their risk perception was lower than in those employees who thought otherwise.

Question 6: ***‘What different risks associated with oil and gas extraction do you have experience in dealing with in your job?’*** (Please check all that apply): No Experience, Have Personal Experience, or Don’t Know.

This question gives information about some of the health symptoms that have been noticed within affected communities due to industrial contamination of the soil, air and/or water. It gives insight on the general perception of risk associated with oil producing regions.

Question 7: ***‘How responsive do you think oil and gas representatives have been in cases of emergency or any perceived risks, including transportation incidents, contact with equipment, fires, explosions, exposure to harmful substances, falls. etc.?’*** (Please check one box): Very immediate, Immediate, Somewhat immediate, Not immediate, or Don’t Know.

This question was used to assess the basic understanding the Saudi Aramco representatives had of the general and specific risks of oil and gas production and extraction activities to the residents of the community, as well as the resources available. This question represented an inquiry about their degree of satisfaction with the emergency response by the gas and oil companies. The purpose was to see if there was a relationship between the satisfaction of employees with emergency response and their perception about the risks and impact of their industry on air,

water, soil and community well-being, as well as with their fear of exposure to pollution.

Question 8: ***‘How have environmental and health risks from oil and gas extraction and production been communicated to community residents?’*** (Please check all that apply):

Conversations with other community members, Brochures, Public meetings,
Communications from Saudi Aramco’s Environmental Protection Department,
communications from Jubail Industrial City Royal Commission, To my knowledge no
communications have been made, or Other communications.

This question probed about the amount of information available through various modes of communication the oil and gas company provided for the community about the possible health risks related to the industry.

Question 9: ***‘What do you think that the general public has learned about risks from these communications regarding oil and gas extraction and production activities?’***

This question was asked to estimate the degree of acknowledgement of oil and gas company representatives about the community knowledge of the risks associated with the industry.

Question 10: ***‘How are environmental and health risks from oil and gas extraction and production communicated to field workers?’*** (Please check all that apply): Conversations
with other field workers, Brochures, Public meetings, Communications from Saudi
Aramco’s Environmental Protection Department, Communications from Jubail Industrial
City Royal Commission, To my knowledge no communications have been made, or Other
communications.

This question probed about the amount of information field workers had on the causes of health-related problems, coming from various modes of communication.

Question 11: ***‘Over the past year, what are some of the human health symptoms that you***

have noticed within affected communities that might be attributed to exposure from soil, air, and/or water pollution due to Saudi Aramco Oil Company extraction and production activities?’ (Please check all that apply): Nausea, Shortness of breath, Headaches or migraines, Eye irritation (burning or itchy eyes), Nose irritation (itchy, burning, or runny nose), Throat irritation, Odor, Skin rash, Sores or blisters, Diarrhea, Disorientation, Cancer, No symptoms noticed, or Other symptoms.

This question examined a list of twelve different health issues possibly related to environmental pollution from the oil and gas extraction activities experienced by the field workers. It would provide information about specific health effects from the extraction activities.

Question 12: ***‘Please rate the following issues pertaining to the training and practices by oil and gas extraction workers.’*** (Please check the appropriate rating for each statement: Employer provided training on environmental health and safety issues concerning oil and gas extraction procedures; Employee knowledge of the extraction and production processes; Employee utilization of their environmental health and safety training on the job): Excellent, Good, Average, Poor, or Don’t Know.

This question looks at the level of training and acquisition of knowledge by the Saudi Aramco employees in ensuring that they carried out their job functions adequately. In addition, the third component gives information about how Saudi Aramco management ensures that their employees work safely and prevent any incidents to the community at large.

Question 13: ***‘Based on your understanding of the risks involved in oil and gas extraction, please choose your level of agreement with each statement:*** (Please check one response per statement: Oil and gas from extraction to production is the biggest source of pollution in the Eastern Province of Jubail. Pollution from oil and gas extraction and production

activities is hazardous to human health. Oil and gas extraction and production have negative impacts on agriculture. Oil and gas extraction and production have negative impacts on water quality and water resources.’): Strongly Agree, Agree, Neutral, Disagree, or Strongly Disagree.

Components of this question were designed to assess the attitudes of the residents about the survey topics so that it could then be assessed whether there was an association between their attitude and their fear of exposure to pollution.

Question 14: ‘*Year of birth:*’ 19_____

Question 15: ‘*Gender:*’ Male or Female

Question 16: ‘*Nationality:*’ Saudi Arabian or Other

Question 17: ‘*Education level:*’ Primary education, High school diploma, Technical school, Bachelor’s degree, or Graduate school.

These were demographic questions collected in order to be able to see if any of these variables had an association with the representatives’ perception about the risks and impact of their industry on air, water, soil and community well-being, as well as on their fear of exposure to pollution.

4.4 Survey Implementation and Analysis

The survey of residents of Jubail City consisted of 21 questions (Appendix I), some with multiple parts, calling for a total of 46 responses. The survey was conducted between June and August 2015. Out of these 46 responses, 34 responses were utilized for further analysis. The remaining responses/questions were excluded because they all had identical answers from all

responders or were not answered by anyone (Questions 7, 8, 11, 12, 13, 15, 18 and 19 in the residents' survey). Some original multiple level responses on the Likert scale were combined into a smaller number of scale levels due to a lower number of participants than expected. Both the original and the reduced number of response categories for each question that was kept and used are listed in Table 1.

The remaining survey questions, which were answered and used, were organized in an Excel spreadsheet and summations of the responses to related questions were enumerated in Table 1. Questions, such as the health problems of the participants due to pollution (Question 5a), health problems in the family (Question 5b) and in the community (Question 5c) were combined into one variable called 'Likelihood of health problems due to pollution in family and community'. Similarly, questions about the communication flow from other community members (Question 6a), from the brochures (Question 6b), public meetings (Question 6c) and from the Saudi Aramco Environmental Protection Department (SAEPD, Question 6d) were combined into one variable 'Environmental and Health Risks Communications from Public'. In the same way, 11 questions (Questions 10a-10k) about each individual health issue over the past year possibly attributed to pollution from oil and gas extraction activities were summed for a composite score variable named 'Individual Health Issues'. Answers to questions related to the benefits of the oil and gas extraction (Questions 16a – 16f) were grouped likewise by adding the individual benefits to a composite variable called 'Benefits of oil and gas industry to community'.

The survey for industry representatives consisted of 17 main questions, some with multiple sub-questions, calling for total of 47 responses (Appendix II). Some of these questions were specific to oil and gas industry employees (Table 2) while some of the questions were identical to questions asked to the residents. Out of 47 responses, 40 questions (responses) were

employed in a statistical evaluation. The seven unusable responses were excluded (Question 4, 9, 13, 15, and 16 in SA representatives' survey in Appendix 2) for being unanswered.

In addition to Likert scale questions, qualitative data were collected using open-ended questions where the residents provided their answers in a written format without provided options for answers. Such questions were related to communication from Saudi Aramco's Environmental Protection Department, identified by Cowie et al. (2012) as a self-monitoring outfit and from the Jubail Industrial Royal Commission Environmental Protection Department.

Most of the surveys were administered in English, and in one instance an Arabic translator assisted for better understanding and adequate responses.

Table 1- Questions asked to the residents of Jubail and utilized for analyses.

Question	Sub-questions/ abbreviated names of some questions	Response Categories	Reduced Number of Response Categories
Q1. Are you currently an employee or have you been employed in the past by oil and gas companies? (Please check one box)	Employment status	Current employee, past employee, retired, or never an employee	Past or present employee, or never an employee
Q2. What impact do oil and gas extraction activities have on your community? (Please check one for each impact)	a.Environment air	Very negative, negative, somewhat negative, neutral, somewhat positive, positive, very positive	Negative, neutral, positive
	b.Environment water		
	c. Environment soil		
	d. Community well being		
Q3. What different risks associated with oil and gas extraction are you aware of? (Please check one for each risk)	a. Awareness from fires	Unaware, aware but no personal experience, or aware and have personal experience	Aware with experience, Aware without experience or unaware
	b. Awareness of physical injuries		Aware or unaware
Q4. How much do you worry about exposure to pollution related to the extraction of oil and natural gas? (Please check one for each pollution)	a. Air pollution	Very worried, worried, somewhat worried, not worried	Worried, not worried
	b. Water pollution		
	c. Land pollution		
Q5. What is the likelihood that pollution resulting from oil and gas activities has caused health problems for you, your family, or members of your community? (Please check one response for each)	a. Health problems due to pollution-self	Don't know, not likely, somewhat likely, likely, or very likely	Numerical value ranging from 0 to 12 representing the summation of 'very likely' responses
	b. Health problems due to pollution – family	Don't know, not likely, somewhat likely, likely, or very likely	
	c. Health problems due to pollution – community	Don't know, not likely, somewhat likely, likely, or very likely	
Q6. How have environmental and	a. Communication from other people	Yes or no	No or little communication/

Question	Sub-questions/ abbreviated names of some questions	Response Categories	Reduced Number of Response Categories
health risks from oil and gas extraction and production been communicated to you in the past? (Please check all that apply)	b. Communication from Brochures	Yes or no	medium amount of communication/ lots of communication
	c. Communication from public meeting	Yes or no	
	d. Communication from SAEPD	Yes or no	
	e. Communication from JICRC	Yes or no	Yes or no
Q9. Have you ever experienced any environmental / health hazard resulting from oil and gas extraction and production in Eastern Province of Jubail? (Please check only one)	Experience of environment and health hazards	Yes or no	Yes or no
Q10. Over the past year, what are some of the health symptoms that you have noticed within affected communities that might be attributed to exposure to soil, air, and/or water pollution due to Saudi Aramco Oil Company extraction and production activities? (Please check all that apply)	a. Nausea	Yes or no	Numerical value ranging from 0 to 11 representing the summation of the Yes responses
	b. Shortness of breath	Yes or no	
	c. Headaches	Yes or no	
	d. Eye irritation	Yes or no	
	e. Nose irritation	Yes or no	
	f. Throat irritation	Yes or no	
	g. Odor	Yes or no	
	h. Skin rash	Yes or no	
	i. Sore or Blisters	Yes or no	
	j. Diarrhea	Yes or no	
	k. Disorientation	Yes or no	
	l. Cancer	Yes or no	Yes or no

Question	Sub-questions/ abbreviated names of some questions	Response Categories	Reduced Number of Response Categories
Q14. How responsive were oil and gas representatives in cases of emergency or any perceived risks, including transportation incidents, contact with equipment, fires, explosions, exposure to harmful substances, falls. etc.? (Please check one box)	Oil and Gas companies emergency response	Not immediate, somewhat immediate, immediate, or very immediate	Slow response or immediate response
Q16. From your perspective, what are the benefits resulting from oil and gas production and extraction activities to the communities in the Eastern Province of Jubail? (Please check all that apply)	a. Benefit of gas and oil for economy	Yes or no	Numerical value ranging from 0 to 6 representing the summation of the Yes responses
	b. Benefit of gas and oil for employment opportunities	Yes or no	
	c. Benefit of gas and oil for city development	Yes or no	
	d. Benefit of gas and oil for other business	Yes or no	
	e. Benefit of gas and oil for infrastructure	Yes or no	
	f. Benefit of gas and oil for scholarships to residents	Yes or no	
Q17. Year of birth:19__	Birth date year	Written response	Calculated age in years
Q20. Educational level	Educational level	Primary education, high school diploma, technical school, bachelor's degree, or graduate school	High school diploma and lower or bachelor's degree and above
Q21. Occupation	Occupational level	Employed, unemployed, stay-at-home spouse, or student	Employed, not currently employed, or student

Table 2- Questions unique in the survey for the Saudi Aramco representatives only.

Question	Sub-questions/ abbreviated names of some questions	Response Categories	Reduced Number of Response Categories
Q2. Based on the impacts listed in the previous question, are there adequate policies in place to combat any negative effects to the environment or community members resulting from the extraction activities of oil and gas? (Please check one box and explain)	Awareness of policies to combat negative effects of industry on environment and community well-being	Yes or no	Yes or no
Q3. What methods are used by regulatory bodies incorporated under the Royal Commission for Jubail and Yanbu (RCJY) ensure that oil and gas companies operate or carry out the extraction activities within the confines of the laws? (Please check all that apply)	a. Inspections	Yes or no	Summation of “yes” answers into 2 categories: 0 to 1 or 2-4 regulations
	b. Citations		
	c. Fines		
	d. Sanctions		
Q5. In your opinion, how would you rate the practices that are applied in retorting and refining procedures utilized by the Saudi Aramco Oil Company based on OSHA standard? (Please check one response for each)	Practices based on OSHA standards applied by Saudi Aramco	Below minimum practice, minimum practice, below maximum but above minimum practice, or maximum practice	Below minimum practice and minimum practice, above minimum practice and maximum practice
Q6. What different risks associated with oil and gas extraction do you have experience in dealing with in your job? (Please check all that apply)	a. Awareness of fires and explosions	No experience, have personal experience, don't know	Aware or unaware
	b. Awareness of physical injuries		
Q7. How are environmental and health risks from oil and gas extraction and production communicated to field workers? (Please check all that apply)	a. Conversations with field workers	Yes or no	Summation of “yes” responses, forming 3 categories on number of modes of health communication 0 to 1, 2 or 3 to 4
	b. Brochures		
	c. Public meetings		
	d. SAEPD		
	e. JICRC	Yes or no	Yes or no

Question	Sub-questions/ abbreviated names of some questions	Response Categories	Reduced Number of Response Categories
Q12. Please rate the following issues pertaining to the training and practices by oil and gas extraction workers. (Please check the appropriate rating for each statement)	a. Training and environmental safety practices from SA to workers	Poor, average, good, or excellent	Bad or good
	b. Production knowledge of workers		
	c. Employee utilization of environmental health and safety training on the job		

4.5. Sample Description

The population under study consisted initially of all of the residents of Jubail Industrial City, Saudi Arabia, with a population of 300,000. Ideally, a random sample of the city population would be taken (Orcher, 2007). However, people in Saudi Arabia are not familiar with a survey process and would very unlikely respond to a mailed survey, thus personal communication and persuasion had to be used, which placed considerable time and sample size constraints on the sampling process. In addition it is not customary to talk and give surveys to females.

After considering these constraints, the survey population was narrowed to three groups of male residents of Jubail, to whom the surveys were personally delivered and collected in Jubail City between June and August 2015.

The first survey frame included the staff, faculty and students at Jubail Technical College with a population size of 5,000, representing literate residents who did not themselves at that time work at the oil and gas company. At the college, the residents' survey was administered to 80 students and employees selected at random by the administrators of the college. Out of 80

personally delivered surveys, 42 were completed and returned, constituting a 54.50% response rate. This group is referred to as ‘Residents’ or ‘Residents of Jubail’.

The second survey frame was all of the 30 employees employed by the Saudi Aramco (SA) Oil Company Environmental Protection Department (EPD). The SA employees were approached personally at the company. Out of 30 surveys delivered to SA representatives, 11 were completed and returned, constituting a 36.70% response rate. This group is referred to as the ‘SA representatives’.

A third survey frame was 30 government officials at the Jubail Industrial City Royal Commission (JICRC). The JICRC employees were approached personally at their offices. None of them were willing to participate in this research.

Not each person answered all of the questions. Number of answers for each question and each survey are listed in table 3 and 4 in Appendix III. Of the 11 open-ended questions from the residents and 9 for the representatives, adequate responses from residents were only obtained for one question (20/42, 47 % responded), “What did you learn from Saudi Aramco Environmental Protection Department?”

4.6. Statistical Analyses

Three kinds of variables were obtained from the questions: i) quantitative continuous data, such as the age of the participants, ii) quantitative categorical ordinal data, such as environmental hazards and health questions, where the number represented the relative quantity and order, or a degree of response and iii) categorical nominal, qualitative categories such as occupation and employment with the oil company.

The responses of Jubail residents were combined into a total of 14 independent variables and 7 dependent variables used in statistical analyses (Table 5). Responses from the SA EPD

representatives from questions common with the residents' questions were organized into 7 independent and 4 dependent variables (Table 6); and responses unique to the SA EPD representatives were organized into 10 independent variables and 4 dependent variables (Table 7). Similar to the survey of the residents, some original multiple level responses in questions for SA representatives on the Likert scale were combined into a smaller number of scale levels due to a lower number of participants than expected (Tables 6 and 7).

Both quantitative (logistic regression) and qualitative approaches (categorical data analyses methods such as the Chi-square test of independence and Fisher's exact test) were used in analyzing the data following Hossler and Vesper (1993) and Suzuki et al, (2015). Only one variable from the questions with an open-ended answer had a sufficient number of responses (20/42). This variable was not analyzed with any statistical tool, but frequencies of different types of answers were summarized in a pie chart (see Figure 15).

Table 3- List of responses and explanatory variables from the resident survey.

34 Explanatory variables corresponding to the original survey questions (Original Question #)	14 Explanatory variables derived from original 34 variables; grouped for the purpose of statistical analyses Each of the 14 variables were studied for statistical association with each and all of the 7 response variables listed in the next column	7 Response Variables (Original Question #) Perception and awareness of citizens with respect to their:
Q1. Employment status	i. Employment with gas/oil	Q2a. Community Air Q2b. Community Water Q2c. Community Soil Q2d. Community well-being Q4a. Exposure to Air Pollution Q4b. Exposure to Water Pollution Q4c. Exposure to Land Pollution
Q3a. Awareness from fires	ii. Awareness from fires	
Q3b. Awareness of physical injuries	iii. Awareness of physical injuries	
Q5a. Health problems due to pollution-self	iv. Likelihood of Health problems due to pollution in family and community	
Q5b. Health problems due to pollution – family		
Q5c. Health problems due to pollution – community		
Q6a. Communication from other people	v. Environmental and Health Risks Communications from Public	
Q6b. Communication from Brochures		
Q6c. Communication from public meeting		
Q6d. Communication from SAEPD		
Q6e. Communication from JICRC	vi. Communication from government	
Q9. Experience of environment and health hazards	vii. Experience of environment and health hazards	
Q10a. Nausea	viii. Individual Health Issues composite score	
Q10b. Shortness of breath		
Q10c. Headaches		
Q10d. Eye irritation		

34 Explanatory variables corresponding to the original survey questions (Original Question #)	14 Explanatory variables derived from original 34 variables; grouped for the purpose of statistical analyses Each of the 14 variables were studied for statistical association with each and all of the 7 response variables listed in the next column	7 Response Variables (Original Question #) Perception and awareness of citizens with respect to their:
Q10e. Nose irritation		Q2a. Community Air Q2b. Community Water
Q10f. Throat irritation		
Q10g. Odor		
Q10h. Skin rash		
Q10i. Sore or Blisters		
Q10j. Diarrhea		
Q10k. Disorientation		
Q10l. Cancer	ix. Cancer	Q2c. Community Soil
Q14. Oil and Gas companies emergency response	x. Oil and Gas companies emergency response	Q2d. Community well-being
Q16a. Benefit of gas and oil for economy	xi. Benefits of oil and gas industry to community	Q4a. Exposure to Air Pollution
Q16b. Benefit of gas and oil for employment opportunities		Q4b. Exposure to Water Pollution
Q16c. Benefit of gas and oil for city development		Q4c. Exposure to Land Pollution
Q16d. Benefit of gas and oil for other business		
Q16e. Benefit of gas and oil for infrastructure		
Q16f. Benefit of gas and oil for scholarships to residents		
Q17. Birth date year	xii. . Age	
Q20. Educational level	xiii. Education	
Q21. Occupational level	xiv. Occupation rank	

Table 4- Questions to the representatives of the oil and gas company that share similarities with the questions to the residents.

20 Explanatory variables corresponding to the 5 original survey questions	7 Explanatory variables derived from original variables; grouped for the purpose of statistical analyses Each of the 7 variables were studied for statistical association with each and all of the 4 response variables listed in the next column	4 Response variables Perception and awareness of citizens with respect to their:
Q6a. Conversations to the community members	i. Environmental and Health Risks Communications with Public	Q2a. Community Air Q2b. Community Water Q2c. Community Soil Q2d. Community well-being
Q6b. Communication to the community members using Brochures		
Q6c. Communication to the community members using public meetings		
Q6d. Communication from SAEPD		
Q6e. Communication from JICRC	ii. Environmental and Health Risks Communications from JICRC	
Q10a. Nausea	iii. Individual Health Issues	
Q10b. Shortness of breadth		
Q10c. Headaches		
Q10d. Eye irritation		
Q10e. Nose irritation		
Q10f. Throat irritation		
Q10g. Odor		
Q10h. Skin rash		
Q10i. Sore or Blisters		
Q10j. Diarrhea		
Q10k. Disorientation		
Q10l. Cancer	iv. Cancer	
Q14.Speed of Oil and Gas companies emergency response	v. Speed of Oil and Gas companies emergency response	
Q17. Birth date year	vi. Age	
Q20. Educational level	vii. Education	

Table 5- Questions unique in the survey for the Saudi Aramco representatives only.

Question	Sub-questions/ abbreviated names of some questions	Response Categories	Reduced Number of Response Categories
Q2. Based on the impacts listed in the previous question, are there adequate policies in place to combat any negative effects to the environment or community members resulting from the extraction activities of oil and gas? (Please check one box and explain)	Awareness of policies to combat negative effects of industry on environment and community well-being	Yes or no	Yes or no
Q3. What methods are used by regulatory bodies incorporated under the Royal Commission for Jubail and Yanbu (RCJY) ensure that oil and gas companies operate or carry out the extraction activities within the confines of the laws? (Please check all that apply)	e. Inspections	Yes or no	Summation of “yes” answers into 2 categories: 0 to 1 or 2-4 regulations
	f. Citations		
	g. Fines		
	h. Sanctions		
Q5. In your opinion, how would you rate the practices that are applied in retorting and refining procedures utilized by the Saudi Aramco Oil Company based on OSHA standard? (Please check one response for each)	Practices based on OSHA standards applied by Saudi Aramco	Below minimum practice, minimum practice, below maximum but above minimum practice, or maximum practice	Below minimum practice and minimum practice, above minimum practice and maximum practice
Q6. What different risks associated with oil and gas extraction do you have experience in dealing with in your job? (Please check all that apply)	c. Awareness of fires and explosions	No experience, have personal experience, don't know	Aware or unaware
	d. Awareness of physical injuries		
Q7. How are environmental and health risks from oil and gas extraction and production communicated to field workers? (Please check all that apply)	f. Conversations with field workers	Yes or no	Summation of “yes” responses, forming 3 categories on number of modes of health communication 0 to 1, 2 or 3 to 4
	g. Brochures		
	h. Public meetings		
	i. SAEPD		
	j. JICRC	Yes or no	Yes or no

Question	Sub-questions/ abbreviated names of some questions	Response Categories	Reduced Number of Response Categories
Q12. Please rate the following issues pertaining to the training and practices by oil and gas extraction workers. (Please check the appropriate rating for each statement)	d. Training and environmental safety practices from SA to workers	Poor, average, good, or excellent	Bad or good
	e. Production knowledge of workers		
	f. Employee utilization of environmental health and safety training on the job		

Continuous variables and their effect on opinion level or hazard awareness were analyzed one at a time using logistic regression. Ordinal categorical variables were analyzed using ordinal logistic regression. The rest of the data was analyzed using frequency analysis to examine the independence of the two variables, using the Chi-square test or Fisher's exact test if the counts in 20% of combination categories were less than 5 (Stokes et al. 1995). The specified statistical tests were initially done separately on data from the survey of Jubail residents and are listed in Table 8 and for the SA representatives in Table 9.

The Chi-square analysis and Fisher's exact test are statistical tools to test if two variables are associated with each other. For example, this test was used to see if oil and gas company employment (never employed in oil/gas industry, or employed by oil/gas industry at some time in life) was associated with perception about the oil and gas company's impact on the environmental air (negative, neutral or positive). In other words, if there is an association of the perception on employment with an oil and gas company, then the proportions of people with negative, neutral and positive perceptions would be different for those who work/had worked for

an oil and gas company than for those who had not.

Because the number of responses in each group (Jubail residents, n=42 and SA representatives, n=11) were much smaller than expected, and there was a subset of 7 common questions asked to both residents and SA representatives, the two datasets were combined and analysis was also performed on the combined data (n=53). This allowed for testing of the effect of the group (residents vs. oil/gas company representatives) in addition to the 7 explanatory variables (Table 6). Another advantage of combining data set was increased statistical power to detect the relationships. The list of statistical tests done on the combined data set is listed in Table 10.

Table 6 - List of statistical tools used in hypothesis testing for residents (n=42). The same statistical tests were performed for response variables perception about the impact of industry on environmental water, soil, community well-being and concern about personal exposure to polluted water and land.

Explanatory variable	Levels of explanatory variable	Response variable	Levels of response variable	Statistical test
i. Employment status	Employed, not currently employed, or student	Persons' worry about personal exposure to air polluted from the oil and gas industry	Worried/ not worried	Fisher's exact test
ii. Age	Continuous numerical value	Persons' worry about personal exposure to air polluted from the oil and gas industry	Worried/ not worried	Logistic regression
iii. Education	High school diploma and lower / bachelor's degree and above	Persons' worry about personal exposure to air polluted from the oil and gas industry	Worried/ not worried	Fisher's exact test
iv. Occupation level	Employed, not currently employed, or student	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Fisher's exact test
v. Awareness of fires	Aware with experience/aware without experience or unaware	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Fisher's exact test

Explanatory variable	Levels of explanatory variable	Response variable	Levels of response variable	Statistical test
vi. Awareness of physical injuries	Aware / unaware	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Fisher's exact test
vii. Health problems due to pollution in family and community	Numerical value ranging from 0 to 12	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Logistic regression
viii. Experience of environment and health hazards	Yes / no	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Fisher's exact test
ix. Individual Health Issues composite score	Numerical value ranging from 0 to 11	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Logistic regression
x. Cancer	Yes / no	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Fisher's exact test
xi. Environmental and Health Risks Communications from Public	0-1 (no or little) / 2 (medium amount) / 3-4 (lots of communication)	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Fisher's exact test
xii. Communications from government	Yes / no	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Fisher's exact test
xiii. Speed of oil and gas company emergency response	Slow response / immediate response	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Fisher's exact test
xiv. Benefits of oil and gas industry to community	Numerical value ranging from 0 to 6	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Logistic regression

Table 7- List of statistical tools used in hypothesis testing for SA representatives (n=11). The same statistical tests were performed for response variables perception about the impact of industry on environmental water, soil, and community well-being. The first 7 variables are the common variables for both SA representatives and Jubail residents.

Explanatory variable	Levels of explanatory variable	Response variable	Levels of response variable	Statistical test
i. Age	Continuous numerical value	Persons' worry about personal exposure to air polluted from the oil and gas industry	Worried/ not worried	Logistic regression
ii. Education	High school diploma and lower / bachelor's degree and above	Persons' worry about personal exposure to air polluted from the oil and gas industry	Worried/ not worried	Fisher's exact test
iii. Individual Health Issues composite score	Numerical value ranging from 0 to 11	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Logistic regression
iv. Cancer	Yes / no	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Fisher's exact test
v. Environmental and Health Risks Communications from Public	0-1 (no or little) / 2 (medium amount) / 3-4 (lots of communication)	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Fisher's exact test

Explanatory variable	Levels of explanatory variable	Response variable	Levels of response variable	Statistical test
vi. Communications from government	Yes / no	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Fisher's exact test
vii. Speed of oil and gas company emergency response	Slow response / immediate response	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Fisher's exact test
viii. Awareness of policies to combat negative effects of oil/gas industry on environment and community well-being	Yes / no	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Fisher's exact test
ix. Implementation of regulations by the RCJY (inspections, citation, fines and sanctions)	Summation of "yes" answers into 2 categories: 0 to1 or 2-4 regulations	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Fisher's exact test

Explanatory variable	Levels of explanatory variable	Response variable	Levels of response variable	Statistical test
x. Practices based on OSHA standards applied in oil refining in Saudi Aramco	Below minimum practice and minimum practice / above minimum practice and maximum practice	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Fisher's exact test
xi. Awareness of fires and explosions at work	Aware / unaware	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Fisher's exact test
xii. Awareness of physical injuries at work	Aware / unaware	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Fisher's exact test
xiii. Environmental and Health Risks Communications to the Saudi Aramco's field workers, as a summation of the responses number – representing the number of modes of communication	Aware / unaware	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Fisher's exact test

Explanatory variable	Levels of explanatory variable	Response variable	Levels of response variable	Statistical test
xiv. Communication to the Saudi Aramco's field workers from government (JICRC)	Summation of "yes" responses, 3 categories on number of modes of health communication 0 to 1, 2 or 3 to 4	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Fisher's exact test
xv. Training and environmental health and safety practices from the SA to oil and gas extraction workers	Bad / good	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Fisher's exact test
xvi. Production knowledge of oil and gas extraction workers	Bad / good	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Fisher's exact test
xvii. Employee utilization of their environmental health and safety training on the job	Bad / good	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Fisher's exact test

Table 8- List of statistical tools used in hypothesis testing for residents combined with SA representatives (n=53). The same statistical tests were performed for response variables perception about the impact of industry on environmental water, soil, and community well-being.

Explanatory variable	Levels of explanatory variable	Response variable	Levels of response variable	Statistical test
i. Group	Jubail residents / SA representatives	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Logistic Regression, Fisher's exact test
ii. Age	Continuous numerical value	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Logistic Regression
iii. Education	High school diploma and lower / bachelor's degree and above	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Logistic Regression
iv. Environmental and Health Risks Communications between Public and SA	0-1 (no or little) / 2 (medium amount) / 3-4 (lots of communication)	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Logistic Regression Fisher's exact test
v. Communications from government (JICRC)	Yes / no	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Logistic Regression
vi. Individual Health Issues composite score	Numerical value ranging from 0 to 11	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Logistic regression

Explanatory variable	Levels of explanatory variable	Response variable	Levels of response variable	Statistical test
vii. Cancer	Yes / no	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Logistic Regression Fisher's exact test
viii. Speed of oil and gas company emergency response	Slow response / immediate response	Perception about impact of oil/gas industry on environmental air	Negative / neutral / positive	Logistic Regression, Fisher's exact test

Typical simple logistic regression applies to two-level response, (yes and no, or 0 and 1, etc.) This method was used in this study when the responses to *'How much do you worry about exposure to pollution related to the extraction of oil and natural gas?'* were evaluated because it has two response levels (worried or not worried). However, logistic regression is also applicable to multi-level responses (Stokes et al., 1995, p 217). The response variables (the perception and/or awareness for air, water, soil and well-being) in these analyses have three ordered levels: negative, neutral and positive. For ordinal response outcomes, useful modeling functions are cumulative logits in ordered logistic regression using the proportional odds model (Stokes et al, 1995).

For example, consider the question 'Is the perception and awareness of citizens with respect to their community air related to the group they belong to (resident lay people vs. Saudi Aramco representatives) and to the amount of communication that flows between the public and Saudi Aramco?' In the statistical model using logistic regression, the variables 'Environmental and Health Risks Communications with Public' and 'Group' would be cast in the roles of explanatory variables and the 'Perception and awareness of citizens with respect to their

community air' variable in the role of response variable. The explanatory variable 'Environmental and Health Risks Communications with Public' has three levels of response (no, medium or lots of communication) and variable 'Group' has two levels (residents or SA representatives). The data and the frequencies of the response levels for the perception are summarized in Table 11 below.

Table 9- Distribution of perception and awareness of Jubail residents and SA representatives and their level of communication with each other about the community air

Group of citizens	Communication of oil company with public	Perception and awareness of citizens with respect to community air			Total
		<i>Negative</i>	<i>Neutral</i>	<i>Positive</i>	
Jubail Residents	Less	27	1	0	28
Jubail Residents	Moderately	5	1	3	9
Jubail Residents	More	4	0	0	4
SA Representatives	Less	5	0	0	5
SA Representatives	Moderately	3	1	1	5
SA Representatives	More	1	0	0	1

Considering the quantities $\theta_{GCnegative} = \pi_{GCnegative}$, $\theta_{GCneutral} = \pi_{GCnegative} + \pi_{GCneutral}$,

where $\pi_{GCnegative}$ denotes the probability of negative perception, $\pi_{GCneutral}$ denotes the probability of neutral perception, $\pi_{GCpositive}$ denotes the probability of neutral perception and θ_{GCR} represents cumulative probabilities: $\theta_{GCnegative}$ is the probability of negative perception and $\theta_{GCneutral}$ is the probability of negative or neutral perception (G=1 for Jubail residents, G=2 for SA representatives; C=1 for less, C=2 for moderately and C=3 for more means of communication). The forms of the three-level response (negative, neutral and positive) are two cumulative logits:

$$\text{Logit} (\theta_{GCnegative}) = \log \left[\frac{\pi_{negative}}{\pi_{neutral} + \pi_{positive}} \right],$$

$$\text{Logit } (\theta_{\text{CC neutral}}) = \log \left[\frac{\pi_{\text{negative}} + \pi_{\text{neutral}}}{\pi_{\text{positive}}} \right]$$

These cumulative logits are the log odds of negative perception to neutral and positive, and the log odds of negative and neutral perceptions to positive perception. Both odds focus on less favorable to more favorable responses.

Similarly, the remaining 6 variables (Environmental and Health Risks Communications from JICRC, Individual Health Issues, Cancer, Speed of Oil and Gas companies' emergency response, Age and Education) were used individually plus the Group variable as explanatory variables for each of the remaining response variables, such as perception and awareness of citizens with respect to their community water, soil and community well-being. For the results of logistic regression, the significant whole model Chi-square p-values are reported.

The two-factor analyses were followed by multiple logistic regression for the combined dataset from residents and SA representatives, using the 7 variables that were common for both groups plus the group classification variable (resident or SA representative). This procedure served to confirm the finding within each individual group.

The general form of the logit model is:

$$\text{Logit } (\theta_{\text{Gnegative}}) = \text{intercept and parameters for explanatory variables}$$

$$\text{Logit } (\theta_{\text{Gneutral}}) = \text{intercept and parameters for explanatory variables}$$

The example of one logit for a full model for predicting the opinion about the impact on the air quality is:

Logit ($\theta_{GCnegative}$) = Intercepts + Group + Age + Education + Communication from non-government + Communication from government + Individual health issues + Cancer + Speed of Emergency Response.

The aim is to determine if and which of the listed explanatory variables on the right side of the equation may be the best at predicting the probability of the awareness being negative for air quality. Based on the significant contribution of respective variables of the full model above, the model was reduced and re-analyzed with only those variables that were significant in the first round of the analyses.

However, the single and multiple logistic regression was not possible in every case and variable, because there were some combinations of variables represented by zero responders. In case the error message was received for the logistic regression (quasi-separation of data occurred) the maximal likelihood estimates could not be calculated and instead of logistic regression, Fisher's exact test was done.

The sample size requirement for logistic regression is demanding, as it is recommended to have approximately five observations at each outcome at each level of the main effect (Stokes et al. 1991, p 222), which was not possible here due to the low survey response level. This may constitute an issue, especially before the data from the Jubail Residents and SA representatives was combined, thus caution was used while interpreting the results and the more conservative significance criterion alpha of 0.05 (Dowdy and Wearden, 1991, Steel et al. 1997, Sokal and Rohlf, 1995) was decided upon. Data were analyzed using JMP and SAS software (JMP®, Version Pro 11, SAS Institute Inc., Cary, NC, Copyright ©2013; SAS®, Version 9.3, SAS Institute Inc., Cary, NC, Copyright ©2002-2010).

CHAPTER 5

RESULTS

5.1. Awareness and Risk Assessment of Hazards with Oil and Gas Industry, Residents (n=42) Survey Results.

A. Relationships Related to Perceptions of the Impact of the Oil and Gas Industry on Air Quality

i. Employment Status

All respondents who were employed at some time by the oil and gas company (n=17)) thought that the industry had a negative impact on the air in their community, while 79.17% of respondents who had never worked for the gas and oil company (n=19) shared this opinion. There was no statistical significance to this relationship according to Fisher's exact test (p=0.20).

ii. Age

Using logistic regression, no relationship was detected between the age of the respondent and their opinion on the impact of the gas and oil industry on community air quality (p=0.22). Thirty one people (total of 35 answered the age question) corresponding to 88.60% of all respondents agreed that the impact was negative, with the average age of 33.39 ± 2.20 standard error of the mean (SEM). Only one person (2.80%) had a neutral opinion and he was 54 years old. Three people (8.60%) had a positive outlook on the impact of the gas and oil industry on the environmental air; their average age was 38.68 ± 12.88 SEM years.

iii. Education

Respondents with a high school diploma or less (n=6) mostly had a negative opinion about the impact of the oil and gas industry on air quality (85.71%), which was very similar proportion to

negative opinion of respondents with a university degree or more (n=30), 88.24%. There was no statistical significant relationship between education (high school diploma versus university degree) and respondents' views on the gas and oil industry's impact on community air quality according to Fisher's exact test (p=0.63).

iv. Occupation Level

There was no statistical significance to the relationship between respondents' occupation level and their views on the gas and oil industry's impact on community air quality according to Fisher's exact test (p=0.44). 88.89% of respondents who were employed (n=24), 90% of respondents who were unemployed (n=9), and 75% of students (n=3) agreed that the impact of the industry was negative.

v. Awareness of Fires

Ninety percent of those who were unaware (n=9), 84.62% of those who were aware but had no experience with fires or explosions (n=22), and 100% of those who were aware and had experience with fires or explosions (n=5) felt that the impact of the industry was negative. There was no statistical significance to the relationship between respondents' awareness about the risks of fires and explosions and their views on the gas and oil industry's impact on community air quality according to Fisher's exact test (p=0.44).

vi. Awareness of Physical Injuries

No statistical significance in the relationship between respondents' awareness of physical injuries and their views on the gas and oil industry's impact on community air quality was found according to Fisher's exact test (p=0.64). 85.71% of those who were unaware of physical injuries (n=6), 87.88% of those who were aware of, but had no experience with, physical injuries

(n=29), and 87.50% of those who were aware of, and had experience with physical injuries (n=35), agreed that the impact of the industry was negative.

vii. Health Problems of Residents due to Pollution Experienced by themselves, in Family and/or in Community

Logistic regression showed no relationship between the number of health problems in respondents' families and communities, ranging from 0-12, and their views on the gas and oil industry's impact on community air quality ($p=0.96$). 84.18% of all respondents (n=34) agreed that the impact was negative. The mean number of health issues for the opinion categories are listed in Table 10.

Table 10- Summary of the counts of responders, number of health problems in residents' families and communities categorized by their views on the industry's impact on community air quality.

Impact Group Level	Number of responses	Mean number of health problems	Standard error of the mean
1 Negative	34	6.35	0.59
2 Neutral	2	8.50	0.50
3 Positive	3	5.00	1.53

viii. Experience of the Environment and Health Hazards

Regardless of the previous experience of responders with the environmental and health hazard, most of the residents believed the impact was negative (87.88% of those without experience of environmental and health hazards (n=29) and 87.50% of those with experience of environmental and health hazards (n=7)). There was no statistical significance to the relationship between respondents' experience with environmental and health hazards and their views on the gas and oil industry's impact on community air quality according to Fisher's exact test ($p=0.68$).

ix. Number of Individual Health Issues

Using logistic regression, no statistical significance was detected to the relationship between the number of health issues suffered by respondents and their views on the gas and oil industry's impact on community air quality ($p=0.17$). Most of the responders ($n=36$ out of 41), 87.80% agreed that the impact was negative. The mean number of individual health issues for the opinion categories are listed in Table 11.

Table 11- Summary of the counts of responders, their number of health problems suffered categorized by their views on the industry's impact on community air quality.

Impact Group Level	Number of responses	Mean number of health problems	Standard error of the mean
1 Negative	36	2.60	0.40
2 Neutral	2	2.50	0.50
3 Positive	3	4.30	1.30

x. Cancer

There was no statistical significance to the relationship between whether respondents had been diagnosed with cancer and their views on the gas and oil industry's impact on community air quality according to the Fisher's exact test ($p=0.43$). 81.48% of respondents without cancer ($n=22$) and 100% of respondents with cancer ($n=12$) agreed that the impact of the industry was negative.

xi. Communications Directed to the Residents from Public Sources and Saudi Aramco

A statistical significant relationship was detected between how informed respondents were about environmental and health problems from non-governmental sources and their views on the gas and oil industry's impact on community air quality according to Fisher's exact test ($p=0.01$). This means that the proportions of residents exhibiting negative, neutral and positive perception were different across different levels of communication modes. Specifically, proportions of

those that were not well informed and well informed having negative perception were rather high (96.43% and 100%, respectively), compared to those who were moderately informed and had less of the negative perception proportion (55.56%). In addition, the group with moderate amount of information given was the only group having representation with positive perception (Figure 2). The number of modes of communication included any combination of personal communication, brochures, public meeting, and information from the oil and gas company (SAEPD).

Communication	Negative Opinion	Neutral Opinion	Positive Opinion
Less Informed (0-1)	96.43% (n=27)	3.57% (n=1)	0% (n=0)
Moderately Informed (2)	55.56% (n=5)	11.11% (n=1)	33.33% (n=3)
More Informed (3-4)	100% (n=4)	0% (n=0)	0% (n=0)

Figure 2- Bar graph and detailed table showing the survey results of residents' level of information and their views on the industry's impact on community air quality.

xii. Communications Directed to Residents from the Government

There was no statistical significance to the relationship between how informed respondents were about environmental and health problems from the governmental source and their views on the

gas and oil industry's impact on community air quality according to Fisher's exact test ($p=0.79$). 85.19% of those who were not informed by the governmental source ($n=23$) and 92.86% of those who were informed by the governmental source ($n=13$) agreed that the impact of the industry was negative.

xiii. Speed of Emergency Response by the Companies

No statistically significant relationship was detected between how fast the respondents thought the oil and gas companies responded to the emergencies and their views on the gas and oil industry's impact on community air quality using the Fishers exact test ($p=0.38$). Most of the respondents had a negative view on the gas and oil industry's impact on community air quality (90% of those with no information about the speed of emergency response, 100% of those with slow perception of speed of emergency response and 79% of those who thought the emergency responses were immediate).

xiv. Benefits from the Oil and Gas Industry to the Community

Using logistic regression, no statistical significance was detected to the relationship between the number of benefits respondents reported receiving from the gas and oil industry and their views on the industry's impact on community air quality ($p=0.82$). Most of the responders, 87.80%, ($n=36$ out of 41) agreed that the impact was negative, and their average number of benefits they listed was 3.00 ± 0.31 (SEM). This average number was identical to the responders with neutral opinion (3.00 ± 3.00 SEM, corresponding to 2 (4.90 %) people in this category. Positive impact of oil and gas industry on the environmental air was represented by three responders (7.30%) with average number of benefits 3.33 ± 1.20 SEM.

B. Relationships Related to the Perceptions of the Impact of the Oil and Gas Industry on Water Quality

i. Employment Status

There was statistical significance to the relationship between respondents' employment status at the oil and gas company and their views on the gas and oil industry's impact on community water quality according to Fisher's exact test ($p=0.01$). The percent of responders (*negative, neutral and positive*) for each group (*employed or never employed with the oil and gas company*) are graphically represented in Figure 3. The amount of negative opinion was lower in people who worked for the oil and gas industry at some point in their life (43.75%) compared to people who never worked for the industry (68%). In addition, number of people who had positive opinion was larger for those employed than those not employed in the industry.

Employment status	Negative Opinion	Neutral Opinion	Positive Opinion
Employed ever	43.75% (n=7)	31.25% (n=5)	25% (n=4)
Never employed	68% (n=17)	32% (n=8)	0% (n=0)

Figure 3- Bar graph and detailed table showing the survey results of residents' employment status and their views on the industry's impact on community water quality.

ii. Age

Using logistic regression, no relationship was detected between the age of the respondent and their opinion on the impact of the gas and oil industry on community water quality ($p=0.17$).

Twenty one people (total of 36 answered the age and the water quality question) corresponding to 58.33 % of all respondents agreed that the impact was negative, with the average age of 36.19 years $\pm$ 2.71 SEM years. Twelve people (33.33%) held a neutral opinion with average age of 33.17 $\pm$ 4.40 SEM. Three people (8.33 %) had a positive outlook on the impact of the gas and oil industry on the environmental air; their average age was 23.33 years $\pm$ 1.45 SEM.

iii. Education Level

There was no statistical significance to the relationship between respondents' education level and their views on the gas and oil industry's impact on community water quality according to Fisher's exact test ($p=0.71$). 57.14% of those with a high school diploma or less ($n=4$) and 58.82% of those with a university diploma or more ($n=20$) agreed that the impact of the industry was negative.

iv. Occupation Level

There was no statistical significance to the relationship between respondents' occupation level and their views on the gas and oil industry's impact on community water quality according to Fisher's exact test ($p=0.82$).

v. Awareness About the Risks of Fires and Explosions

There was no statistical significance to the relationship between respondents' awareness about the risks of fires and explosions and their views on the gas and oil industry's impact on community water quality according to Fisher's exact test ($p=0.19$). 33.33% of those who were

unaware (n=3), 66.67% of those who were aware but had no experience with fires or explosions (n=18), and 60% of those who were aware and had experience with fires or explosions (n=3) felt that the impact of the industry was negative.

vi. Awareness of Physical Injuries

There was statistical significance to the relationship between respondents' awareness of physical injuries and their views on the gas and oil industry's impact on community water quality according to Fisher's exact test ($p=0.03$). This means that the proportions of residents exhibiting negative, neutral and positive perception were different across different levels of awareness. Specifically, the proportion of those who were aware of physical injuries that held negative opinions (64.71%) was significantly higher than the proportion of those who were unaware (16.67%). The largest portion of those who were unaware were neutral (50%) compared to just 29.41% of those who were aware. Those with positive opinions were the smallest groups in both cases. Just 33.33% of those who were unaware and 5.88% of those who were aware held positive opinions. This relationship can be seen in Figure 4.

Awareness about physical injuries	Negative Opinion	Neutral Opinion	Positive Opinion
Unaware of physical injuries	16.67% (n=1)	50% (n=3)	33.33% (n=2)
Aware of physical injuries	64.71% (n=22)	29.41% (n=10)	5.88% (n=2)

Figure 4- Bar graph and detailed table showing the survey results of residents' awareness of physical injuries and their views on the industry's impact on community water quality.

vii. Health Problems of Residents due to Pollution Experienced by Themselves, in Family and/or in Community

Logistic regression showed no relationship between the number of health problems in respondents' families and communities, ranging from 0-12, and their views on the gas and oil industry's impact on community water quality ($p=0.20$). 58.97 % of all respondents ($n=22$) agreed that the impact was negative, 33.33% of all respondents ($n=13$) had neutral opinion and 10.26 % ($n=4$) has positive opinion. The respective means and SEM of the number of health problem issues for themselves, in their family and community are listed in Table 12.

Table 12- Summary of the counts of responders, their number of health problems in residents' families and communities categorized by their views on the industry's impact on community water quality.

Group Level	Number	Mean	St Error of the Mean
1 Negative	22	6.90	0.82
2 Neutral	13	5.30	0.86
3 Positive	4	6.00	0.70

viii. Experience with Environmental and Health Hazards

There was no statistical significance to the relationship between respondents' experience with environmental and health hazards and their views on the gas and oil industry's impact on community water quality according to Fisher's exact test ($p=0.28$). 60.61% of those without experience with environmental and health hazards ($n=20$) and 50% of those with experience with environmental and health hazards ($n=4$) agreed that the impact of the industry was negative.

ix. Number of Individual Health Issues

Using logistic regression, no statistical significance was detected to the relationship between the number of health issues suffered by respondents and their views on the gas and oil industry's impact on community air quality ($p=0.45$). More than a half of the responders, ($n=24$) 58.54%, of all respondents ($n=41$) agreed that the impact was negative with reported mean number of individual health issues 2.40 ± 1.48 SEM. The other respective means and SEM are listed in the Table 13.

Table 13- Summary of the counts of responders and their number of health problems suffered categorized by their views on the industry's impact on community water quality.

Group Level	Number	Mean	St Error of the Mean
1 Negative	24	2.40	0.39
2 Neutral	13	2.60	0.89
3 Positive	4	4.70	0.47

x. Cancer

There was no statistical significance to the relationship between whether respondents had been diagnosed with cancer and their views on the gas and oil industry's impact on community water quality according the weighted least squares method ($p=0.37$). 53.57% of respondents without cancer ($n=28$) and 72.72% of respondents with cancer ($n=11$) agreed that the impact of the industry was negative.

xi. Level of Information about Environmental and Health Problems from Non-governmental Sources

There was almost statistical significance to the relationship between how informed respondents were about environmental and health problems from non-governmental sources and their views on the gas and oil industry's impact on community water quality according to Fisher's exact test ($p=0.06$). This means that the proportions of residents exhibiting negative, neutral and positive perception were different across different levels of communication modes. Specifically, the proportions of those who were not well informed and those who were well informed with negative perceptions were high (64.29% and 100%, respectively), compared to those who were moderately informed (22.22%). None of those who were well informed had neutral or positive opinions. Those who were moderately informed had both a larger proportion of respondents with neutral opinions than those who were uninformed (66.67% compared to 25%) and a larger proportion of respondents with positive opinions (11.11% compared to 10.71%). This relationship can be seen in Figure 5.

Communication	Negative Opinion	Neutral Opinion	Positive Opinion
Less Informed (0-1)	64.29% (n=18)	25% (n=7)	10.71% (n=3)
Moderately Informed (2)	22.22% (n=2)	66.67% (n=6)	11.11% (n=1)
More Informed (3-4)	100% (n=4)	0% (n=0)	0% (n=0)

Figure 5- Bar graph and detailed table showing the survey results of residents' level of information and their views on the industry's impact on community water quality.

xii. Level of Information about Environmental and Health problems from the Governmental Source

There was no statistical significance to the relationship between how informed respondents were about environmental and health problems from the governmental source and their views on the gas and oil industry's impact on community water quality according to Fisher's exact test ($p=0.19$). 57.69% of those who were not informed by the governmental source ($n=15$) and 60% of those who were informed by the governmental source ($n=9$) agreed that the impact of the industry was negative.

xiii. Speed of Emergency Response from the Companies

There was no statistical significance to the relationship between the speed of emergency response from the oil and gas company and respondents' views on the gas and oil industry's impact on community water quality according to the least squares method ($p=0.28$). 47.37% of those who did not know, 66.66% of those who said emergency response was slow, and 70% of those who said emergency response was immediate agreed that the impact of the industry was negative.

xiv. Number of Benefits Received from the Industry

Using logistic regression, no statistical significance was detected to the relationship between the number of benefits respondents reported receiving from the gas and oil industry and their views on the industry's impact on community air quality ($p=0.44$). More than a half (58.54%) of all responders ($n=24/41$) agreed that the impact was negative, while they listed, on average, 2.70 benefits community received from the oil and gas industry. This value was similar to the 3.30 and 3.20 in the other two opinion category (see Table 14).

Table 14- Summary of the counts of responders, number of benefits they receive from the industry categorized by their views on the industry's impact on community water quality.

Group Level	Number	Mean	St Error of the Mean
1 Negative	24	2.70	0.41
2 Neutral	13	3.30	0.58
3 Positive	4	3.20	0.48

C. Relationships Related to Perceptions of the Impact of the Oil and Gas Industry on Soil Quality

i. Employment by the Oil and Gas Company

There was no statistical significance to the relationship between respondents' employment by the oil and gas company and their views on the industry's impact on community soil quality according to Fisher's exact test ($p=1.00$). 62.50% of respondents who were employed at some time by the company ($n=10$) and 61.90% of respondents who were never employed by the company ($n=13$) agreed that the impact of the industry was negative.

ii. Age

Using logistic regression, no relationship was detected between the age of respondents and their opinion on the impact of the gas and oil industry on community environmental soil quality ($p=0.21$). Twenty people (total of 32 answered the age and the water quality question) corresponding to 62.50% of all respondents agreed that the impact was negative, with the average age of 36.35 years $\pm$ 2.60 SEM years. Ten people (31.25%) held a neutral opinion with average age of 31.70 $\pm$ 4.61 SEM. Two people (6.25 %) had a positive outlook on the impact of the gas and oil industry on the environmental air; their average age was 27.50 years $\pm$ 2.50 SEM.

iii. Education

There was no statistical significance to the relationship between education and respondents' views on the gas and oil industry's impact on community soil quality according to Fisher's exact test ($p=1.00$). 66.67% of respondents with a high school diploma or less ($n=4$) and 61.29% of respondents with a university degree or more ($n=19$) agreed that the impact was negative.

iv. Occupation Level

There was statistical significance to the relationship between respondents' occupation level and their views on the gas and oil industry's impact on community soil quality according to Fisher's exact test ($p=0.05$). This means that the proportions of residents exhibiting negative, neutral and positive perception were different across different levels of employment.

Specifically, the proportion of residents with negative opinions was the largest for employed and unemployed people at 72% and 55.56%, respectively, while no students had negative opinions.

The only respondents with positive opinions were employed, and even so represented just 8% of that group. A wide range of neutral opinion can be seen, as 100% of student respondents, 44.44% of unemployed respondents, and just 20% of employed respondents felt neutral about the topic. This relationship can be seen in Figure 6.

Occupation Level	Negative Opinion	Neutral Opinion	Positive Opinion
Employed	72% (n=18)	20% (n=5)	8% (n=2)
Unemployed	55.56% (n=5)	44.44% (n=4)	0% (n=0)
Student	0% (n=0)	100% (n=3)	0% (n=0)

Figure 6- Bar graph and detailed table showing the survey results of residents' occupation level and their views on the industry's impact on community soil quality.

v. Awareness About the Risks of Fires and Explosions

There was no statistical significance to the relationship between respondents' awareness about the risks of fires and explosions and their views on the gas and oil industry's impact on community soil quality according to Fisher's exact test ($p=0.44$). 62.50% of those who were unaware ($n=5$), 54.17% of those who were aware but had no experience with fires or explosions ($n=13$), and 100% of those who were aware and had experience with fires or explosions ($n=5$) felt that the impact of the industry was negative.

vi. Awareness of Physical Injuries

There was no statistical significance to the relationship between respondents' awareness of physical injuries and their views on the gas and oil industry's impact on community soil quality according to Fisher's exact test ($p=0.69$). 50% of those who were unaware of physical injuries ($n=2$) and 62.50% of those who were aware of physical injuries ($n=20$) agreed that the impact of the industry was negative.

vii. Health Problems of Residents due to Pollution Experienced by Themselves, in Family and/or in Community

Using logistic regression, no statistical significance was detected to the relationship between the number of health problems in respondents' families and communities and their views on the gas and oil industry's impact on community soil quality ($p=0.55$). Sixty percent of all respondents ($n=21/35$) agreed that the impact was negative with average number of health issues in themselves, family or community was 6.29, which was similar to 6.83 and 7.50 in the neutral and positive opinion groups. The corresponding means and SEM are in Table 15.

Table 15- Summary of the counts of responders, number of health problems in residents' families and communities categorized by their views on the industry's impact on community soil quality.

Group Level	Number	Mean	St Error of the Mean
1 Negative	21	6.29	0.85
2 Neutral	12	6.83	0.74
3 Positive	2	7.50	1.50

viii. Experience with Environmental and Health Hazards

There was no statistical significance to the relationship between respondents' experience with environmental and health hazards and their views on the gas and oil industry's impact on community soil quality according to Fisher's exact test ($p=0.64$). 62.07% of those without experience with environmental and health hazards ($n=18$) and 62.50% of those with experience with environmental and health hazards ($n=5$) agreed that the impact of the industry was negative.

ix. Number of Individual Health Issues

Using logistic regression, no statistical significance was detected to the relationship between the number of health issues suffered by respondents and their views on the gas and oil industry's impact on community soil quality ($p=0.80$). 62.16% of all respondents ($n=23/37$) agreed that the impact was negative and the mean number of individual health issues was 2.96, while in the neutral and positive opinion group the mean number of health issues were 3.67 and 3.50 respectively, listed in Table 16.

Table 16- Summary of the counts of responders, number of health problems suffered by respondents and their views on the industry's impact on community soil quality.

Group Level	Number	Mean	St Error of the Mean
1 Negative	23	2.96	0.58
2 Neutral	12	3.67	0.61
3 Positive	2	3.50	0.50

x. Cancer

There was no statistical significance to the relationship between whether respondents had been diagnosed with cancer and their views on the gas and oil industry's impact on community soil quality according to the weighted least squares method ($p=0.61$). 56% of respondents without cancer ($n=25$) and 72.72% of respondents with cancer ($n=11$) agreed that the impact of the industry was negative.

xi. Level of Information about Environmental and Health Problems from Non-governmental Sources

There was statistical significance to the relationship between how informed respondents were about environmental and health problems from non-governmental sources and their views on the gas and oil industry's impact on community soil quality according to Fisher's exact test ($p=0.01$). This means that the proportions of residents exhibiting negative, neutral and positive perception were different across different levels of communication modes. Specifically, the high proportion of negative opinion between those who were uninformed and those who were well informed was similar at 72% and 75%, respectively. While just 28% of uninformed respondents felt neutral, the proportion of moderately informed respondents who felt that way was more than twice as large at 62.5%. The proportion of well-informed residents who had a positive opinion (25%) was twice that of moderately informed residents (12.5%). This relationship can be seen in Figure 7.

Communication	Negative Opinion	Neutral Opinion	Positive Opinion
Less Informed (0-1)	72% (n=18)	28% (n=7)	0% (n=0)
Moderately Informed (2)	25% (n=2)	62.50% (n=5)	12.50% (n=1)
More Informed (3-4)	75% (n=3)	0% (n=0)	25% (n=4)

Figure 7- Bar graph and detailed table showing the survey results of residents' level of information and their views on the industry's impact on community soil quality.

xii. Level of Information about Environmental and Health Problems from the Governmental Source

There was no statistical significance to the relationship between how informed respondents were about environmental and health problems from the governmental source and their views on the gas and oil industry's impact on community soil quality according to Fisher's exact test ($p=0.30$). 70.83% of those who were not informed by the governmental source ($n=17$) and 46.15% of those who were informed by the governmental source ($n=6$) agreed that the impact of the industry was negative.

xiii. Speed of Emergency Response from the Companies

There was statistical significance to the relationship between the speed of emergency response from the oil and gas company and respondents' views on the gas and oil industry's impact on community soil quality according to the least squares method ($p=0.01$). This means that the proportions of residents exhibiting negative, neutral and positive perception were different across different emergency response speeds. Specifically, the highest proportion of negative opinion was from people who felt that response was slow at 90.9% is nearly double the proportions for those who did not know (55.56%) and those who felt that response was immediate (47.06%). The proportions of residents who did not know and residents who felt that response was immediate with neutral opinions were virtually identical at 44.44% and 41.18%, respectively. Only residents who felt that response was immediate had any proportion of positive opinion, at 11.77%. This relationship can be seen in Figure 8.

Speed of Emergency Response	Negative Opinion	Neutral Opinion	Positive Opinion
Unknown	55.56% (n=5)	44.44% (n=4)	0% (n=0)
Slow response	90.90% (n=10)	9.09% (n=1)	0% (n=0)
Immediate response	47.06% (n=8)	41.18% (n=7)	11.77% (n=2)

Figure 8- Bar graph and detailed table showing the survey results relating the speed of emergency response to residents' views on the industry's impact on community soil quality.

xiv. Number of Benefits Received from the Industry

Using logistic regression, no statistical significance was detected to the relationship between the number of benefits respondents reported receiving from the gas and oil industry and their views on the industry's impact on community soil quality ($p=0.67$). Majority of responders (62.16 %, $n=23/37$) agreed that the impact on soil was negative and their average number of benefits of the oil and gas industry on the community was 3.13. The other proportions, means and SEM are listed in Table 17.

Table 17- Summary of the counts of responders, number of benefits they receive from the industry categorized by their views on the industry's impact on community soil quality.

Group Level	Number	Mean	St Error of the Mean
1 Negative	23	3.13	0.41
2 Neutral	12	3.25	0.59
3 Positive	2	4.00	0.00

D. Relationships Related to Perceptions of the Impact of the Oil and Gas Industry on Community Well-being

i. Employment Status

There was no statistical significance to the relationship between respondents' employment status at the oil and gas company and their views on the gas and oil industry's impact on community well-being according to Fisher's exact test ($p=0.08$). 88.89% of respondents who were employed at some time by the company ($n=8$), and 42.86% of respondents who were never employed by the company ($n=3$), and 40.91% of students ($n=9$) agreed that the impact of the industry was negative.

ii. Age

Using logistic regression, no statistical significance was detected to the relationship between respondents' ages and their views on the gas and oil industry's impact on community well-being ($p=0.38$). About a half of the responders (53.13%; $n=17/32$) agreed that the impact on the community well-being was negative; this group mean age was 37.00 years ± 2.82 SEM. Seven people (21.88 %) had a neutral opinion and their mean age was 25.86 ± 3.26 SEM. Eight people (25 %) with average age 35.50 years ± 5.33 SEM thought of positive impact of industry on the community well-being.

iii. Education

There was no statistical significance to the relationship between education and respondents' views on the gas and oil industry's impact on community well-being according to Fisher's exact test ($p=1.00$). 60% of respondents with a high school diploma or less ($n=3$) and 51.52% of respondents with a university degree or more ($n=17$) agreed that the industry's impact was negative.

iv. Occupation Level

There was no statistical significance to the relationship between respondents' occupation level and their views on the gas and oil industry's impact on community well-being according to Fisher's exact test ($p=0.32$). 60% of respondents who were employed ($n=15$), 40% of respondents who were unemployed ($n=4$), and 33.33% of students ($n=1$) agreed that the impact of the industry was negative.

v. Awareness about the Risks of Fires and Explosions

There was almost statistical significance to the relationship between respondents' awareness about the risks of fires and explosions and their views on the gas and oil industry's impact on community well-being according to Fisher's exact test ($p=0.08$). This means that the proportions of residents exhibiting negative, neutral and positive perception were different across different levels of awareness. Specifically, the majority of negative opinion holders was nearly identical between those who were unaware and those who were aware with experience, at 77.78% and 80% respectively, while the proportion of those who were aware with no experience was nearly half that at 37.5%. The proportions of those who were unaware and those who were aware with no experience that held neutral opinions were nearly identical (22.22% and 25%, respectively), while none of those who were aware with experience held a neutral opinion. None of those who were unaware, 37.5% of those who were aware with no experience, and 20% of those who were aware with experience held positive opinions. This relationship can be seen in Figure 9.

Awareness about risks of fires and explosions	Negative Opinion	Neutral Opinion	Positive Opinion
Unaware	77.78% (n=7)	22.22% (n=2)	0% (n=0)
Aware with no experience	37.50% (n=9)	25% (n=6)	37.50% (n=9)
Aware with experience	80% (n=4)	0% (n=0)	20% (n=1)

Figure 9- Bar graph and detailed table showing the survey results of residents' awareness about the risks of fires and explosions and their views on the industry's impact on community well-being.

vi. Awareness of Physical Injuries

There was no statistical significance to the relationship between respondents' awareness of physical injuries and their views on the gas and oil industry's impact on community well-being according to Fisher's exact test ($p=0.2814$). 60% of those who were unaware of physical injuries ($n=3$) and 53.13% of those who were aware of physical injuries ($n=17$) agreed that the impact of the industry was negative.

vii. Health Problems of Residents due to Pollution Experienced by Themselves, in Family and/or in Community

Logistic regression showed no relationship between the number of health problems in respondents' families and communities and their views on the gas and oil industry's impact on community well-being ($p=0.97$). Little more than a half of all responders ($n=20/36$; 55.56%) agreed that the impact on community well-being was negative. These individuals had on average 6.45 health issues, while the people with negative and positive opinion had similar number of health issues reported (7.00 and 6.22, respectively). The relevant summary statistics are listed in Table 18.

Table 18- Summary of the counts of responders, number of health problems in residents' families and communities categorized by their views on the industry's impact on community well-being.

Group Level	Number	Mean	St Error of the Mean
1 Negative	20	6.45	0.88
2 Neutral	7	7.00	0.95
3 Positive	9	6.22	0.85

viii. Experience with Environmental and Health Hazards

There was no statistical significance to the relationship between respondents' experience with environmental and health hazards and their views on the gas and oil industry's impact on community well-being according to Fisher's exact test ($p=0.54$). 54.84% of those without experience with environmental and health hazards ($n=17$) and 42.86% of those with experience with environmental and health hazards ($n=3$) agreed that the impact of the industry was negative.

ix. Number of Individual Health Issues

Using logistic regression, no statistical significance was detected to the relationship between the number of health issues suffered by respondents and their views on the gas and oil industry's impact on community well-being ($p=0.75$). 52.63% of all respondents ($n=20/38$) agreed that the

impact on community well-being was negative and had reported on average almost three health issues (2.95). People who had positive outlook on the impact of industry on the community well-being (n=10; 26.32 %) had on average 3.30 individual health issues reported. The relevant summaries can be found in Table 19.

Table 19- Summary of the counts of responders, number of health problems suffered by respondents categorized by their views on the industry's impact on community well-being.

Group Level	Number	Mean	St Error of the Mean
1 Negative	20	2.95	0.65
2 Neutral	8	1.38	0.63
3 Positive	10	3.30	0.56

x. Cancer

There was no statistical significance to the relationship between whether respondents had been diagnosed with cancer and their views on the gas and oil industry's impact on community well-being according to the weighted least squares method ($p=0.11$). 48% of respondents without cancer (n=25) and 63.63% of respondents with cancer (n=11) agreed that the impact of the industry was negative.

xi. Level of Information about Environmental and Health Problems from Non-governmental Sources

There was statistical significance to the relationship between how informed respondents were about environmental and health problems from non-governmental sources and their views on the gas and oil industry's impact on community well-being according to Fisher's exact test ($p=0.0007$). This means that the proportions of residents exhibiting negative, neutral and positive perception were different across different levels of communication modes. Specifically, the proportion of uninformed residents with negative opinions was nearly identical to that of moderately informed residents with positive opinions (70.37% and 71.43%, respectively), while no moderately informed residents had negative opinions and just 11.11% of uninformed

residents felt positively. The proportion of neutral opinions across all levels of informedness was fairly similar at 18.52% for uninformed residents, 28.57% for moderately informed residents and 25% for well-informed residents. This relationship can be seen in Figure 10.

Communication	Negative Opinion	Neutral Opinion	Positive Opinion
Less Informed (0-1)	70.37% (n=19)	18.52% (n=5)	11.11% (n=3)
Moderately Informed (2)	0% (n=0)	28.57% (n=2)	71.43% (n=5)
More Informed (3-4)	25% (n=1)	25% (n=1)	50% (n=2)

Figure 10- Bar graph and detailed table showing the survey results of residents' level of information and their views on the industry's impact on community well-being.

xii. Level of Information about Environmental and Health Problems from the Governmental Source

There was no statistical significance to the relationship between how informed respondents were about environmental and health problems from the governmental source and their views on the gas and oil industry's impact on community well-being according to Fisher's exact test ($p=0.17$). 60% of those who were not informed by the governmental source ($n=15$) and 38.56%

of those who were informed by the governmental source (n=5) agreed that the impact of the industry was negative.

xiii. Speed of Emergency Response by the Companies

There was no statistical significance to the relationship between the speed of emergency response from the oil and gas company and respondents' views on the gas and oil industry's impact on community well-being according to the least squares method ($p=0.71$). 30% of those who did not know (n=3), 63.63% of those who said emergency response was slow (n=7), and 58.82% of those who said emergency response was immediate (n=10) agreed that the impact of the industry was negative.

xiv. Number of Benefits Received from the Industry

Using logistic regression, no statistical significance was detected to the relationship between the number of benefits respondents reported receiving from the gas and oil industry and their views on the industry's impact on community well-being ($p=0.62$). About a half of the responders (n=20/38, 52.63 %) agreed that the impact on community well-being was negative, while listed about 3.15 benefits of the oil and gas industry to the community well-being. This average was not very different from the other two opinion groups, (mean 2.60 and 3.70 benefits listed for neutral and positive group, respectively).

E. Relationships Related to a Respondent's Concerns about Personal Exposure to Air Pollution from Oil and Natural Gas Extraction

i. Occupation Level

There was no statistical significance to the relationship between respondents' occupation level and their concern about their personal exposure to air pollution from oil and gas activities according to Fisher's exact test ($p=0.31$). 64.71% of respondents who were employed ($n=11$) and 80% of respondents who were unemployed ($n=20$) were worried about the impact of the industry.

ii. Age

Using logistic regression, no relationship was detected between the age of the respondent and their concern about their personal exposure to air pollution from oil and gas activities ($p=0.56$). Minority of residents who did not worry about the air pollution ($n=3/36$; 8.33%) were on average 34.33 years old (± 10.48 SEM) and majority of people who did worry about their personal exposure to air pollution were of similar age, 34.09 years old (± 2.27 SEM).

iii. Education

There was no statistical significance to the relationship between education and respondents' concern about their personal exposure to air pollution from oil and gas activities according to Fisher's exact test ($p=1.00$). 85.71% of respondents with a high school diploma or less ($n=6$) and 71.43% of respondents with a university degree or more ($n=25$) were worried about the impact of the industry.

iv. Occupation Level

There was no statistical significance to the relationship between respondents' occupation level and their concern about their personal exposure to air pollution from oil and gas activities

according to Fisher's exact test ($p=0.25$). 66.67% of respondents who were employed ($n=18$), 90.91% of respondents who were unemployed ($n=10$), and 75% of students ($n=3$) were worried about the impact of the industry.

v. Awareness about the Risks of Fires and Explosions

There was no statistical significance to the relationship between respondents' awareness about the risks of fires and explosions and their concern about their personal exposure to air pollution from oil and gas activities according to Fisher's exact test ($p=0.43$). 70% of those who were unaware ($n=7$), 77.78% of those who were aware but had no experience with fires or explosions ($n=21$), and 60% of those who were aware and had experience with fires or explosions ($n=3$) were worried about the impact of the industry.

vi. Awareness of Physical Injuries

There was no statistical significance to the relationship between respondents' awareness of physical injuries and their concern about their personal exposure to air pollution from oil and gas activities according to Fisher's exact test ($p=1.00$). 85.71% of those who were unaware of physical injuries ($n=6$) and 70.59% of those who were aware of physical injuries ($n=24$) were worried about the impact of the industry.

vii. Number of Health Problems in Families and Communities

Logistic regression showed no relationship between the number of health problems in respondents' families and communities and their concern about their personal exposure to air pollution from oil and gas activities ($p=0.12$). Only three people (7.50%) did not worry about the exposure to air pollution and their average number of reported health problems in family or community was 3.67, while it was almost a double number of health issues (6.59 on average) for those who worried ($n=37/40$; 92.5 %). The relevant summaries can be found in Table 20.

Table 20- Summary of the counts of responders, number of health problems in residents' families and communities and their concern about personal exposure to air pollution.

Group Level	Number	Mean	St Error of the Mean
1 Not worried	3	3.67	0.33
2 Worried	37	6.59	0.55

viii. Experience with Environmental and Health Hazards

There was no statistical significance to the relationship between respondents' experience with environmental and health hazards and their concern about their personal exposure to air pollution from oil and gas activities according to Fisher's exact test ($p=1.00$). 91.18% of those without experience with environmental and health hazards ($n=31$) and 100% of those with experience with environmental and health hazards ($n=8$) were worried about the impact of the industry.

ix. Number of Individual Health Issues

Using logistic regression, no statistical significance was detected to the relationship between the number of health issues suffered by respondents and their concern about their personal exposure to air pollution from oil and gas activities ($p=0.24$). The responders who did no worry about the health hazards from the air pollution (3/42; 7.14%) had on average about 4.00 health issues, while the people who worried (39/42, 92.86 %) had on average 2.59 individual health issues. The summary can be found in Table 21.

Table 21- Summary of the counts of responders and number of health problems they suffered by respondents categorized by their concern about personal exposure to air pollution.

Group Level	Number	Mean	St Error of the Mean
1 Not worried	3	4.00	1.53
2 Worried	39	2.59	0.38

x. Cancer

There was no statistical significance to the relationship between whether respondents had been diagnosed with cancer and their concern about their personal exposure to air pollution from oil and gas activities according to the Chi-Square test ($p=0.24$). 89.29% of respondents without cancer ($n=25$) and 100% of respondents with cancer ($n=12$) were worried about the impact of the industry.

xi. Level of Information about Environmental and Health Problems from Non-governmental Sources

There was no statistical significance to the relationship between how informed respondents were about environmental and health problems from non-governmental sources and their concern about their personal exposure to air pollution from oil and gas activities according to Fisher's exact test ($p=1.00$). 93.10% of those who were less informed (0-1 modes of communication, $n=27$), 88.89% of those who were moderately informed (2 modes of communication, $n=8$), and 100% of those who were more informed (3-4 modes of communication, $n=4$) were worried about the impact of the industry.

xii. Level of Information about Environmental and Health Problems from the Governmental Source

There was no statistical significance to the relationship between how informed respondents were about environmental and health problems from the governmental source and their concern about their personal exposure to air pollution from oil and gas activities according to Fisher's exact test ($p=0.2866$). 96.30% of those who were not informed by the governmental source ($n=26$) and 86.67% of those who were informed by the governmental source ($n=13$) were worried about the impact of the industry.

xiii. Speed of Emergency Response from the Companies

There was statistical significance to the relationship between the speed of emergency response from the oil and gas company and respondents' views on the gas and oil industry's impact on community water quality according to Fisher's exact test ($p=0.03$). This means that the proportions of residents exhibiting negative, neutral and positive perception were different across different emergency response speeds. Specifically, the only group that had any proportion of respondents who were not worried was the group that felt response was slow, at 25%. 100% of those who did not know, 75% of those who felt response was slow and 100% of those who felt response was immediately held positive opinions. This relationship can be seen in Figure 11.

Speed of emergency response	Not worried	Worried
Unknown	0% (n=0)	100% (n=11)
Slow response	25% (n=3)	75% (n=9)
Immediate response	0% (n=0)	100% (n=19)

Figure 11- Bar graph and detailed table showing the survey results of the speed of emergency response and residents' concern about their personal exposure to air pollution.

xiv. Number of Benefits Received from the Industry

Using logistic regression, no statistical significance was detected to the relationship between the number of benefits respondents reported receiving from the gas and oil industry and concern about their personal exposure to air pollution from oil and gas activities ($p=0.10$). Respondents who did not worry ($n=3/42$; 7.14 %) had reported on average 1.33 benefits, while residents who did worry about the air pollution ($n=29/42$; 92.86 %) had reported on average about three times more of the benefits of the not worried group. The summaries are in Table 22.

Table 22- Summary of the counts of responders, number of benefits they receive from the industry and their concern about personal exposure to air pollution.

Group Level	Number	Mean	St Error of the Mean
1 Not worried	3	1.33	0.33
2 Worried	39	3.10	0.31

F. Relationships Related to a Respondent's Concerns about Personal Exposure to Water Pollution from Oil and Natural Gas Extraction

i. Occupation Level

There was statistical significance to the relationship between respondents' occupation level and their concern about their personal exposure to water pollution from oil and gas activities according to Fisher's exact test ($p=0.02$). This means that the proportions of residents exhibiting negative, neutral and positive perception were different across different occupation levels. Specifically, while no proportion of the employed respondents were worried, just 12% of student respondents were worried. Respondents who were unemployed were evenly split between worried and not worried. The great majority of employed and student respondents were not worried, at 100% and 88%, respectively. This relationship can be seen in Figure 12.

Occupation level	Worried	Not worried
Employed	0% (n=0)	100% (n=9)
Unemployed	50% (n=4)	50% (n=4)
Student	12% (n=3)	88% (n=22)

Figure 12- Bar graph and detailed table showing the survey results of respondents' occupation level and their concern about their personal exposure to water pollution.

ii. Age

Using logistic regression, no relationship was detected between the age of the respondent and their concern about their personal exposure to water pollution from oil and gas activities ($p=0.59$). Responders, who were not worried about the effect of the water pollution on their health ($n=7/36$; 19.44 %) were on average 34.14 year old ± 6.65 SEM, while the group of responders, which expressed fear of the water pollution on their health were of similar age, 34.10 ± 2.29 years old on average.

iii. Education

There was no statistical significance to the relationship between education and respondents' concern about their personal exposure to water pollution from oil and gas activities according to Fisher's exact test ($p=0.73$). 57.14% of respondents with a high school diploma or less ($n=4$) and 57.14% of respondents with a university degree or more ($n=20$) were worried about the impact of the industry.

iv. Occupation Level

There was no statistical significance to the relationship between respondents' occupation level and their concern about their personal exposure to water pollution from oil and gas activities according to Fisher's exact test ($p=0.15$). 66.67% of respondents who were employed ($n=18$), 45.45% of respondents who were unemployed ($n=5$), and 25% of respondents who were students ($n=1$) were worried about the impact of the industry.

v. Awareness about the Risks of Fires and Explosions

There was no statistical significance to the relationship between respondents' awareness about the risks of fires and explosions and their concern about their personal exposure to water pollution from oil and gas activities according to Fisher's exact test ($p=0.75$). 50% of those who were unaware ($n=5$), 55.56% of those who were aware but had no experience with fires or explosions ($n=27$), and 80% of those who were aware and had experience with fires or explosions ($n=4$) were worried about the impact of the industry.

vi. Awareness of Physical Injuries

There almost statistical significance to the relationship between respondents' awareness of physical injuries and their concern about their personal exposure to water pollution from oil and gas activities according to Fisher's exact test ($p=0.08$). This means that the proportions of residents exhibiting negative, neutral and positive perception were different across different levels of awareness. The proportion of respondents who were aware and not concerned (11.76%) was nearly a quarter of the proportion of those who were unaware and not concerned (42.86%). Alternatively, 88.24% of those who were aware were concerned, compared to 57.14% of those who were not aware. This relationship can be seen in Figure 13.

Awareness of physical injuries	Not concerned	Concerned
Unaware of physical injuries	42.86% (n=3)	57.14% (n=4)
Aware of physical injuries	11.76% (n=4)	88.24% (n=30)

Figure 13- Bar graph and detailed table showing the survey results of residents' awareness of physical injuries and their concern about their personal exposure to water pollution.

vii. Health Problems of Residents due to Pollution Experienced by Themselves, in Family and/or in Community

Logistic regression showed no relationship between the number of health problems in respondents' families and communities and their concern about their personal exposure to water pollution from oil and gas activities ($p=0.64$). Seven people (17.50%), who did not worry about the water pollution from the oil industry possibly affecting their health reported on average 5.90 health issues in family or community. Thirty three people (33/40; 82.50 %) who worried about water pollution from the oil industry possibly affecting their health reported on average 6.50 health issues in family or community. The relevant details can be found in Table 23.

Table 23- Summary of the counts of responders and their number of health problems in residents' families and communities categorized by their concern about personal exposure to water pollution.

Group Level	Number	Mean	St Error of the Mean
Not worried	7	5.86	1.08
Worried	33	6.48	0.59

viii. Experience of the Environment and Health Hazards

There was no statistical significance to the relationship between how much experience respondents have had with the environmental and health hazards and their concern about their personal exposure to water pollution from oil and gas activities according to Fisher's exact test ($p=0.60$). 85.29% of those who had no experience with environmental and health hazards ($n=29/34$) and 75% of those who had experience with environmental and health hazards ($n=6/8$) were worried about the impact of the industry.

ix. Number of Individual Health Issues

Using logistic regression, no statistical significance was detected to the relationship between the number of health issues suffered by respondents and their concern about their personal exposure to water pollution from oil and gas activities ($p=0.20$). Responders who did not worry ($n=7/42$; 16.67 %) about the water pollution and their health, had on average 3.57 individual health issues, while the group who worried ($n=35$). The relevant regression data can be found in Table 24.

Table 24- Summary of the counts of responders, their number of health problems suffered by respondents and their concern about their personal exposure to water pollution.

Group Level	Number	Mean	St Error of the Mean
1 Not worried	7	3.57	0.78
2 Worried	35	2.51	0.42

x. Cancer

There was no statistical significance to the relationship between whether respondents had been diagnosed with cancer and their concern about their personal exposure to water pollution from oil and gas activities according to the Chi-Square test ($p=0.41$). 85.71% of respondents without cancer ($n=24$) and 75% of respondents with cancer ($n=9$) were worried about the impact of the industry.

xi. Level of Information about Environmental and Health Problems from Non-governmental Sources

There was no statistical significance to the relationship between how informed respondents were about environmental and health problems from non-governmental sources and their concern about their personal exposure to water pollution from oil and gas activities according to Fisher's exact test ($p=0.15$). 89.66% of those who were less informed (0-1 modes of communication, $n=26$), 66.67% of those who were moderately informed (2 modes of communication, $n=6$), and 75% of those who were more informed (3-4 modes of communication, $n=3$) were worried about the impact of the industry.

xii. Level of Information about Environmental and Health Problems from the Governmental Source

There was no statistical significance to the relationship between how informed respondents were about environmental and health problems from the governmental source and their concern about their personal exposure to water pollution from oil and gas activities according to Fisher's exact test ($p=0.69$). 85.19% of those who were not informed by the governmental source ($n=23$) and 80% of those who were informed by the governmental source ($n=12$) were worried about the impact of the industry.

xiii. Speed of Emergency Response from the Companies

There was no statistical significance to the relationship between the speed of emergency response from the oil and gas company and respondents' concern about their personal exposure to water pollution from oil and gas activities according to Fisher's exact test ($p=0.57$). 90.91% of those who did not know ($n=10$), 75% of those who said emergency response was slow ($n=9$), and 84.21% of those who said emergency response was immediate ($n=16$) were worried about the impact of the industry.

xiv. Number of Benefits Received from the Industry

Using logistic regression, no statistical significance was detected to the relationship between the number of benefits respondents reported receiving from the gas and oil industry and concern about their personal exposure to water pollution from oil and gas activities ($p=0.53$). Resident who did not worry about the water pollution affecting their health ($n=7/42$, 16.67%) reported on average 2.60 benefits of the gas and oil industry to the community, while the residents who worried ($n=35/42$; 83.33%) reported 3.1 benefits on average, Table 25.

Table 25- Summary of the counts of responders, number of benefits respondents receive from the industry and their concern about their personal exposure to water pollution.

Group Level	Number	Mean	St Error of the Mean
Not concerned	7	2.57	0.48
Concerned	35	3.06	0.34

G. Relationships Related to a Respondent's Concerns about Personal Exposure to Land Pollution from Oil and Natural Gas Extraction

i. Employed by Saudi Aramco

There was no statistical significance to the relationship between respondents' employment by the oil and gas company and their concern about their personal exposure to land pollution from oil and gas activities according to Fisher's exact test ($p=0.74$). 58.82% of respondents who were employed at some time by the company ($n=10$) and 62.5% of respondents who were never employed by the company ($n=15$) were worried about the impact of the industry.

ii. Age

Using logistic regression, no relationship was detected between the age of the respondent and their concern about their personal exposure to the land pollution from oil and gas activities ($p=0.79$). Responders, who were not worried about the effect of the land pollution on their health ($n=6/35$; 17.14 %) were on average 31.83 years old ± 5.79 SEM, while the group of responders, which expressed fear of the land pollution on their health were on average 34.21 ± 2.47 years old.

iii. Education

There was no statistical significance to the relationship between education and respondents' concern about their personal exposure to land pollution from oil and gas activities according to Fisher's exact test ($p=0.37$). 42.86% of respondents with a high school diploma or less ($n=3$) and 64.71% of respondents with a university degree or more ($n=22$) were worried about the impact of the industry.

iv. Occupation Level

There was no statistical significance to the relationship between respondents' occupation level and their concern about their personal exposure to land pollution from oil and gas activities according to Fisher's exact test ($p=0.39$). 61.54% of respondents who were employed ($n=16$), 72.73% of respondents who were unemployed ($n=8$), and 25% of respondents who were students ($n=1$) were worried about the impact of the industry.

v. Awareness about the Risks of Fires and Explosions

There was no statistical significance to the relationship between respondents' awareness about the risks of fires and explosions and their concern about their personal exposure to land pollution from oil and gas activities according to Fisher's exact test ($p=0.72$). 50% of those who were unaware ($n=5$), 65.38% of those who were aware but had no experience with fires or explosions ($n=26$), and 60% of those who were aware and had experience with fires or explosions ($n=3$) were worried about the impact of the industry.

vi. Awareness of Physical Injuries

There was no statistical significance to the relationship between respondents' awareness of physical injuries and their concern about their personal exposure to land pollution from oil and gas activities according to Fisher's exact test ($p=1.00$). 71.43% of those who were unaware of risks of physical injuries ($n=5/7$) and 58.82% of those who were not aware of risks of physical injuries ($n=20/34$) were worried about the impact of the industry on health through the land pollution.

vii. Health Problems of Residents due to Pollution Experienced by Themselves, in Family and/or in Community

Logistic regression showed no relationship between the number of health problems in respondents' families and communities and their concern about their personal exposure to land pollution from oil and gas activities ($p=0.41$). Seven responders (7/40; 17.50%) were not worried about the impact of the industry on health risks through the land pollution, with an average number of health issues in family and community 7.29, while those that worried (33/40; 82.50%) had reported on average 6.18 health issues (Table 26).

Table 26- Summary of the counts of responders and their number of health problems in residents' families and communities and their concern about their personal exposure to land pollution.

Group Level	Number	Mean	St Error of the Mean
1 Not worried	7	7.29	1.13
2 Worried	33	6.18	0.58

viii. Experience with Environmental and Health Hazards

There was no statistical significance to the relationship between respondents' experience with environmental and health hazards and their concern about their personal exposure to land pollution from oil and gas activities according to Fisher's exact test ($p=0.31$). 78.79% of those without experience with environmental and health hazards ($n=26$) and 100% of those with experience with environmental and health hazards ($n=8$) were worried about the impact of the industry.

ix. Number of Individual Health Issues

Using logistic regression, no statistical significance was detected to the relationship between the number of health issues suffered by respondents and their concern about their personal exposure to land pollution from oil and gas activities ($p=0.80$). The mean response of the number of individual health issues were similar, specifically, in the group of responders who were not

concerned about the land pollution possibly affecting their health (7/41; 17.07 %) had reported on average 2.57 health issues, while the concerned residents (34/41; 82.93%) reported 2.76 health issues on average (Table 27).

Table 27- Summary of the counts of responders and their number of health problems suffered as well as their concern about their personal exposure to land pollution.

Group Level	Number	Mean	St Error of the Mean
1 Not worried	7	2.57	0.97
2 Worried	34	2.76	0.42

x. Cancer

There was almost statistical significance to the relationship between whether respondents had been diagnosed with cancer and their concern about their personal exposure to land pollution from oil and gas activities according to the Chi-Square test ($p=0.07$). This means that the proportions of residents who were worried or not were different depending on whether or not they had been diagnosed with cancer. Specifically, a full 25% of those without cancer were not concerned while 100% of respondents with cancer were concerned. This relationship can be seen in Figure 14.

Cancer diagnosis	Not concerned	Concerned
No cancer	25% (n=7)	75% (n=21)
Cancer	0% (n=0)	100% (n=11)

Figure 14- Bar graph and detailed table showing the survey results of whether or not respondents had been diagnosed with cancer and their concern about their personal exposure to soil pollution.

xi. Level of Information about Environmental and Health Problems from Non-governmental Sources

There was no statistical significance to the relationship between how informed respondents were about environmental and health problems from non-governmental sources and their concern about their personal exposure to land pollution from oil and gas activities according to Fisher's exact test ($p=0.31$). 75.86% of those who were less informed (0-1 modes of communication, $n=22$), 100% of those who were moderately informed (2 modes of communication, $n=8$), and 100% of those who were more informed (3-4 modes of communication, $n=4$) were worried about the impact of the industry.

xii. Level of Information about Environmental and Health Problems from the Governmental Source

There was no statistical significance to the relationship between how informed respondents were about environmental and health problems from the governmental source and their concern about their personal exposure to land pollution from oil and gas activities according to Fisher's exact test ($p=0.69$). 84.62% of those who were not informed by the governmental source ($n=22$) and 80% of those who were informed by the governmental source ($n=12$) were worried about the impact of the industry.

xiii. Speed of Emergency Response

There was no statistical significance to the relationship between the speed of emergency response from the oil and gas company and respondents' concern about their personal exposure to land pollution from oil and gas activities according to Fisher's exact test ($p=0.47$). 70% of those who did not know ($n=7$), 83.33% of those who said emergency response was slow ($n=10$), and 89.47% of those who said emergency response was immediate ($n=17$) were worried about the impact of the industry.

xiv. Number of Benefits Received from the Industry

Using logistic regression, no statistical significance was detected to the relationship between the number of benefits respondents reported receiving from the gas and oil industry and concern about their personal exposure to land pollution from oil and gas activities ($p=0.17$). Resident who did not worry about the water pollution affecting their health ($n=7/41$, 17.07%) reported on average 2.14 benefits of the gas and oil industry to the community, while the residents who worried ($n=34/41$; 82.93%) reported 3.21 benefits on average, Table 28.

Table 28- Summary of counts of respondents and the number of benefits respondents receive from the industry and their concern about their personal exposure to land pollution.

Group Level	Number	Mean	St Error of the Mean
1 Not worried	7	2.14	0.46
2 Worried	34	3.21	0.34

Results for all of the analyses for the residents are summarized in Table 29.

Table 29- Summary table of results for residents of Jubail. Asterisk (*) indicates the p-value less or equal than 0.05, the paragraph (§) indicates the trend (greater than 0.05 but less than 0.1) .

Independent variables	Dependent Variables						
	Opinion about impact of oil and gas industry on environmental and community components				Concern about the oil and gas industry on health risks associated with pollution of components		
	Air	Water	Soil	Well-Being	Air	Water	Land
Employment by the oil and gas company	0.20	0.01*	1.00	0.08	0.31	0.02*	0.74
Age	0.22	0.17	0.21	0.38	0.56	0.59	0.79
Education	0.63	0.71	1.00	1.00	1.00	0.73	0.37
Occupation level	0.44	0.83	0.05*	0.32	0.25	0.15	0.39
Awareness about the risks of fires and explosions	0.44	0.19	0.44	0.08 §	0.43	0.75	0.72
Awareness of physical injuries	0.64	0.03*	0.69	0.28	1.00	0.08 §	1.00
Health problems of residents due to pollution experienced on themselves, in family and/or in community	0.96	0.20	0.55	0.97	0.12	0.64	0.41
Experience with environmental and health hazards	0.68	0.28	0.64	0.54	1.00	0.60	0.31
Number of individual health issues	0.17	0.45	0.80	0.75	0.24	0.20	0.80
Cancer	0.43	0.67	0.40	0.25	0.24	0.41	0.07 §
Level of information about environmental and health problems from non-governmental sources	0.01*	0.06 §	0.02*	0.001*	1.00	0.15	0.31
Number of modes of communication about environmental and health problems from the governmental source	0.79	0.19	0.30	0.17	0.29	0.69	0.69
Speed of emergency response	0.38	0.29	0.01*	0.71	0.03*	0.57	0.47
Number of benefits received from the industry	0.82	0.44	0.67	0.62	0.1	0.53	0.17

H. Qualitative Data Collected from the Residents of Jubail

The distribution of responses to the question about what the residents learned from the Saudi Aramco Environmental Protection department is summarized in Figure 15. However, only 47.6% (20 residents of 42) answered this question.

What did you learn from Saudi Aramco Environmental Protection Department?		
Learned nothing	65%	13/20
Learned about personal protection	20%	4/20
Do not know	10%	2/20
Protecting environment	5%	1/20

Figure 15 - Pie chart and detailed table showing the qualitative survey results of what residents had learned from the Saudi Aramco Environmental Protection Department.

5.2. Awareness and Risk Assessment of Hazards Associated with the Oil and Gas Industry, Saudi Aramco Representative (n=11) Survey Results

A. Relationships Related to Perceptions of the Impact of the Oil and Gas Industry on Air Quality

i. Age

Using logistic regression, no statistical significance was detected to the relationship between respondents' age and their views on the gas and oil industry's impact on community air quality ($p=0.63$). The average age of the eighty percent of respondents ($n=8/10$) who agreed that the impact was negative was 47 years.

ii. Education

Statistical analysis was not applicable to this variable because all of the employee respondents had a high school diploma or above, belonging to only one category. About 82 ($n=9/11$) agreed that the impact of the industry was negative.

iii. Individual Health Issues

Using logistic regression, no statistical significance was detected to the relationship between the number of health issues suffered by respondents and their views on the gas and oil industry's impact on community air quality ($p=0.63$). Average number of individual health issues reported by the employees who had a negative opinion ($9/11$; 82%) about the impact of industry on air quality, was 2.7.

iv. Cancer

There was no statistical significance to the relationship between whether respondents had been diagnosed with cancer and their views on the gas and oil industry's impact on community

air quality according to Fisher's exact test ($p=1.00$). 80% of those without cancer ($n=8$) and 100% of those with cancer ($n=1$) agreed that the impact of the industry was negative.

v. Communication about Environmental and Health Risks Directed to Residents from the Public and Saudi Aramco

There was no statistical significance to the relationship between the level of communication about environmental and health risks from non-governmental sources and respondents' views on the gas and oil industry's impact on community air quality according to Fisher's exact test ($p=0.55$). 100% of those who were less informed (0-1 modes of communication, $n=5$), 60% of those who were moderately informed (2 modes of communication, $n=3$), and 100% of those were more informed (3-4 modes of communication, $n=1$) felt that the impact of the industry was negative.

vi. Communication about Environmental and Health Risks Directed to Residents from the Government

There was no statistical significance to the relationship between the level of communication about environmental and health risks from the governmental source and respondents' views on the gas and oil industry's impact on community air quality according to Fisher's exact test ($p=1.00$). 77.78% of those who had not received communication from the governmental source ($n=7$) and 100% of those who had ($n=2$) agreed that the impact of the industry was negative.

vii. Speed of Emergency Response by the Companies

There was no statistical significance to the relationship between the speed of emergency response of the company and respondents' views on the gas and oil industry's impact on community air quality according to Fisher's exact test ($p=1.00$). 100% of those who felt that the response was not immediate ($n=1$) and 80% of those who felt that the response was immediate ($n=8$) agreed that the impact of the industry was negative.

viii. Awareness of Policies to Combat Negative Effects of the Industry on Environment and Community Well-being

There was no statistical significance to the relationship between awareness of policies to combat negative effects of the industry on the environment and community well-being and respondents' views on the gas and oil industry's impact on community air quality according to Fisher's exact test ($p=0.38$). 50% of those who were not aware of the policies ($n=1$) and 87.50% of those who were aware of the policies ($n=7$) agreed that the impact of the industry was negative.

ix. Methods of Regulation Enforcement

There was no statistical significance to the relationship between respondents' awareness of the number of methods used to enforce regulations and their views on the gas and oil industry's impact on community air quality according to Fisher's exact test ($p=1.00$). 80% of those who were aware of 0-1 methods ($n=4$) and 75% of those who were aware of 2-4 methods ($n=3$) agreed that the impact of the industry was negative.

x. Practices Based on OSHA Standards in Crude Oil Refining Processes Applied by Saudi Aramco

There was no statistical significance to the relationship between how well respondents felt the company adhered to OSHA standards and their views on the gas and oil industry's impact on community air quality according to Fisher's exact test ($p=1.00$). Ninety one percent of all employees (10/11) thought the practices in refining processes were sufficient and eighty percent of them (8/10) had a negative outlook on their company's impact on the environmental air.

xi. Awareness of Fires and Explosions from Job Experience

There was no statistical significance to the relationship between respondents' awareness of the risk of fires and explosions and their views on the gas and oil industry's impact on

community air quality according to Fisher's exact test ($p=1.00$). 100% of those who were unaware ($n=3$) and 71.43% of those who were aware ($n=5$) agreed that the impact of the industry was negative.

xii. Awareness of Physical Injuries from Job Experience

There was no statistical significance to the relationship between respondents' awareness of physical injuries their views on the gas and oil industry's impact on community air quality according to Fisher's exact test ($p=1.00$). 100% of those who were aware ($n=3$) and 66.67% of those who were unaware ($n=4$) agreed that the impact of the industry was negative.

xiii. Communication about Environmental and Health Risks Directed to Field Workers from Saudi Aramco

There was no statistical significance to the relationship between the level of communication about environmental and health risks directed at field workers by the company and their views on the gas and oil industry's impact on community air quality according to Fisher's exact test ($p=0.49$). 50% of those who were less informed (0-1 modes of communication, $n=1$), 100% of those who were moderately informed (2 modes of communication, $n=1$), and 87.50% of those who were more informed (3-4 modes of communication, $n=7$) agreed that the impact of the industry was negative.

xiv. Communication about Environmental and Health Risks Directed to Field Workers from the Government

There was no statistical significance to the relationship between the level of communication about environmental and health risks directed at field workers by the government and their views on the gas and oil industry's impact on community air quality according to Fisher's exact test ($p=0.49$). 87.5% of those who had not received communication from the government ($n=7$) and 66.67% of those who had ($n=2$) agreed that the impact of the industry was negative.

xv. Training and Environmental Safety Practices from SA to Field Workers

There was no statistical significance to the relationship between respondents' ratings of the training and environmental safety practices of Saudi Aramco and their views on the gas and oil industry's impact on community air quality according to Fisher's exact test ($p=0.18$). Ninety percent of employees (9/10) who thought their environmental safety training was sufficient also reported negative attitude towards the oil and gas company's impact on air quality. Only one person who thought the training was not sufficient reported the impact being positive.

xvi. Production Knowledge of SA Workers

There was no statistical significance to the relationship between respondents' ratings of the production knowledge given by Saudi Aramco and their views on the gas and oil industry's impact on community air quality according to Fisher's exact test ($p=0.18$).

xvii. Employee Utilization of Environmental Health and Safety Training on the Job

There was no statistical significance to the relationship between respondents' utilization of environmental health and safety training on the job and their views on the gas and oil industry's impact on community air quality according to Fisher's exact test ($p=0.35$). Fifty percent of those who had reported the utilization of the training was insufficient ($n=1/2$) and 88.89% of those who had thought the utilization was sufficient ($n=8/9$) agreed that the impact of the industry was negative.

B. Relationships Related to Perceptions of the Impact of the Oil and Gas Industry on Water Quality

i. Age

Using logistic regression, no statistical significance was detected to the relationship between respondents' ages and their views on the gas and oil industry's impact on community water quality ($p=0.95$). Average age of the 70 % of employees who had a negative outlook on the impact on water quality was 46 years, and 59 and 28 years for those with neutral and positive outlook, respectively.

ii. Education

Statistical analysis was not applicable to this variable because all of the employee respondents had a high school diploma or above, belonging to only one category. About 83% ($n=8/11$) agreed that the impact of the industry was negative.

iii. Individual Health Issues

Using logistic regression, no statistical significance was detected to the relationship between the number of health issues suffered by respondents and their views on the gas and oil industry's impact on community water quality ($p=0.32$). The average number of individual health issues reported by both groups with positive and negative statement of the impact on water was 3, while there were zero health issues reported by the two individuals with neutral opinion.

iv. Cancer

There was no statistical significance to the relationship between whether respondents had been diagnosed with cancer and their views on the gas and oil industry's impact on community water quality according to Fisher's exact test ($p=1.00$). 70% of those without cancer ($n=7$) and 100% of those with cancer ($n=1$) agreed that the impact of the industry was negative.

v. Communication About Environmental and Health Risks Directed to the Residents from the Public and Saudi Aramco

There was no statistical significance to the relationship between the level of communication about environmental and health risks from non-governmental sources and respondents' views on the gas and oil industry's impact on community water quality according to Fisher's exact test ($p=1.00$). 80% of those who were less informed (0-1 modes of communication, $n=4$), 60% of those who were moderately informed (2 modes of communication, $n=3$), and 100% of those were more informed (3-4 modes of communication, $n=1$) felt that the impact of the industry was negative.

vi. Communication About Environmental and Health Risks Directed to Residents from the Government

There was no statistical significance to the relationship between the level of communication about environmental and health risks from the governmental source and respondents' views on the gas and oil industry's impact on community water quality according to Fisher's exact test ($p=1.00$). 66.67% of those who had not received communication from the governmental source ($n=6$) and 100% of those who had ($n=2$) agreed that the impact of the industry was negative.

vii. Speed of Emergency Response by the Companies

There was no statistical significance to the relationship between the speed of emergency response of the company and respondents' views on the gas and oil industry's impact on community water quality according to Fisher's exact test ($p=1.00$). 100% of those who felt that the response was not immediate ($n=1$) and 70% of those who felt that the response was immediate ($n=7$) agreed that the impact of the industry was negative.

viii. Awareness of Policies to Combat Negative Effects of the Industry on the Environment and Community Well-being

There was no statistical significance to the relationship between respondents' awareness of policies to combat negative effects of the industry on the environment and community well-being and their views on the gas and oil industry's impact on community water quality according to Fisher's exact test ($p=0.22$). 50% of those who were unaware of such policies ($n=1$) and 75% of those who were aware ($n=6$) agreed that the impact of the industry was negative.

ix. Methods of Regulations to Follow the Law

There was no statistical significance to the relationship between respondents' awareness of the number of methods used to enforce regulations and their views on the gas and oil industry's impact on community water quality according to Fisher's exact test ($p=1.00$). 60% of those who were aware of 0-1 methods ($n=3$) and 75% of those who were aware of 2-4 methods ($n=3$) agreed that the impact of the industry was negative.

x. Practices Based on OSHA Standards in the Crude Oil Refining Processes Applied by SA

There was no statistical significance to the relationship between how well respondents felt the company adhered to OSHA standards and their views on the gas and oil industry's impact on community water quality according to Fisher's exact test ($p=1.00$). Ninety one percent of all employees (10/11) thought the practices in refining processes were sufficient and seventy percent of them (8/10) had a negative outlook on their company's impact on the environmental air. Only one person thought the practices were insufficient and also had a negative outlook on the company's impact on the water quality.

xi. Awareness of Fires and Explosions from Job Experience

There was no statistical significance to the relationship between respondents' awareness of the risk of fires and explosions and their views on the gas and oil industry's impact on community water quality according to Fisher's exact test ($p=0.65$). 100% of those who were unaware ($n=3$) and 57.14% of those who were aware ($n=4$) agreed that the impact of the industry was negative.

xii. Awareness of Physical Injuries from Job Experience

There was no statistical significance to the relationship between respondents' awareness of physical injuries their views on the gas and oil industry's impact on community water quality according to Fisher's exact test ($p=1.00$). 100% of those who were aware ($n=3$) and 66.67% of those who were unaware ($n=4$) agreed that the impact of the industry was negative.

xiii. Communication about Environmental and Health Risks Directed to Field Workers from Saudi Aramco

There was no statistical significance to the relationship between the level of communication about environmental and health risks directed at field workers by the company and their views on the gas and oil industry's impact on community air quality according to Fisher's exact test ($p=0.43$). 50% of those who were less informed (0-1 modes of communication, $n=1$), 100% of those who were moderately informed (2 modes of communication, $n=1$), and 75% of those who were more informed (3-4 modes of communication, $n=6$) agreed that the impact of the industry was negative.

xiv. Communication about Environmental and Health Risks Directed to Field Workers from the Government

There was no statistical significance to the relationship between the level of communication about environmental and health risks directed at field workers by the government and their views

on the gas and oil industry's impact on community water quality according to Fisher's exact test ($p=0.32$). 75% of those who had not received communication from the government ($n=6$) and 66.67% of those who had ($n=2$) agreed that the impact of the industry was negative.

xv. Training and Environmental Safety Practices from SA to Field Workers

There was almost statistical significance to the relationship between respondents' ratings of the training and environmental safety practices of Saudi Aramco and their views on the gas and oil industry's impact on community water quality according to Fisher's exact test ($p=0.09$). This means that the proportions of company representatives exhibiting negative, neutral and positive perception were different across different ratings of the training and environmental safety practices. Specifically, the one employee who felt that training was bad had a positive opinion while none of the respondents who felt training was good had a positive opinion. 80% felt negatively and the other 20% were neutral. This relationship can be seen in Figure 16.

Figure 16 Bar graph and detailed table showing the survey results of the quality of training received by employees and their views on the industry's impact on community water quality.

Employee Training	Negative	Neutral	Positive
Bad training	0% (n=0)	0% (n=0)	100% (n=1)
Good Training	80% (n=8)	20% (n=2)	0% (n=0)

xvi. Production Knowledge of SA Workers

There was almost a statistical significance to the relationship between respondents' ratings of the production knowledge given by Saudi Aramco and their views on the gas and oil industry's impact on community air quality according to Fisher's exact test ($p=0.09$). This means that the proportions of company representatives exhibiting negative, neutral and positive perception were different across different ratings of the production knowledge provided by SA. Specifically, the one employee who felt that production knowledge was bad had a positive opinion while none of the respondents who felt production knowledge was good had a positive opinion. 80% felt negatively and the other 20% were neutral. This relationship can be seen in Figure 17.

Figure 17 Bar graph and detailed table showing the survey results of the production knowledge of employees and their views on the industry's impact on community water quality.

Production Knowledge	Negative	Neutral	Positive
Bad knowledge	0% (n=0)	0% (n=0)	100% (n=1)
Good knowledge	80% (n=8)	20% (n=2)	0% (n=0)

xvii. Employee Utilization of Environmental Health and Safety Training on the Job

There was no statistical significance to the relationship between respondents' utilization of environmental health and safety training on the job and their views on the gas and oil industry's impact on community water quality according to Fisher's exact test ($p=0.20$). Fifty percent of those who had reported the utilization of the training was insufficient ($n=1/2$) and 78% of those who had thought the training utilization was sufficient ($n=7/9$) agreed that the impact of the industry was negative.

C. Relationships Related to Perceptions of the Impact of the Oil and Gas Industry on Soil Quality

i. Age

Using logistic regression, no statistical significance was detected to the relationship between respondents' ages and their views on the gas and oil industry's impact on community soil quality ($p=0.89$). Average age of the 60 % of employees who had a negative outlook on the impact on water quality was 45 years, and 57 and 28 years for those with neutral and positive outlook, respectively.

ii. Education

Statistical analysis was not applicable to this variable because all of the employee respondents had a high school diploma or above, belonging to only one category. About 64 ($n=7/11$) agreed that the impact of the industry was negative.

iii. Individual Health Issues

Using logistic regression, no statistical significance was detected to the relationship between the number of health issues suffered by respondents and their views on the gas and oil industry's impact on community soil quality ($p=0.45$). The average number of individual health issues reported by both groups with positive and negative statement of the impact on soil was 3, while there were average of 1 health issue reported by the three individuals with neutral opinion.

iv. Cancer

There was no statistical significance to the relationship between whether respondents had been diagnosed with cancer and their views on the gas and oil industry's impact on community soil quality according to Fisher's exact test ($p=1.00$). 60% of those without cancer ($n=6$) and 100% of those with cancer ($n=1$) agreed that the impact of the industry was negative.

v. Communication about Environmental and Health Risks Directed to the Residents from the Public and Saudi Aramco

There was no statistical significance to the relationship between the level of communication about environmental and health risks from non-governmental sources and respondents' views on the gas and oil industry's impact on community soil quality according to Fisher's exact test ($p=0.47$). 80% of those who were less informed (0-1 modes of communication, $n=4$), 60% of those who were moderately informed (2 modes of communication, $n=3$), and 0% of those were more informed (3-4 modes of communication, $n=0$) felt that the impact of the industry was negative.

vi. Communication about Environmental and Health Risks Directed to Residents from the Government

There was no statistical significance to the relationship between the level of communication about environmental and health risks from the governmental source and respondents' views on the gas and oil industry's impact on community soil quality according to Fisher's exact test ($p=1.00$). 55.56% of those who had not received communication from the governmental source ($n=5$) and 100% of those who had ($n=2$) agreed that the impact of the industry was negative.

vii. Speed of Emergency Response by the Companies

There was no statistical significance to the relationship between the speed of emergency response of the company and respondents' views on the gas and oil industry's impact on community soil quality according to Fisher's exact test ($p=1.00$). 100% of those who felt that the response was not immediate ($n=1$) and 60% of those who felt that the response was immediate ($n=6$) agreed that the impact of the industry was negative.

viii. Awareness of Policies to Combat the Negative Effects of the Industry on the Environment and Community Well-being

There was no statistical significance to the relationship between respondents' awareness of policies to combat negative effects of the industry on the environment and community well-being and their views on the gas and oil industry's impact on community soil quality according to Fisher's exact test ($p=0.27$). 50% of those who were unaware of such policies ($n=1$) and 62.5% of those who were aware ($n=5$) agreed that the impact of the industry was negative.

ix. Methods of Regulations to Follow the Law

There was no statistical significance to the relationship between respondents' awareness of the number of methods used to enforce regulations and their views on the gas and oil industry's impact on community soil quality according to Fisher's exact test ($p=1.00$). Only nine employees answered this question; 60% of those who were aware of 0-1 methods ($n=3/5$) and 50% of those who were aware of 2-4 methods ($n=2/4$) agreed that the impact of the industry was negative.

x. Practices Based on OSHA Standards in the Crude Oil Refining Processes Applied by SA

There was no statistical significance to the relationship between how well respondents felt the company adhered to OSHA standards and their views on the gas and oil industry's impact on community soil quality according to Fisher's exact test ($p=1.00$). Ninety one percent of all employees (10/11) thought the practices in refining processes were sufficient and sixty percent of them (6/10) had a negative outlook on their company's impact on the environmental air. Only one person thought the practices were insufficient and also had a negative outlook on the company's impact on the water quality.

xi. Awareness of Fires and Explosions from Job Experience

There was no statistical significance to the relationship between respondents' awareness of the risk of fires and explosions and their views on the gas and oil industry's impact on community soil quality according to Fisher's exact test ($p=1.00$). 66.67% of those who were unaware ($n=2$) and 57.14% of those who were aware ($n=4$) agreed that the impact of the industry was negative.

xii. Awareness of Physical Injuries from Job Experience

There was no statistical significance to the relationship between respondents' awareness of physical injuries their views on the gas and oil industry's impact on community soil quality according to Fisher's exact test ($p=1.00$). 66.67% of those who were aware ($n=2$) and 66.67% of those who were unaware ($n=4$) agreed that the impact of the industry was negative.

xiii. Communication about Environmental and Health Risks Directed to Field Workers from Saudi Aramco

There was no statistical significance to the relationship between the level of communication about environmental and health risks directed at field workers by the company and their views on the gas and oil industry's impact on community soil quality according to Fisher's exact test ($p=0.41$). 50% of those who were less informed (0-1 modes of communication, $n=1$), 100% of those who were moderately informed (2 modes of communication, $n=1$), and 62.50% of those who were more informed (3-4 modes of communication, $n=5$) agreed that the impact of the industry was negative.

xiv. Communication about Environmental and Health Risks Directed to Field Workers from the Government

There was no statistical significance to the relationship between the level of communication about environmental and health risks directed at field workers by the government and their views

on the gas and oil industry's impact on community soil quality according to Fisher's exact test ($p=0.41$). 62.50% of those who had not received communication from the government ($n=5$) and 66.67% of those who had ($n=2$) agreed that the impact of the industry was negative.

xv. Training and Environmental Safety Practices from SA to Field Workers

There was almost statistical significance to the relationship between respondents' ratings of the training and environmental safety practices of Saudi Aramco and their views on the gas and oil industry's impact on community soil quality according to Fisher's exact test ($p=0.09$). This means that the proportions of residents exhibiting negative, neutral and positive perception were different across different ratings of the training and environmental safety practices. Specifically, the one employee who felt that training was bad had a positive opinion while none of the respondents who felt training was good had a positive opinion. 70% felt negatively and the other 30% were neutral. This relationship can be seen in Figure 18.

Figure 18 Bar graph and detailed table showing the survey results of the quality of training received by employees and their views on the industry's impact on community soil quality.

Employee training	Negative	Neutral	Positive
Bad training	0% (n=0)	0% (n=0)	100% (n=1)
Good Training	70% (n=7)	30% (n=3)	0% (n=0)

xvi. Production Knowledge of SA Workers

There was almost a statistical significance to the relationship between respondents' ratings of the production knowledge given by Saudi Aramco and their views on the gas and oil industry's impact on community air quality according to Fisher's exact test ($p=0.09$) across different ratings of the production knowledge provided by SA. Specifically, the one employee who felt that training was bad had a positive opinion while none of the respondents who felt training was good had a positive opinion. 70% felt negatively and the other 30% were neutral. This relationship can be seen in Figure 19.

Production knowledge	Negative	Neutral	Positive
Bad knowledge	0% (n=0)	0% (n=0)	100% (n=1)
Good knowledge	70% (n=7)	30% (n=3)	0% (n=0)

Figure 19 Bar graph and detailed table showing the survey results of the production knowledge of employees and their views on the industry's impact on community soil quality.

xvii. Employee Utilization of Environmental Health and Safety Training on the Job

There was no statistical significance to the relationship between respondents' utilization of environmental health and safety training on the job and their views on the gas and oil industry's impact on community soil quality according to Fisher's exact test ($p=0.24$). Fifty percent of those who had reported the utilization of the training was insufficient ($n=1/2$) and 67% of those who had thought the training utilization was sufficient ($n=6/9$) agreed that the impact of the industry was negative.

D. Relationships Related to Perceptions of the Impact of the Oil and Gas Industry on Community Well-being

i. Age

Using logistic regression, no statistical significance was detected to the relationship between respondents' ages and their views on the gas and oil industry's impact on community soil quality ($p=0.87$). Average age of the 30 % of employees who had a negative outlook (3/10) on the impact on community well-being was 46 years, and 47 years of age for those with positive (7/10; 70%) outlook.

ii. Education

Statistical analysis was not applicable to this variable because all of the employee respondents had a high school diploma or above, belonging to only one category. About 36 ($n=4/11$) agreed that the impact of the industry was negative.

iii. Individual Health Issues

Using logistic regression, no statistical significance was detected to the relationship between the number of health issues suffered by respondents and their views on the gas and oil industry's impact on community air quality ($p=0.24$). The average number of individual health issues reported by group with positive statement was 3.80 and with negative statement of the impact on community well-being was 1.70, while there no individuals who neutral opinion.

iv. Cancer

There was no statistical significance to the relationship between whether respondents had been diagnosed with cancer and their views on the gas and oil industry's impact on community soil quality according to Fisher's exact test ($p=0.36$). 30% of those without cancer ($n=3$) and 100% of those with cancer ($n=1$) agreed that the impact of the industry was negative.

v. Communication about Environmental and Health Risks Directed to Residents from the Public and Saudi Aramco

There was no statistical significance to the relationship between the level of communication about environmental and health risks from non-governmental sources and respondents' views on the gas and oil industry's impact on community well-being according to Fisher's exact test ($p=0.70$). 60% of those who were less informed (0-1 modes of communication, $n=3$), 20% of those who were moderately informed (2 modes of communication, $n=1$), and 0% of those were more informed (3-4 modes of communication, $n=0$) felt that the impact of the industry was negative.

vi. Communication About Environmental and Health Risks Directed to Residents from the Government

There was no statistical significance to the relationship between the level of communication about environmental and health risks from the governmental source and respondents' views on the gas and oil industry's impact on community soil quality according to Fisher's exact test ($p=1.00$). 33.33% of those who had not received communication from the governmental source ($n=3$) and 50% of those who had ($n=2$) agreed that the impact of the industry was negative.

vii. Speed of Emergency Response of the Companies

There was no statistical significance to the relationship between the speed of emergency response of the company and respondents' views on the gas and oil industry's impact on community air quality according to Fisher's exact test ($p=1.00$). 0% of those who felt that the response was not immediate ($n=0$) and 40% of those who felt that the response was immediate ($n=4$) agreed that the impact of the industry was negative.

viii. Awareness of Policies to Combat the Negative Effects of the Industry on the Environment and Community Well-being

There was no statistical significance to the relationship between awareness of policies to combat negative effects of the industry on the environment and community well-being and respondents' views on the gas and oil industry's impact on community well-being according to Fisher's exact test ($p=1.00$). 0% of those who were not aware of the policies ($n=0$) and 37.50% of those who were aware of the policies ($n=3$) agreed that the impact of the industry was negative.

ix. Methods of Regulations to Follow the Law

There was no statistical significance to the relationship between respondents' awareness of the number of methods used to enforce regulations and their views on the gas and oil industry's impact on community well-being according to Fisher's exact test ($p=0.52$). 20% of those who were aware of 0-1 methods ($n=1$) and 50% of those who were aware of 2-4 methods ($n=2$) agreed that the impact of the industry was negative.

x. Practices Based on OSHA Standards in the Crude Oil Refining Processes Applied by SA

There was no statistical significance to the relationship between how well respondents felt the company adhered to OSHA standards and their views on the gas and oil industry's impact on community well-being according to Fisher's exact test ($p=0.36$). Ninety one percent of all employees (10/11) thought the practices in refining processes were sufficient and thirty percent of them (3/10) had a negative outlook on their company's impact on the community well-being. Only one person thought the practices were insufficient and also had a negative outlook on the company's impact on the water quality.

xi. Awareness of Fires and Explosions from Job Experience

There was no statistical significance to the relationship between respondents' awareness of the risk of fires and explosions and their views on the gas and oil industry's impact on community well-being according to Fisher's exact test ($p=1.00$). 33.33% of those who were unaware ($n=1$) and 28.57% of those who were aware ($n=2$) agreed that the impact of the industry was negative.

xii. Awareness of Physical Injuries from Job Experience

There was no statistical significance to the relationship between respondents' awareness of physical injuries their views on the gas and oil industry's impact on community well-being according to Fisher's exact test ($p=1.00$). 33.33% of those who were aware ($n=1$) and 33.33% of those who were unaware ($n=2$) agreed that the impact of the industry was negative.

xiii. Communication about Environmental and Health Risks Directed to Field Workers from Saudi Aramco

There was no statistical significance to the relationship between the level of communication about environmental and health risks directed at field workers by the company and their views on the gas and oil industry's impact on community well-being according to Fisher's exact test ($p=0.45$). 0% of those who were less informed (0-1 modes of communication, $n=0$), 100% of those who were moderately informed (2 modes of communication, $n=1$), and 37.50% of those who were more informed (3-4 modes of communication, $n=3$) agreed that the impact of the industry was negative.

xiv. Communication about Environmental and Health Risks Directed to Field Workers from the Government

There was no statistical significance to the relationship between the level of communication about environmental and health risks directed at field workers by the government and their views

on the gas and oil industry's impact on community well-being according to Fisher's exact test ($p=1.00$). 37.50% of those who had not received communication from the government ($n=3$) and 33.33% of those who had ($n=1$) agreed that the impact of the industry was negative.

xv. Training and Environmental Safety Practices from SA to Field Workers

There was no statistical significance to the relationship between respondents' ratings of the training and environmental safety practices of Saudi Aramco and their views on the gas and oil industry's impact on community air quality according to Fisher's exact test ($p=1.00$). Ninety percent of employees (9/10) who thought their environmental safety training was sufficient and sixty percent of them (6/10) reported positive and forty percent of them (4/10) negative attitude towards the oil and gas company's impact on air quality. Only one person who thought the training was not sufficient reported the impact being positive.

xvi. Production Knowledge of SA Workers

There was no statistical significance to the relationship between respondents' ratings of the production knowledge given by Saudi Aramco and their views on the gas and oil industry's impact on community well-being according to Fisher's exact test ($p=1.00$). 0% of those who thought production knowledge was bad ($n=0$) and 40% who thought it was good ($n=4$) agreed that the impact of the industry was negative.

xvii. Employee Utilization of Environmental Health and Safety Training on the Job

There was no statistical significance to the relationship between respondents' utilization of environmental health and safety training on the job and their views on the gas and oil industry's impact on community well-being according to Fisher's exact test ($p=0.49$). Fifty six percent of those who had reported the utilization of the training was sufficient ($n=5/9$) and 100% of those

who had thought the training utilization was insufficient (n=2/2) agreed that the impact of the industry on community well-being was positive.

Results for all of the analyses for the SA EPD representatives are summarized in Table 30.

Table 30- Summary table of results for representatives of SA. Asterisk (*) indicates the p-value less or equal than 0.05, the paragraph (§) indicates the trend (greater than 0.05 but less than 0.1)

Independent variables	Opinion about impact of oil and gas industry on environmental and community components			
	Air	Water	Soil	Well-Being
Age	0.63	0.95	0.89	0.87
Education	N/A	N/A	N/A	N/A
Awareness of policies to combat negative effects of industry on environment and community well-beings	0.38	0.228	0.27	1.00
Methods of regulations to follow the law	1.00	1.00		0.52
Practices based on OSHA standards in crude oil refining processes applied by SA	1.00	1.00	1.00	0.36
Awareness of fires and explosions from job experience	1.00	0.65	1.00	1.00
Awareness of physical injuries from job experience	1.00	1.00	1.00	1.00
Number of individual health issues	0.63	0.32	0.45	0.24
Cancer	1.00	1.00	1.00	0.36
Level of information about environmental and health problems from non-governmental sources	0.55	1.00	0.47	0.70
Level of information about environmental and health problems from the governmental source	1.00	1.00	1.00	1.00
Speed of emergency response	1.00	1.00	1.00	1.00
Communication about environmental and health risks directed to the field workers from Saudi Aramco	0.49	0.43	0.41	0.45
Communication about environmental and health risks directed to the field workers the government	0.495	0.32	0.41	1.00
Training and environmental safety practices from SA to field workers	0.18	0.09§	0.09§	1.00
Production knowledge of SA workers	0.18	0.09§	0.09§	1.00
Employee utilization of environmental health and safety training on the job	0.35	0.20	0.24	0.49

5.3. Awareness and risk assessment of hazards associated with oil and gas industry, Jubail residents (n=42) compared or combined with Saudi Aramco representatives (n=11) survey results.

A. Relationships Related to Perceptions of the Impact of the Oil and Gas Industry on Air Quality

i. Group

There was no statistical significance to the relationship between which survey group respondents belonged to and their views on the gas and oil industry's impact on community air quality according to Fisher's exact test ($p=0.79$) and by the logistic regression (Wald Chi-Square $=0.2384$; $p=0.625$). The opinion distribution can be seen in Figure 20.

Group	Negative	Neutral	Positive
Residents	87.80% (n=36)	4.88% (n=2)	7.32% (n=3)
SA Representatives	81.82% (n=9)	9.09% (n=1)	9.09% (n=1)

Figure 20 Bar graph and detailed table showing the survey results of the group respondents were in and their views on the industry's impact on community air quality.

ii. Age

Using logistic regression, no statistical significance was detected to the relationship between respondents' age and their views on the gas and oil industry's impact on community air quality (Wald Chi-Square=0.9512, $p=0.3294$).

iii. Education

Using logistic regression, no statistical significance was detected to the relationship between respondents' education and their views on the gas and oil industry's impact on community air quality (Wald Chi-Square=0.0208; $p=0.8854$).

iv. Communication about Environmental and Health Risks Directed to the Residents from the Public and Saudi Aramco

Using Fisher's exact test, statistical significance was detected to the relationship between how informed respondents were about environmental and health hazards from non-governmental sources, and their views on the gas and oil industry's impact on community air quality ($p=0.0044$). This means that the proportions of residents and company representatives exhibiting negative, neutral and positive perception were different across different levels of communication modes. Specifically, negative opinion was nearly universal among uninformed and well-informed respondents (96.97% and 100%, respectively), while just 57.14% of moderately informed respondents agreed. Neutral opinion varied widely between uninformed and moderately informed respondents at 3.03% and 14.29%, respectively. Only moderately informed respondents had any proportion of positive opinion, at 28%. This relationship can be seen in Figure 21. The height of the graph bars represent percentages of combined residents and SA representatives.

Communication	Negative	Neutral	Positive
Less Informed (0-1)	96.97% (n=32)	3.03% (n=1)	0% (n=0)
Moderately Informed (2)	57.14% (n=8)	14.20% (n=2)	28.57% (n=4)
More Informed (3-4)	100% (n=5)	0% (n=0)	0% (n=0)

Figure 21 - Bar graph and detailed table showing the combined survey results of the respondents' level of information and their views on the industry's impact on community air quality.

v. Communication about Environmental and Health Risks Directed to Residents from the Government

Using logistic regression, no statistical significance was detected to the relationship between which survey group respondents belonged to, how informed respondents were about environmental and health hazards from the governmental source, and their views on the gas and oil industry's impact on community air quality (Wald Chi-Square=0.8954; p=0.344).

vi. Individual Health Issues

Using logistic regression, no statistical significance was detected to the relationship between which survey group respondents belonged to, the number of individual health issues suffered,

and their views on the gas and oil industry's impact on community air quality (Wald Chi-Square=0.217; p=0.6414).

vii. Cancer

Using Fisher's exact test, no statistical significance was detected to the relationship between whether or not they had been diagnosed with cancer and their views on the gas and oil industry's impact on community air quality (p=0.503). Specifically, while all 13 (100%) of respondents with cancer felt negatively, 30 (81.08%) of respondents without cancer agreed. The remaining seven cancer-free respondents were split almost equally between neutral opinion (8.11%) and positive opinion (10.81%). Frequencies in this relationship can be seen in Figure 22.

Cancer diagnosis	Negative	Neutral	Positive
No cancer	81.08% (n=30)	8.11% (n=3)	10.81% (n=4)
Cancer	100% (n=13)	0% (n=0)	0% (n=0)

Figure 22 - Bar graph and detailed table showing the combined survey results of whether or not respondents had been diagnosed with cancer and their views on the industry's impact on community air quality.

viii. Speed of Emergency Response by the Companies

According to Fisher's exact test no association was detected between the responder's perception about the speed of emergency response and their views on the gas and oil industry's impact on community air quality ($p=0.2566$). While 72.73% of respondents who felt response was immediate held negative opinions, only 58.54% of respondents who felt response was slow agreed, this was not statistically different even though the proportion of respondents who felt response was slow with neutral opinions was nearly double that of respondents who felt response was immediate (31.71% compared to 18.18%, respectively). The proportions with positive opinions were nearly equal at 9.76% and 9.09%, respectively. This relationship can be seen in Figure 23.

Speed of emergency response	Negative	Neutral	Positive
Immediate response	58.54% (n=24)	31.71% (n=13)	9.76% (n=4)
Slow response	72.73% (n=8)	18.18% (n=2)	9.09% (n=1)

Figure 23 - Bar graph and detailed table showing the combined survey results of the speed of emergency response and respondents' views on the industry's impact on community air quality.

Results for all analyses for the residents combined with SA EPD representatives with regard to their perception about the environmental air is summarized in Table 31.

Table 31- Summary of logistic regression tests and Fisher's exact test with regards the environmental air. Asterisk (*) indicates the p-value less or equal than 0.05.

Independent variables	Response: Perception about impact of oil and gas industry on Air (negative, neutral, positive)				
	Maximum Likelihood Estimates (MLE)	Wald test Chi-Square p-value	Likelihood Ratio	Odds Ratio Estimates	95% Wald Confidence Limits
Group (Jubail residents, SA representatives)	-0.2236	0.625	0.632	Jubail Residents vs. SA representatives: 0.639	0.1036 - 3.849
Age	0.0309	0.3294	0.3191	1.031 (for each year increase in age)	0.969-1.098
Education	0.082	0.8854	0.8898	High School and less vs. University: 1.178	0.127-10.948
Communication (from non - government, like Saudi Aramco)	MLE do not exist	N/A; Fisher's exact test p-value 0.0044 *	N/A	N/A	N/A
Communication (from government)	0.5265	0.344	0.3024	No communication vs. communication: 0.5265	0.324-25.382
Health issues	0.0713	0.64	0.6501	1.074 (for increase in number of hearth issues by 1)	0.796-1.45
Cancer	MLE does not exist	N/A; Fisher's exact test p-value 0.5029	N/A	N/A	N/A
Speed of emergency response	MLE does not exist	N/A; Fisher's exact test p-value 0.2566	N/A	N/A	N/A

B. Relationships Related to Perceptions of the Impact of the Oil and Gas Industry on Water Quality

i. Group

Overall, using logistic regression, no statistical significance was detected to the relationship between which survey group respondents belonged to and their views on the gas and oil industry's impact on community water quality (Wald Chi-Square=0.6216; p=0.4305). The opinion distribution can be seen in Figure 24.

Group	Negative	Neutral	Positive
Residents	58.54% (n=24)	31.71% (n=13)	9.76% (n=4)
SA Representatives	72.73% (n=8)	18.18% (n=2)	9.09% (n=1)

Figure 24 - Bar graph and detailed table showing the survey results of the group respondents were in and their views on the industry's impact on community water quality.

ii. Age

No statistically significant effect was detected with logistic regression between respondents' age and their views on the gas and oil industry's impact on community water quality (Wald Chi-Square = 1.7478; $p=0.1862$).

iii. Education

Using logistic regression, no statistical significance was detected to the relationship between respondents' education and their views on the gas and oil industry's impact on community water quality (Wald Chi-Square = 0.0002; $p=0.9886$).

iv. Communication about Environmental and Health Risks Directed to Residents from the Public and Saudi Aramco

Nearly statistical significance was detected to the relationship between how informed respondents were about environmental and health hazards from non-governmental sources, and their views on the gas and oil industry's impact on community water quality ($p=0.0944$) using Fisher's exact test. This means that the proportions of residents and company representatives exhibiting negative, neutral and positive perception may be different across different levels of communication modes. Specifically, while 100% of well-informed respondents felt negatively, just 66.67% of uninformed respondents and 35.71% of moderately-informed respondents agreed. The proportion of moderately-informed respondents with neutral opinions was nearly double that of uninformed respondents (50% compared to 24.24%), while the proportions with positive opinions were fairly similar between the two groups (14.29% and 9.09%, respectively). This relationship can be seen in Figure 25.

Communication	Negative	Neutral	Positive
Less Informed (0-1)	66.67% (n=22)	24.24% (n=8)	9.09% (n=3)
Moderately Informed (2)	35.71% (n=5)	50% (n=7)	14.29% (n=2)
More Informed (3-4)	100% (n=5)	0% (n=0)	0% (n=0)

Figure 25 - Bar graph and detailed table showing the combined survey results respondents' level of information and their views on the industry's impact on community water quality.

v. Communication about Environmental and Health Risks Directed to Residents from the Government

Using logistic regression, no statistical significance was detected to the relationship between which survey group respondents belonged to, how informed respondents were about environmental and health hazards from the governmental source, and their views on the gas and oil industry's impact on community water quality (Wald Chi-Square =0.0006; p=0.9809).

vi. Individual Health Issues

Using logistic regression, no statistical significance was detected to the relationship between which survey group respondents belonged to, the number of individual health issues suffered, and their views on the gas and oil industry's impact on community water quality (Wald Chi-Square = 0.071; p=0.5221).

vii. Cancer

Using logistic regression, no statistical significance was detected to the relationship between which survey group respondents belonged to, whether or not they had been diagnosed with cancer, and their views on the gas and oil industry's impact on community water quality (Wald Chi-Square =0.9951; p=0.3185).

viii. Speed of Emergency Response by the Companies

Using logistic regression, no statistical significance was detected to the relationship between which survey group respondents belonged to, the speed of emergency response, and their views on the gas and oil industry's impact on community water quality (Wald Chi-Square =0.4014; p=0.5223).

Results for all analyses for the residents combined with SA EPD representatives with regard to their perception about the environmental water are summarized in Table 32.

Table 32- Summary of logistic regression tests and Fisher's exact test with regards the environmental water. The paragraph (§) indicates the trend (greater than 0.05 but less than 0.1).

Independent variables	Response: Perception about impact of oil and gas industry on Water (negative, neutral, positive)				
	Maximum Likelihood Estimates for n-1 levels of independent variable	Wald test Chi-square p-value	Likelihood Ratio	Odds Ratio Estimates	95% Wald Confidence Limits
Group (Jubail residents, SA representatives)	Jubail Residents 0.2891	0.4305	0.4235	Jubail Residents vs. SA representatives: 1.783	0.424-7.503
Age	-0.0296	0.1862	0.1688	0.971 (for each year increase in age)	0.929-1.014
Education	0.00583	0.9886	0.988	High School and less vs. University: 1.012	0.204-5.007
Communication (from non-government, like Saudi Aramco)	MLE do not exist	N/A Fisher's exact test p-value 0.0944 §	N/A	N/A	N/A
Communication (from government)	-0.0071	0.981	0.9813	No communication vs. communication: 0.986	0.308-3.158
Health issues	0.071	0.5221	0.5076	1.074 (for increase in number of hearth issues by 1)	0.864-1.334
Cancer	0.3643	0.3185	0.3063	Cancer vs. without cancer 2.072	0.495-8.673
Speed of emergency response	0.219	0.5223	0.526	Immediate vs. Slow emergency response: 1.55	0.405-5.926

C. Relationships Related to Perceptions of the Impact of the Oil and Gas Industry on Soil Quality

i. Group

Both responders groups (Jubail residents and SA representatives) had very similar views, and there was no statistical significance detected to the relationship between group of respondents and their views on the gas and oil industry's impact on community soil quality according to Fisher's exact test ($p=1.00$) and logistic regression (Wald Chi-Square = 0.0; $p\text{-value}=1.00$). In fact, almost identical pattern is observed between the groups. The opinion distribution can be seen in Figure 26.

Group	Negative	Neutral	Positive
Residents	62.16% (n=23)	32.43% (n=12)	5.41% (n=2)
SA Representatives	63.64% (n=7)	27.27% (n=3)	9.09% (n=1)

Figure 26 - Bar graph and detailed table showing the survey results of the group respondents were in and their views on the industry's impact on community soil quality.

ii. Age

Using logistic regression, no statistical significance was detected to the relationship between respondents' ages, and their views on the gas and oil industry's impact on community soil quality (Wald Chi-Square=0.6145; $p=0.4331$).

iii. Education

Using logistic regression, no statistical significance was detected to the relationship between respondents' education, and their views on the gas and oil industry's impact on community soil quality (Wald Chi-Square=0.1012; $p=0.7504$).

iv. Communication about Environmental and Health Risks Directed to the Residents from the Public and Saudi Aramco

Using logistic regression, nearly statistical significance was detected to the relationship between how informed respondents were about environmental and health hazards from non-governmental sources, and their views on the gas and oil industry's impact on community soil quality (Wald Chi-Square=5.4307; $p=0.0662$).

v. Communication about Environmental and Health Risks Directed to Residents from the Government

Using logistic regression, no statistical significance was detected to the relationship between which survey group respondents belonged to, how informed respondents were about environmental and health hazards from the governmental source, and their views on the gas and oil industry's impact on community soil quality (Wald Chi-Square=0.6732; $p=0.4119$).

vi. Individual Health Issues

Using logistic regression, no statistical significance was detected to the relationship between the number of individual health issues suffered by respondents, and their views on the gas and oil industry's impact on community soil quality (Wald Chi-Square=0.2401; $p=0.6242$).

vii. Cancer

No statistical significance was detected to the relationship between whether or not they had been diagnosed with cancer and their views on the gas and oil industry's impact on community soil quality (Wald Chi-Square =0.9498; p=0.3298) using logistic regression.

viii. Speed of Emergency Response by the Companies

Using logistic regression, statistical significance was detected to the relationship between the speed of emergency response and their views on the gas and oil industry's impact on community air quality (Wald Chi-Square =4.4114; p=0.0357). This means that the proportions of residents and company representatives exhibiting negative, neutral and positive perception were different across different emergency response speeds. Specifically, the proportion of respondents who felt that response was slow with negative opinions was nearly double that of respondents who felt that response was immediate (91.67% compared to 51.85%, respectively). The proportion of respondents who felt that response was immediate was more than four times that of respondents who felt that response was slow (37.04% versus 8.33%, respectively). Only those who felt that response was immediate had any proportion of positive opinion, at 11.11%. This relationship can be seen in Figure 27.

Speed of emergency response	Negative	Neutral	Positive
Immediate response	51.85% (n=14)	37.04% (n=10)	11.11% (n=3)
Slow response	91.67% (n=11)	8.33% (n=1)	0% (n=0)

Figure 27 - Bar graph and detailed table showing the combined survey results of the speed of emergency response and respondents' views on the industry's impact on community soil quality.

Results for all analyses for the residents combined with SA EPD representatives with regard to their perception about the environmental soil are summarized in Table 33.

Table 33- Summary of logistic regression and Fisher's exact tests with regards the environmental soil. Asterisk (*) indicates the p-value less or equal than 0.05.

Independent variables	Response: Perception about impact on Soil				
	Maximum Likelihood Estimates for n-1 levels of independent variable	Wald test Chi-square p-value	Likelihood Ratio	Odds Ratio Estimates	95% Wald Conf. Limits
Group (Jubail residents, SA representatives)	Jubail Residents: 0	1	1	Jubail Residents vs. SA representatives: 1.0	0.254-3.932
Age	-0.0187	0.4333	0.4156	0.981 (for each year increase in age)	0.937-1.028
Education	-0.1469	0.75	0.74	High School and less vs. University: 0.745	0.122-4.555
Communication from non-government, like Saudi Aramco	Very little communication: -0.8297	0.066 §	0.059	Very little communication vs. Lots of communication: 0.404	0.06-2.696

Independent variables	Response: Perception about impact on Soil				
	Maximum Likelihood Estimates for n-1 levels of independent variable	Wald test Chi-square p-value	Likelihood Ratio	Odds Ratio Estimates	95% Wald Conf. Limits
	Medium amount of communication: 0.7526			Medium amount of communication vs. Lots of communication: 1.965	0.264-14.652
Communication from government	-0.2555	0.4119	0.4115	No communication vs. Lots of communication: 0.6	0.177-2.033
Health issues	-0.0588	0.6242	0.616	0.943 (for increase in number of health issues by 1)	0.745-1.193
Cancer	0.3579	0.3298	0.3226	Cancer vs. without cancer 2.045	0.485-8.624

Independent variables	Response: Perception about impact on Soil				
	Maximum Likelihood Estimates for n-1 levels of independent variable	Wald test Chi-square p-value	Likelihood Ratio	Odds Ratio Estimates	95% Wald Conf. Limits
Speed of emergency response	1.173	0.0357 *	0.0089	Immediate vs. Slow emergency response: 10.44	1.17-93.253

D. Relationships Related to Perceptions of the Impact of the Oil and Gas Industry on Community Well-being

i. Group

There was almost statistical significance to the relationship between which survey group respondents belonged to and their views on the gas and oil industry's impact on community well-being according to logistic regression (Wald Chi-Square = 3.2276; $p=0.0724$). This means that the proportions of residents and company representatives exhibiting negative, neutral and positive perception were somewhat different across the different populations. Specifically, while 52.63% of residents felt negatively, only 36.36% of company representatives agreed. The proportion of company representatives who felt positively was more than double that of residents who agreed (63.64% compared to 26.32%, respectively). Only residents expressed neutral opinions, at 21.05%. More negative views were observed among the group of residents and more positive views among the SA representatives. The opinion distribution can be seen in Figure 28.

Group	Negative	Neutral	Positive
Residents	52.63% (n=20)	21.05% (n=8)	26.32% (n=10)
SA Representatives	36.36% (n=4)	0% (n=0)	63.64% (n=7)

Figure 28 - Bar graph and detailed table showing the survey results of the group respondents were in and their views on the industry's impact on community well-being.

ii. Age

Using logistic regression, no statistical significance was detected to the relationship between age of the responders and their views on the gas and oil industry's impact on community well-being (Wald Chi-Square =0.0071; $p=0.7427$).

iii. Education

No significant relationship was detected to the relationship between respondents' education and their views on the gas and oil industry's impact on community well-being (Wald Chi-Square =0.3906; 2; $p=0.5320$) using logistic regression.

iv. Communication about Environmental and Health Risks Directed to Residents from the Public and Saudi Aramco

Using logistic regression, statistical significance was detected to the relationship between how informed respondents were about environmental and health hazards from non-governmental sources, and their views on the gas and oil industry's impact on community well-being (Wald Chi-Square =15.0649; $p=0.0005$). This means that the proportions of residents and company representatives exhibiting negative, neutral and positive perception were different across different levels of communication modes, but not across the different populations. Specifically, while 68.75% of uninformed respondents felt negatively held negative opinions, just 8.33% of moderately-informed respondents and 20% of well-informed respondents agreed. The proportion of neutral opinions was fairly consistent across all groups, at 15.63% for uninformed, 16.67% for moderately-informed and 20% of well-informed respondents. While quite large proportions of moderately- and well-informed respondents felt positively (75% and 60%, respectively), just 15.63% of uninformed respondents shared this opinion. This relationship can be seen in Figure 29.

Communication	Negative	Neutral	Positive
Less Informed (0-1)	68.75% (n=22)	15.63% (n=5)	15.63% (n=5)
Moderately Informed (2)	8.33% (n=1)	16.67% (n=2)	75% (n=9)
More Informed (3-4)	20% (n=1)	20% (n=1)	60% (n=3)

Figure 29 - Bar graph and detailed table showing the combined survey results of respondents' level of information and their views on the industry's impact on community well-being.

v. Communication about Environmental and Health Risks Directed to Residents from the Government

Using logistic regression, no statistical significance was detected to the relationship between how informed respondents were about environmental and health hazards from the governmental source, and their views on the gas and oil industry's impact on community well-being (Wald Chi-Square =1.1423; p=0.2853).

vi. Individual Health Issues

Using logistic regression, no statistical significance was detected to the relationship between the number of individual health issues suffered and their views on the gas and oil industry's impact on community well-being (Wald Chi-Square =0.5439; p=0.4608).

vii. Cancer

Nearly significant relationship between whether or not responders had been diagnosed with cancer and their perception on the gas and oil industry's impact on community well-being (Wald Chi-Square =3.1454; p=0.0761) using logistic regression. People (combined residents and representatives), who were cancer-free had the negative and positive outlooks in similar proportions (43% and 46%, respectively), while those that suffered from cancer had mostly negative outlooks (8/12, 67%). The relationship can be seen in Figure 30.

Cancer diagnosis	Negative	Neutral	Positive
No Cancer	42.86% (n=15)	11.43% (n=4)	45.71% (n=16)
Cancer	66.67% (n=8)	25% (n=3)	8.33% (n=1)

Figure 30 - Bar graph and detailed table showing the combined survey results of whether or not respondents had been diagnosed with cancer and their views on the industry's impact on community well-being.

viii. Speed of Emergency Response by the Companies

Using logistic regression, no statistical significance was detected to the relationship between which survey group respondents belonged to, the speed of emergency response, and their views on the gas and oil industry's impact on community well-being (Wald Chi-Square =0.1719; $p=0.6784$).

Results for all analyses for the residents combined with SA EPD representatives with regard to their perception about the impact of the oil and gas industry on the community well-being are summarized in Table 34.

Table 34- Summary table of results combined residents and SA representatives for Community Well-Being. Asterisk (*) indicates the p-value less or equal than 0.05, the paragraph (§) indicates the trend (greater than 0.05 but less than 0.1).

	Response: Perception about impact of oil and gas industry on Community Well-Being (negative, neutral, positive)				
	Maximum Likelihood Estimates for n-1 levels of independent variable	Wald test Chi-square p-value	Likelihood Ratio	Odds Ratio Estimates	95% Wald Confidence Limits
Group (Jubail residents, SA representatives)	Jubail Residents: 0.6038	0.0724 §	0.0816	Jubail Residents <i>vs.</i> SA representatives: 0.299	0.08-1.116
Age	0.0071	0.7427	0.7439	1.007 (for each year increase in age)	0.965-1.051
Education	-0.2941	0.532	0.5143	High School and less <i>vs.</i> University: 0.555	0.088-3.513
Communication (from non-government, like Saudi Aramco)	Very little communication: -1.6827	0.0003 *	<0.0001	Very little communication <i>vs.</i> Lots of communication: 0.115	0.017-0.784
	Medium amount of communication: 1.2057	0.0298 *		Medium amount of communication <i>vs.</i> Lots of communication: 2.073	0.236-18.17
Communication (from government)	-0.3142	0.2852	0.2879	No communication <i>vs.</i> communication: 0.533	0.169-1.689
Health issues	-0.0812	0.4608	0.459	0.922 (for increase in number of health issues by 1)	0.743-1.144
Cancer	0.6227	0.0761§	0.0543	Cancer <i>vs.</i> without cancer 3.474	0.877-13.759
Speed of emergency response	0.142	0.6784	0.6764	Immediate <i>vs.</i> Slow emergency response: 1.329	0.347-5.089

Multiple Ordinal Logistic Regression Results

Planned multiple ordinal logistic regression to confirmed the simple analyses for the combined data from residents and SA representatives using all eight independent variables (listed in Table 33) in the model (full, or saturated model) could not be performed on all of the responses due to the small number of observations per all the combinations. Simpler models were examined using the variables found important by the Chi-Square or Fisher's exact test analyses. However, a similar problem was found. Specifically, for the response *Environmental Air* when data are divided into 9 categories to calculate the probabilities (3 categories for Communication from non-governmental sources: 0-1, 2 or 3-4 modes of communication times 3 categories of the perception response: negative, neutral and positive), there are 3 combinations without any counts. Namely, no-one in 0-1 level of communication had a positive perception about the air impact; similarly, there was no one in 3-4 level of communication with neutral and positive attitude. Since these missing categories, the logistic model can't be evaluated properly. When another variable, for instance Cancer, was added to the model, this further complicated the problem by dividing the total of 53 observations into $9 \times 2 = 18$ combinations with very low or missing counts in each. Error message about quasi-complete separation of data was provided, indicating that it was very likely a sample size issue (Boyle, 1996) and that the estimation of the logistic regression parameters can't be estimated. Similar situation occurred for the response *Environmental Water* thus multiple logistic regression method could not be reliably performed.

Multiple logistic regression for variables *Environmental Soil* and *Community well-being* results indicated that Communication from non-governmental sources and Speed of the Emergency response to be significant factors for former and Communication from non-governmental sources and Cancer for later. Logistic regression parameters, such an intercept and

slope of the logit, including the standard errors, test statistics Wald Chi-square test, and the associated p-values are listed in Tables 37 and 38.

*Logit(Awareness about the impact of oil and gas on **environmental soil**) = Communication from non-government + Speed of Emergency Response*

Table 35- Maximum likelihood Estimates for the awareness about the impact of oil and gas on the soil. Asterisk (*) indicates the p-value less or equal than 0.05.

Analysis of Maximum Likelihood Estimates						
Parameter	Level of Variable	Degrees of Freedom	Estimate	Standard Error	Wald Chi-Square	Probability > Chi-Square
Intercept	3	1	-3.6303	0.8996	16.2871	<.0001
Intercept	2	1	-0.8634	0.5944	2.1099	0.1463
Communication (non-governmental sources)	0-1	1	-1.8314	0.6685	7.5044	0.0062 *
Communication (non-governmental sources)	2	1	0.7838	0.5982	1.7167	0.1901
Speed of emergency response	Immediate	1	1.765	0.6845	6.649	0.0099 *

*Logit(Awareness about the impact of oil and gas on **community well-being**) = Communication from non-government + Cancer*

Table 36- Maximum likelihood Estimates for the awareness about the impact of oil and gas on the community well-being. Asterisk (*) indicates the p-value less or equal than 0.05.

Analysis of Maximum Likelihood Estimates						
Parameter	Level of Variable	Degrees of Freedom	Estimate	Standard Error	Wald Chi-Square	Probability > Chi-Square
Intercept	3	1	-0.4615	0.4895	0.8889	0.3458
Intercept	2	1	0.5685	0.4876	1.3595	0.2436
Communication (non-governmental sources)	0-1	1	-2.1998	0.6055	13.1996	0.0003 *
Communication (non-governmental sources)	2	1	1.2674	0.6272	4.0842	0.0433 *
Cancer	No	1	1.199	0.4948	5.8724	0.0154 *

CHAPTER 6

DISCUSSION

In this study, the relationship between environmental and health risk perceptions of residents and Saudi Aramco employees in the Industrial City of Jubail in the Eastern Province of Saudi Arabia and demographic factors, risk awareness, personal and community health issues, emergency response by the oil and gas company and amount of communication concerning the dangers of oil/gas production in the region's rural and urban communities was examined. The primary issues considered in this study were oil and natural gas-related contamination of air, water resources and farmland.

Catalan-Vazquez et al. (2014), in their research evaluating the risks of mining activities by different social actors in Mexico, reported that residents viewed "mining activities as synonymous with contamination and therefore, as having affected all areas of their environment, health, and daily life" (p. 28). Theodori and Jackson-Smith (2010) used data from a sample of the residents of Tarrant County, Texas to explore issues surrounding their perception of the natural gas industry. They linked public perception of the industry with dependent measures, such "individual-level actions that (a) may or may not have been taken and/or (b) may or may not be taken in response to the exploration and production of natural gas." Their findings matched those from two previously studied neighboring counties, indicating that residents found certain activities undertaken by industry representatives objectionable and took issue with the social and environmental effects they believed to be linked with industrial development. On the other hand, residents appreciated the economic and service-related improvements brought about by this same development. The authors concluded that the social and environmental perceptual variable is

more important than previously thought with regards to explaining and predicting public response to natural gas exploration and production activities, and made several proposals for the industry based on their findings.

Similar results were expected for residents of Jubail with regards to the oil and gas industry. Specifically, this study aimed to determine whether residents felt that the environmental and health hazards were attributable mainly to oil and gas activities and were related to demographic and health-related factors, as well as their level of information about the risk factors.

6.1. Factors Related to the Perception of the Impact of the Oil and Gas Industry on the Environmental Air and Air Pollution

Concerning the impact of the oil and gas industry on the environmental air quality among the residents, the significant factor related to this concern was found to be the amount of information about environmental and health problems received by residents from public sources and Saudi Aramco. Information modes included personal communication, brochures, public meetings and communications with Saudi Aramco EPD, and the number of modes were summed up to produce a numerical score reflecting the diversity of information resources for the residents. Specifically, residents who were not well informed and received only 0-1 mode of information had mostly negative opinions about the impact of the oil and gas extraction activities on air quality. On the other hand, only about half of residents, who were moderately informed had negative opinions (55.56%), while some were neutral (11.11%) and 33.33 % even had positive opinions about the issue. However, these later groups were represented by very few individuals, 9 in moderate group, further divided into 5 in negative, 1 neutral and 3 in positive perception groups. Interestingly, all of the residents who received 3-4 modes of information had

negative judgments about the impact of the industry on the environmental air. Nonetheless, only 4 people were in the 'well informed group' with 3-4 modes of communication.

It was expected that more communication would lead to better awareness and perception; however, it was a surprise that the less informed residents had mostly negative perceptions of the impact of the oil and gas industry on the environmental air. This negative sentiment among uninformed residents may represent a social stigmatization of the population, defined as an actual or feared negative psychological experience associated with living in a community where the natural resource extraction and/or procession activities are seen as potentially destructive among some groups (Miller and Sinclair, 2013). In a study that investigated the effect of communication on people's perception of environment pollution resulting from industrial activities in the basin of Mexico, it was discovered that, despite the fact that environmental problems had acutely affected the Basin of Mexico for about 15-20 years, the inhabitants of the capital city had been relatively slow to respond. A lack of information about deteriorating environmental quality, basic ecological processes and the possible effects of increasing pollution levels contributed to this slow reaction. However, when a group of intellectuals interested in environmental issues was formed, their complaints and opinions were well received by a large part of the Mexican middle class because members of the group were well-known. The increased communication brought about an increased awareness.

The concern of residents about their exposure to **air pollution** from the oil and gas industry was significantly related to their opinion about the speed of emergency response. Residents were expected to be more sensitive (higher response value in worrying) to risk and safety issues if the emergency response was inadequate or not readily available (lower values). Almost the opposite was found, with 75 % of residents who thought the emergency response was

slow (12 residents total), being concerned about air pollution while 100 % of those who thought the emergency response was adequate and immediate (19 in total) were concerned about air pollution. Interestingly, there were 11 responders who did not have any awareness about the speed of emergency response, but their opinion about air pollution was also 100 % negative.

None of the other demographic, health-related or beneficial factors of the oil and gas industry were found to be significantly related to opinion about the air quality or air pollution. This was unexpected, as it had been hypothesized that the number of health issues, especially cancer, would be likely related to air pollution risk awareness, as has been observed in other chemical industry-affected communities and countries.

Likewise, none of the variables gathered on the employees of Saudi Aramco were significantly related to opinion about the air quality when analyzed separately. This may be because of the very low number of observations used due to the low survey response rate. The sample size requirement for logistic regression is demanding, as it is recommended to have approximately five observations at each outcome at each level of the main effect (Stokes et al. 1991, p. 222), which was not possible here due to the low survey response level. This may constitute an issue, especially before the data from the Jubail Residents and SA representatives was combined, thus caution was used while interpreting the results and the more conservative significance criterion alpha of 0.05 (Dowdy and Wearden, 1991) was decided upon.

Further analysis about the impact of the industry on the environmental air included the group in the model, it was of interest to investigate if opinion differed significantly between the residents of Jubail (n=42) and Saudi Aramco representatives (n=11). The group did not make any difference for the impact on environmental air analysis, as both the residents and SA representatives shared similar views. This result led to the group variable being dropped from the

model, which proved to be a benefit due to the increased number of responders when the groups got combined (n=53).

With increased statistical power, it was then possible to confirm the significant effect of the amount of information about environmental hazards from the public and non-governmental sources. While the amount of information from non-governmental sources and SA was related to the awareness about the impact on the air, it was found not to be related to concern of residents about the pollution of air on their health. Specifically, regardless of the amount of information received, residents had mostly worried about the issue. Numerically, 93 % of residents in little-informed group, 89% in medium- informed group and 100% in well- informed group expressed their worry about their exposure to oil and gas- related air pollution. One possible reason why information seems to affect the awareness but not the concern about the air pollution may be that the concern (fear or worry) or exposure may represent emotions related to self-preserving instinct, thus may be stronger than the knowledge (awareness) and exist independently of the amount of information received.

6.2. Factors related to the Perception of the Impact of the Oil and Gas Industry on Water Quality

Risk perceptions of the impact of the oil and gas industry on environmental water quality and the possible health issues due to water pollution were found to be significantly related to the demographic factor of being employed by the oil and gas company, awareness of physical injuries and the amount of information about environmental and health problems received by residents from the public sources and Saudi Aramco. Specifically, it was found that less than half of the residents (44%) who were employed by Saudi Aramco had negative opinions about the impact of the industry on water quality, while a larger proportion (68%) of those who had never worked for the company shared that negative outlook. Some of the residents who were employed

by the industry had a positive outlook; there were no such positive opinions to be found among those who had never worked in the industry.

It was expected that current or past employees of the oil and gas industry would have a higher level of awareness about the safety of oil and gas exploration than people who had never been employed by the industry. These results agree with that hypothesis, and also indicate loyalty to Saudi Aramco among the residents, who work, or had at one time worked, for the company. A positive relationship between the awareness of actual physical injuries of residents resulting from oil and oil exploration activities and their risk perception was hypothesized. People who had directly experienced or had relations to people who had experienced physical injuries resulting from oil and gas exploration activities were expected to be highly aware of the risk attached to the activities of the industry. Indeed, it was found that only about 17% of residents without previous physical injuries had negative opinions about the impact while about 65% of those residents who had experienced injuries had negative opinions about the impact of the industry on water quality.

This result agrees with Lave (1987), who noted that people feel strongly about health and safety issues and become deeply uncomfortable when thinking about situations that involve danger to their children or to themselves. Crawford-Brown (1999) noted that residents' perceived risks might depend not only on social and cultural factors, but on the evidence they possess regarding the frequency, severity and variability of effects. The physical injuries in our survey represented a very factual and obviously notable variable for the residents, supporting Crawford-Brown's conclusions that laypeople's risk assessments involve judgments of probability, severity of catastrophic consequences and perceived control.

The information flow from local public officials and from Saudi Aramco to the residents was also related to judgements about the impacts on water, as was the case with environmental air. As expected, residents who were not well informed and received only 0-1 mode of information were largely negative (64%), with some positive opinions (11%) about the impact of the oil and gas extraction activities on air quality. Of the residents who were moderately informed (2-3 modes of communication), only 22 % had negative opinions while more had a neutral opinion (67%) and 11% had a positive opinion about the issue. Interestingly, all of the residents who received 3-4 modes of information had a negative judgment about the impact of the industry on environmental water.

While the amount of information from non-governmental sources and SA was related to the awareness about the impact on the water, it was found not to be related to concern of residents about the pollution of water on their health. Specifically, regardless of the amount of information received, residents had mostly worried about the issue. Numerically, 90 % of residents in little-informed group, 67% in medium- informed group and 75% in well- informed group expressed their worry about their exposure to oil and gas- related air pollution. One possible reason why information seems to affect the awareness but not the concern about the water pollution, similarly as with air pollution, may be that the concern (fear or worry) or exposure may represent emotions related to self-preserving instinct, thus may be stronger than the knowledge (awareness) and exist independently of the amount of information received.

It was expected that more communication would lead to better awareness and an increased perception of risks. Likewise, Burningham and Thrush (2004) considered the appropriate risk communication strategies the most important instrument for citizens living in chemical-industrial communities to understand the environmental and health-related issues. They concluded that the

differences in risk judgments among laypeople, governments and the industrial sector were a major cause of the problems in risk communication.

Examining the attitude of the Saudi Aramco employees about the impact of the industry they are working in on the environmental water, two factors were found to be almost significant ($0.05 < p < 0.10$) relation to their attitude: training and environmental safety practices, as well as the production knowledge of field workers. Most of the employees (10/11, or 90.91 %) reported the safety training to be adequate, and only one representative reported the training to be insufficient. However, 80% of employees who thought that the training about the safety practices was adequate nevertheless had negative opinions about the impact on water, 20% were neutral and no one had a positive outlook on the issue. The employee who thought the training was bad, interestingly, reported that he thought the impact of the industry on environmental water was positive. This would be an interesting variable to explore with larger number of responders. A very similar situation arose with regard to the production knowledge of the field workers. 80% of those who thought the knowledge was adequate had negative opinions and 20% had neutral opinions about the impact of industry on the environmental water, while only one person who reported inadequate training thought the impact was positive.

When the datasets from residents and SA representatives were combined, the most significant factor related to opinion about the impact of the industry on environmental water remained the number of modes of communication from public and industry (non-governmental sources). All of those who had the maximum number of resources (thus being well informed) had negative opinions about the impact. Among those who were not well informed, about 67% had negative opinions while some had neutral and some had positive opinions about the impact of the industry on water. This is in agreement with earlier data which suggested that the amount

of information from non-governmental sources was a driving factor behind opinion on the nature of the industry's impact on air and water.

6.3. Factors Related to the Perception of the Impact of the Oil and Gas Industry on the Environmental Soil and Land Pollution Concern

Three variables were found to have significant relationships with the attitudes of residents towards the impact of the oil and gas industry on environmental soil. These were occupation, amount of information about the health risks from public and from Saudi Aramco, and the speed of emergency response by the oil and gas company. It was hypothesized that awareness and perceptions about risk would depend upon occupation. Specifically, employed people were expected to have higher levels of awareness about the safety of oil and gas exploration than unemployed, retired, or stay-at-home individuals. That was indeed observed; 72% of the residents that were employed had negative attitudes towards Saudi Aramco's impact on soil quality compared to 56% of unemployed people who had negative attitudes. None of the student residents had negative attitudes about the impact on soil. The proportion of residents with neutral opinions was very different across the employment categories, with 20% of employed, 44% of unemployed and 100% of students holding such an opinion.

It was also found that the amount of information about environmental and health problems received by residents from public sources and Saudi Aramco played an important role in the residents' attitudes about the soil quality and oil and gas industry's impact on it. Specifically, residents who were not well informed and received only 0-1 mode of communication had mostly (72%) negative opinions about the impact of oil and gas extraction activities on air quality, and no one had a positive opinion. On the other hand, only about 25% of residents who were moderately informed had negative opinions and most had neutral (62.5%) or positive (12.5%)

opinions about the issue. Interestingly, a large proportion (75%) of all residents who received 3-4 modes of information had negative judgments about the impact of the industry on environmental air and 25% had positive judgments. It was expected that more communication would lead to better awareness and risk perception; however, it came as a surprise that the less informed residents had mostly negative perceptions of the impact of the oil and gas industry on environmental soil.

While the amount of information from non-governmental sources and SA was related to the awareness about the impact on the soil, it was found not to be related to concern of residents about the pollution of soil and their health. Specifically, regardless of the amount of information received, residents had mostly worried about the issue. Numerically, 76 % of residents in little-informed group, 100% in medium- informed group and 100% in well- informed group expressed their worry about their exposure to oil and gas- related air pollution. One possible reason why information seems to affect the awareness but not the concern about the soil pollution, similarly as with air and water pollution, may be that the concern (fear or worry) or exposure may represent emotions related to self-preserving instinct, thus may be stronger than the knowledge (awareness) and exist independently of the amount of information received.

The attitudes of residents towards the oil and gas company's impact on soil quality were significantly related to their opinions about the speed of the emergency response. Residents were expected to be more sensitive (higher response value in worrying) to risk and safety issues if the emergency response was judged to be inadequate or not readily available (lower values). This expectation was met, as about 91% of residents who thought the emergency response was slow (11 residents total) had negative attitudes about the impact on soil quality. Only 47% of those

who thought the emergency response was adequate and immediate (17 in total) had negative opinions about the soil issue.

In addition, a close to significant relationship was found between the cancer occurrence and concern of residence about the land pollution possibly causing health problems. Specifically, 21 of 28 residents (75%) that did not report ever having cancer of any type had concerns about the soil pollution from the gas and oil drilling activities possibly affecting their health, while all (100 %) of the residents who reported having some type of cancer in their life were concerned about soil pollution from gas and oil activities.

Cancer is a diverse group of diseases characterized by an abnormal growth of cells that can escape the boundaries of the original tissue or organ and spread throughout the body. The immune system is responsible for killing these invasive cells. Exposure to toxic chemicals may weaken the function of the immune system, allowing cancer cells to grow and spread. Fibrosis and cancer are examples of chemically-induced toxicities, according to Klaassen and Watkins (2003), and the most common carcinogens are benzene and polycyclic aromatic hydrocarbons (PAHs), mainly derived from products of oil and gas exploration. While it is not conclusive to report from this research that the cancer of residents was caused or directly related to soil pollution from the oil and gas company, there may be a risk associated with such exposure (Benford, 2008).

Inspecting the attitudes of the Saudi Aramco employees about the impact of the industry they are working in on environmental soil, two factors were found close to significant ($0.05 < p < 0.10$ in both cases) related to their attitudes: training and environmental safety practices and the production knowledge of field workers. Most of the employees (10/11, 90.91 %) reported the

safety training to be adequate, and only one representative reported the training to be insufficient. However, 70% of employees who felt that the training about the safety practices was adequate had negative opinions about the impact on soil, 30% were neutral and none had a positive outlook on the issue. The one employee who thought the training was bad, interestingly, reported the impact of the industry on environmental soil was positive. This would be an interesting variable to explore with a larger number of responders. Very similar situation arose with regard to the production knowledge of field workers. 70% of those who thought their knowledge was adequate had negative opinions, 30% had neutral opinions about the impact of industry on the environmental soil and only one representative who reported inadequate training thought that the impact was positive.

No differences were found between residents' and Saudi Aramco representatives' opinions about the impact of the industry on the soil, which may represent similarities in their opinion regardless of employment status with the oil and gas industry. A significant relationship that was discovered and confirmed was that of the awareness of combined residents and SA representatives and their opinion about the speed of emergency response. Of the individuals, who assumed the emergency response was immediate, about 52% had negative opinions, while of those who thought the emergency response was slow, 92% had negative opinions about the impact of the industry on soil. This negative correlation of opinions about the efficacy of the company's response and the impact on the soil seems to be a natural, common-sense response by community members, yet to my knowledge this is the first time this sentiment has been described in relation to the oil and gas industry.

6.4. Factors Related to the Perception of the Impact of the Oil and Gas Industry on Community Well-Being

Findings in this study indicate that the amount of information about environmental and health problems received by residents from public sources and Saudi Aramco plays an important role not only in the residents' attitude about the air, water and soil quality, but is also significantly related to opinions about community well-being. Specifically, residents who received only 0-1 modes of information and were regarded as not well informed had mostly (70%) negative opinions about the impact of the oil and gas extraction activities on community well-being, with a few being neutral (19%), and fewer still held positive opinions (11%). In comparison, none of residents who were moderately informed (2-3 modes of communication) had negative opinions, a few were neutral (29%), and most had positive (71%) opinions about the issue. Interestingly, only 25% of residents who claimed to receive 3-4 modes of information had negative judgments about the impact of the industry on community well-being. Similarly, 25% held neutral positions on the issue and 50% had positive attitudes. This may reflect the possibility that those well-informed residents may also be well aware of the positive impacts of the industry on the community, such as economic and employment benefits. However, it is worth mentioning that most of the residents (28/39, 72%) indicated that they were not well informed, while the moderately informed (7/39) and well informed (4/39) were much smaller proportions.

In addition, the attitude of residents about the impact of the industry on soil was found to be almost significantly related to the awareness about the risks of fires and explosions. It was expected that there would be a positive relationship, and it was found that about 38% of residents who were aware of fire possibilities, but never experienced any fire, had negative opinions about the impact of the industry on community well-being. Meanwhile, 80% of those residents who

had experienced a fire or explosion had negative opinions. The possibility of fires and explosions from the industry and their consequences on the well-being of the community would be something very prominent in the minds of community members, and therefore it is not unanticipated to find this positive relationship. As it was also concluded by Crawford-Brown (1999) that laypeople's risk judgments involve judgments of probability and severity of catastrophic consequences.

None of the other socio-demographic variables collected from the representatives of the Saudi Aramco Company besides the safety training and knowledge of field procedures on water and soil impact, as discussed earlier, were found related in a significant way to their attitude about the impact of their employing industry on any of the environmental factors studied. This may be because the representatives of Saudi Aramco Oil Company consider these activities to be generators of economic development. Their real perception of the risks of oil and gas production and extraction in this region may be accurate, but their shared or reported perception of risk may be minimized and subjective. It may represent a positive response to negative rhetoric propagated by the media and communities to pressure Saudi Aramco to provide more economic benefits to residents. However, since Saudi Aramco is the largest state-owned oil company in this region, it was expected that the risk perception and interpretation of the SA representatives would be similar to those of residents. It is worth noting that only 11 representatives of Saudi Aramco answered the survey, and therefore it may be an insufficient sample size for drawing sufficient conclusions.

Comparing solely the opinions of the SA representatives and Jubail residents, it was observed that the relationship was very close to being statistically significant, as the SA representatives had more positive outlooks of their company on community well-being as compared to the

residents. However, when this grouping was used (Jubail residents, SA representatives) individually with the seven variables common between both groups (Table 3) in the models predicting the opinion about the impact on well-being, the group variable was not found to be significant.

The two instances when the group in the model yielded close to significant results in the model were with age and with level of information from the government. The most important variable related to the opinion about the impact of the industry on community well-being was found to be the level of information about the environmental and health hazards from public and industry resources, just as it was in the case of environmental air and water. Which group respondents belonged to did not contribute significantly, and the pattern that emerged was different than that observed with respect to the air and water impact. The amount of information seems to have a positive correlation with positive opinion, as more information from public sources relates to more positive outlooks on community well-being.

On the other end of the spectrum, people who did not have any, or only one, source of information shared negative outlooks about the impact of the industry on community well-being. The outlook of combined Jubail residents and SA representatives on the impact of oil and gas industry on community well-being was almost significantly related to the cancer prevalence. However, when the group was dropped from the model, cancer was found to be the important factor by both ordinal logistic regression and frequency analysis. The relationship was as expected, and as observed with respect to the impact on air quality- namely, people diagnosed with cancer had a more than 20% larger group with negative opinions about the impact of the industry on community well-being than people free of cancer. Also, people without cancer had about 38% more people with positive outlooks on the impact of the oil and gas industry on the

community than people who experienced some sort of cancer. It is noteworthy that a very high overall proportion of people reported having cancer: 13 of the 51 residents and representatives, constituting 25.5% of the survey respondents. If this were a true estimate of cancer prevalence, then serious measures would need to be taken. Jubail City's population is approximately 300,000 people, so if every fourth person has a risk of cancer that means ~75,000 people may be diagnosed with cancer sooner or later. More research should be dedicated to this problem. Although there is previous literature pointing out increased cancer prevalence in areas with heavy oil and gas industry activity (Khuhaprema et al., 2010), it is not possible to conclude from this research that the cancer was caused or directly related to air, water or land pollution from the oil and gas company. There may be a risk associated with exposure to the polluted air (Benford, 2008), which affects the residents' and SA representatives' opinions. Thus it is natural to see that the people who had cancer were more aware and critical about the environmental issues.

The significance of oil and gas industry pollution as a public risk factor has been evaluated in Baton Rouge, Louisiana, U.S.A., home of the 11th largest oil complex in the world. The related neighborhoods have been renamed "the cancer valley" (Emelue 2014) due to hundreds of deaths from different kinds of cancer traceable to the operations of the complex over a 20 year period. Cancer has a long latency, and the elevation of cancer can be seen many years after the initial exposure. Since this present research was conducted at one point in time and it was found that cancer survivors had more negative outlooks about the oil and gas industry, it would be valuable to look at the cancer prevalence of Jubail residents using actual medical records over a longer period of time and compare that to an age-matched control cohort, such as residents of similar city in Saudi Arabia without the presence of the oil and gas industry.

Catalan-Vazquez et al. (2014), in their research evaluating risks of mining activities by

the different social actors in Mexico, expressed that residents viewed “mining activities as synonymous with contamination and therefore, as having affected all areas of their environment, health, and daily life” (p. 28). Similar results were expected for the residents of Jubail as well, but with respect to the oil and gas industry. Specifically, of the demographic variables collected, employment with Saudi Aramco (yes or no) and occupation level in general (employed, unemployed or student) were confirmed to be related to the outlook of residents on the industry’s impact on environmental water and water pollution, respectively. Possibly both of these variables relate to how much information a person has about the issue. People who work for Saudi Aramco, as well as those who are employed in general, may have more exposure to the risks of the oil and gas operation than those who have never worked for the company and those who are unemployed. The amount of information from non-governmental sources was found to be strongly related to the outlook of the residents, as well as the representatives on the impact on environmental air, water, soil and community well-being. Cancer and the speed of emergency response have also been found to be important factors in determining the risk awareness among residents and company representatives.

It was expected that representatives of Saudi Aramco would consider their activities to be generators of economic development, and therefore downplay the negative impacts on the environment. This was indeed the case when looking at the responses with respect to community well-being, where more positive outlook was found among the representatives than among residents. Overall, however, it was found that the opinion of residents and risk perception was similar to that of the representatives. It may be because Saudi Aramco is the largest state-owned oil company in this region, and almost everyone is somehow associated with it.

To summarize, this study aimed to determine whether residents felt that the environmental

and health hazards are attributed mainly to the oil and gas activities, and they were found to be related to some demographic and health-related actors as well as residents being informed about the risks factors. In order to enhance a mutually supportive environment that encourages communication across different stakeholders, it is important to study public awareness and perception of risks. Public authority, specifically, the Royal Commission of Jubail City serves as intermediary between the oil and gas interests and the communities, thus it is expected they would be interested in the results of this study. They could utilize it in encouraging freedom of discourse, building dialogues and encouraging negotiations among social actors to promote a better society. These results may contribute to challenging key actors responsible for decision-making about the reduction in oil and gas emissions and risk management.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions of Research

The first four null hypotheses from Chapter 3 (I through IV) were rejected in analyses of risk perceptions about the impacts of Saudi Aramco on environmental and community elements by the Jubail City residents and residents combined with Saudi Aramco representatives:

A. Residents

I. *Ho*: There is no relationship between the demographic distribution of respondents (age, education, occupation and employment with oil and gas companies) and the risk perception of local residents and their awareness about the safety of oil and gas exploration activities in their community.

Specific alternative hypothesis was the awareness about risk and impact of industry **on the environmental water** depends on whether or not the individual is employed in the oil or gas industry. Specifically, probability of negative awareness was lower for those employed by the oil and gas industry (current or past employees) than people never employed with oil and gas industry.

II. *Ho*: There is no relationship between the environmental (spills, fires, explosions), or health issues (individual health problems and cancer) due to the oil and gas industry and the risk perceptions of residents about the safety of oil and gas exploration.

Specific alternative hypothesis was a positive relationship between the awareness of actual physical injuries of residents resulting from oil and oil exploration activities and the risk perception of residents from impact of the industry on the **environmental water**. Most of the people have experienced, or have relations to those who have experienced, physical injuries related to gas exploration 85% (34/40) and most of them (65%) have had negative perception about the industry and its impact on environmental water. The perceptions of the people unaware of injuries were more positive, but this group was represented only by 6 individuals.

III. Ho: There is no relationship between environmental and health risk communication to residents (from the general public, industry and the government) and risk perceptions and awareness of residents about the safety of oil and gas exploration.

The specific alternative hypothesis was a dependency between the amount of public information or communication (conversation with other community members, brochures and public meetings with Saudi Aramco's environmental protection department) and perception and awareness about the safety of residents in relation to the industry and **environmental air, soil and community well-being**. It was expected that more communication leads to better awareness and perception. However, this relationship was not exactly obvious, as both well-informed and uninformed people had negative awareness about the impact of industry on air and soil. A different relationship was found between the level of information and the impact of the industry on community well-being. Specifically, probability of neutral and positive awareness is the highest for people more informed, while less informed have higher probability of negative opinion.

IV. Ho: The responsiveness of oil and gas companies to emergencies (including transportation) related to oil and gas activity is not related to perceptions and awareness of residents about safety of oil and gas exploration.

Specific alternative hypothesis was the responsiveness of oil and gas companies to their business-related emergencies (transportation incidents, contact with equipment, fires, explosions, and exposure to harmful substances or worker injuries) is negatively related to risk perception and awareness of the residents about **environmental soil and air pollution** resulting from oil and gas exploration activities. Residents were expected to be more sensitive (higher response value) to risk and safety issues if the emergency response is inadequate or not readily available (lower values). Indeed the resident who summarized the emergency response of oil and gas company as slow, had mostly negative perception (90.9%) about the impact of the industry on soil, while those who thought the emergency response was adequate, had more positive perception of the industry's impact on soil.

B. Residents Combined with Saudi Aramco Representatives

I. Ho: There is no relationship between the demographic distribution of respondents (age, education, occupation and employment with oil and gas companies) and the risk perception of local residents and SA employees and their awareness about the safety of oil and gas exploration activities in their community.

Specific alternative hypothesis was the awareness about risk and impact of industry **on the environmental water** depends on whether or not the individual is a resident not currently working for the oil or gas industry and whether they are employees of the Saudi Aramco Oil Company Environmental Protection Department (EPD). Specifically, probability of negative

awareness was lower for those employed by SA EPD than residents. At the same time probability of positive awareness was higher for those employed by SA EPD than residents.

II. *Ho*: There is no relationship between the environmental (spills, fires, explosions), or health issues (individual health problems and cancer) due to the oil and gas industry and the risk perceptions of residents and SA employees about the safety of oil and gas exploration.

Specific alternative hypothesis was that there is a positive relationship between the diagnosis of cancer in families or the community attributed to the pollution effects of exploration activities and the risk perception of residents. People with higher prevalence of cancer had higher probability of negative perception of industry's impact on **environmental air and community well-being**.

III. *Ho*: There is no relationship between environmental and health risk communication to residents (from the general public, industry and the government) and risk perceptions and awareness of residents and SA employees about the safety of oil and gas exploration.

The specific alternative hypothesis was a dependency between the amount of public information or communication (conversation with other community members, brochures and public meetings with Saudi Aramco's environmental protection department) and perception and awareness about the safety of residents in relation to the industry and **environmental air, water and community well-being**. It was expected that more communication leads to better awareness and perception. However, this relationship was not exactly obvious, as the well-informed and uninformed people had mostly negative awareness about the impact of industry on air and water. Different relationships were found between level of information and the impact of the industry on community well-being. Specifically, probability of neutral and positive awareness is the

highest for people more informed while less informed have higher probability of negative opinion.

IV. *Ho*: The responsiveness of oil and gas companies to emergencies (including transportation) related to oil and gas activity is not related to perceptions and awareness of residents and SA employees about safety of oil and gas exploration.

Specific alternative hypothesis was the responsiveness of oil and gas companies to their business-related emergencies (transportation incidents, contact with equipment, fires, explosions, and exposure to harmful substances or worker injuries) is negatively related to risk perception and awareness of the residents about **environmental air and soil** resulting from oil and gas exploration activities. People were expected to be more sensitive (higher negative response value) to risk and safety issues if the emergency response is inadequate or not readily available (lower values). Indeed, the residents and SA representatives, who summarized the emergency response of oil and gas company as slow, had mostly negative perceptions (73%) about the impact of the industry on soil, while those who thought the emergency response was adequate had less negative (59%) perceptions of the industry's impact on soil.

The following two main null hypotheses were not rejected in analysis of perception of impact of Saudi Aramco on environmental and community elements by the Jubail City residents and residents combined with Saudi Aramco representatives:

V. The benefits of the oil and gas industry to community (employment, economic development, infrastructure and scholarships) are unrelated to the perception and awareness of residents about the safety of oil and gas explorations.

VI. The presence of adequate policies about the environmental safety and protection (methods of regulations by the Jubail Industrial City Royal Commission (JICRC), practices based on OSHA, specific risks, responsiveness of the oil company to various emergencies developed from the industries' activities, communication to public, communication with JICRC to field workers, environmental safety and health practices and training) are unrelated to the perception of SA representatives about the environmental pollution of air, water, land and effects on community well-being.

To summarize the results, four main characteristics of Jubail City's residents' related to their awareness about the industry's impact on environmental and community elements were 1) the employment with gas and oil company as demographic information; 2) health issues, especially cancer; 3) communication of residents with non-governmental sources and Saudi Aramco and 4) the speed of emergency response of Saudi Aramco.

7.2. Limitations and Suggestions for Future Research

While this study was an important first step, there are a number of ways in which future researchers could expand upon this research in order to better understand the underlying issues and propose more nuanced solutions.

1. First, as with most survey-based studies, a larger sample size would prove beneficial to the quality of the results. As detailed above, on several occasions, it was necessary to combine response categories in order to produce meaningful categories for statistical analyses. Increasing the number of survey participants would allow for increased data granularity and could reveal statistically significant relationships that were missed by the analysis done in this study. Other cities could be included to investigate the effects of

geography, population density, average age, and other factors that may vary from place to place. If the population frame is the residents in academia (faculty, staff and students) at the Jubail Technical College consisting of 5,000 people, then the recommended sample size of 357 (Orcher, 2007) should be used. Accounting for the 54.5 % survey response rate, the survey should be administered to 656 people at the college.

2. Along those same lines, it would also benefit future researchers to expand the survey to include female respondents and investigate the influence of sex, if any, on risk perception and awareness in this context. This could involve a female acquaintance to administer the survey to females.
3. Another useful cohort in the study would be actual field workers of the Saudi Aramco company. This group, however, was not accessible without special permission of Saudi Aramco. In a future study, surveying field workers should be considered.
4. In this study, it was assumed the employees and students attending the Jubail Technical College are representative of the City of Jubail residents. While this is not a valid assumption and the sample represented a rather younger population (the average age of the sampled group was 33.4 years), it was necessary to identify an accessible sample. In addition, the college environment would also allow for higher reception to the idea of conducting the research and thus improve the success of answering the survey.
5. The sampling procedure was limited by numerous confines, related to the novelty of the survey idea, cultural and time constraints. In the future study, perhaps with the collaboration with Saudi Aramco and Saudi Arabia government agencies, a random cluster sampling method should be utilized (Orcher, 2007). The 'cluster' is defined as a pre-existing group. For instance, the clusters in the future study could represent different

non-overlapping representation of the city residents based on their actual proportions, such as Saudi Aramco field workers, Saudi Aramco administrators, residents living (male and female) in close proximity to the refinery and residents (male and female) living further away from the refinery. To draw a random cluster sample, first, the clusters would be numbered and then a simple random sample will be drawn from each cluster based on the size of each cluster. This would ensure the representative sampling from a heterogeneous population (Orcher, 2007).

6. The survey was not a validated instrument. Since there was not a similar instrument available in literature, validation of this survey would be very beneficial. Human perception is a challenging and quite subjective variable to validate. Having measures of actual physical contaminants of air, water and soil in Jubail City, coupled with thorough health records, including cancer on different classes of residents, including field workers, people living in the close proximity to the refinery as well as all of the women and children would add credibility to the study.
7. Finally, for simplicity, future researchers may wish to abstain from including open-ended questions in their survey or to formulate such questions in a way that limits the number of possible responses. This study obtained very little useful qualitative data from the attempts at posing such questions to participants, due both to the low response rate and the low quality of much of the qualitative data that was available.

Even though this study has numerous limitations due to the sampling difficulties, this research represents a first exploratory research and information of this kind for City of

Jubail in Saudi Arabia, representing the awareness and public perception of the impact of the oil and gas industry on the environmental air, water, soil and community well-being.

7.3. Recommendations for Saudi Aramco and for the Saudi Arabia government

The recommendations based on this work apply to two broad groups. As the company responsible for both the positive and negative impacts of the industry on the residents of Jubail, clearly Saudi Aramco can improve. In addition, the government of Saudi Arabia is considered as a crucial player in the well-being of the residents because of its regulatory authority over Saudi Aramco and its unique relationship with its citizens in Jubail.

It is clear that information from non-governmental sources and industry, such as Saudi Aramco, plays a key role in how the residents of Jubail evaluate the risks and impacts associated with the oil and gas industry. Information from non-governmental sources was found to have statistical significance in its relationships to nearly all of the independent variables that were considered, especially to the awareness of residents about the impact of oil and gas industry on the pollution of air, water and community well-being. Any improvements that can be made to this publicly available information could significantly alter public opinion.

Recommendations to Saudi Aramco (SA):

1. Based on the research results, specifically, the finding that only 10% of all residents and of residents combined with Saudi Aramco representatives felt they were well informed (3-4 modes of communication) and majority (63-68%) were informed very little (0-1 modes of communication from Saudi Aramco), it is recommended that SA to begin an integrated an

information campaign across multiple media and information sources to inform both the employees as well as the residents of Jubail City about possible health risks from the activities of oil and gas company.

2. Thorough and regular measurements of air, water and soil pollution throughout the City of Jubail should be funded by Saudi Armco.
3. Results of the monitoring should be immediately available to the public. For example, other methods of communication could be explored, particularly with respect to internet and cellular technologies, to improve the accuracy, speed, and reach of any pollution, emergency and health risks important information that needs to be communicated to residents. From the research results, it was learned that most of residents are concerned about their health through the impact of the industry on the air (93%), water (83%) and land (83%) pollution. Actual measurements of the air, water and soil pollution- monitoring and data readily available to public would be the first two steps to inform the residents. If the monitoring results showed within safe limits, then this information would potentially decrease the fear of the public. If the results of the monitoring revealed above the safety limits, then SA would be responsible to take further steps to protect the health and safety of residents and clean the environment.
4. Saudi Aramco should take specific measures to contain the pollution by investing into building air and water treatment plants, as well as to take care of the soil reclamation in oil spills-affected areas.
5. Saudi Aramco should take a responsibility for health monitoring and treatment not only for their field workers but the residents living in the city.

6. Cancer epidemiology research in Jubail City should be funded by Saudi Aramco, because cancer seems to be prevalent and a concern among residents. For example, it would be beneficial to measure the cancer prevalence of Jubail residents using actual medical records over longer period of time and compare that to an age-matched control cohort, such as residents of similar size cities in Saudi Arabia without the oil and gas industry. While the complexity of cancer treatment is well beyond the scope of this dissertation, a highly-visible effort from Saudi Aramco to identify the causes behind carcinogenic exposure and minimize their impacts on local residents could do much towards easing fears about cancer related to oil and gas extraction.
7. It would benefit Saudi Aramco in the long term to improve its relationship with local governmental and business leaders to develop a plan for well-being of the workers and the residents of City of Jubail by developing and placing regulatory policies in place.

Recommendations to government of Saudi Arabia:

1. Based on the results of this study, the government should act to improve the speed and quality of emergency response from Saudi Aramco. The speed of emergency response in case of oil spills, fires, explosions and other disasters related to the oil and gas extraction activities was found to have a statistically significant effect on several dependent variables that were investigated in this study. Thus improving emergency response should lead to a more positive view of Saudi Aramco and its resource extraction activities. For instance, it would prove helpful to implement more strict legal requirements that dictate an acceptable emergency response procedure and then regularly test and seek to improve such procedures. Ensuring that the requirements and legal consequences for failures to adhere to them are clearly spelled out in the law should help to reduce concern amongst residents about the

company's response to emergency situations. Such a change would improve the confidence residents have in Saudi Aramco when it successfully adhered to the regulations, as well as in the regulatory authority of the government when it reliably and responsibly enforced punishments for any deficiencies. This would also provide an opportunity for Saudi Aramco, the government of Saudi Arabia, and local residents to collaboratively create, improve, and implement disaster management plans.

2. Since it was found that information from governmental sources did not significantly impact any of the examined dependent variables in this survey. Thus, funding for governmental information campaigns could be better spent in other ways that provide a better return on investment with regards to public opinion. While safety regulations and inspections as spelled out above is one area that this funding could go towards, there are others. For example, the government of Saudi Arabia may wish to conduct further surveys on the residents of Jubail to investigate how it could improve the impact and trustworthiness of its information. It may also find that it is more effective to communicate all educational messages to residents through Saudi Aramco, rather than through official government channels, as information from the company seems to have a greater impact on public sentiment.
3. Governmental policies should be placed on Saudi Aramco to oversee, regulate and ensure the company carries out all of the preventable measures for cleaning the air, water, soil and to place regular inspections, followed through by citations, fines and sanctions if not carried out.
4. The government of Saudi Arabia should also place guidelines for Saudi Aramco for the health monitoring of workers as well as residents of City of Jubail, especially cancer. It

should have sanctions in place to hold Saudi Aramco accountable for health risks and negative health consequences of their industry.

5. The government of Saudi Arabia should establish and fund independent research facilities such as National Institute for Oil and Gas Industry Safety and Health and the Environmental Protection Research Facility.
6. It is recommended that the government of Saudi Arabia oversees the establishment of the School of Public Health, college or similar high-level academic institutions dedicated to train Saudi people for gas and oil related safety and health.

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APPENDIX I

OIL AND NATURAL GAS RISK PERCEPTION SURVEY:

FOR RESIDENTS

The purpose of this survey is to collect data for my PhD research. All information gathered in this survey will be kept confidential. The only data released to the public will be in a form where individual responses cannot be identified. Kindly complete the survey in all truthfulness.

1. Are you currently an employee or have you been employed in the past by oil and gas

companies? (Please check one box)

Current employee

☐

Past employee

☐

Retired

☐

Never an employee

☐

Others. Please specify: _____

2. In your option, what type of impacts do oil and gas extraction activities have on your community? (Please check one for each impact)

Impact	Very Negative	Negative	Somewhat Negative	Neutral	Somewhat Positive	Positive	Very Positive	Don't Know
Environment, Air								
Environment, Water								
Environment, Soil								
Community Well- being								

3. What different risks associated with oil and gas extraction are you aware of? (Please check one for each risk)

Risks	Unaware	Aware but no personal experience	Aware and have personal experience	Don't Know
Fires and Explosions				
Physical Injury Incidents				

If others, please specify: _____

4. How much do you worry about exposure to pollution related to the extraction of oil and natural gas? (Please check one response for each type of pollution)

Type of Pollution	Very Worried	Worried	Somewhat Worried	Not Worried
Air Pollution				
Water Pollution				
Land Pollution				

5. What is the likelihood that pollution resulting from oil and gas activities has caused health problems for you, your family, or members of your community? (Please check one response for each)

	Very Likely	Likely	Somewhat Likely	Not Likely	Don't Know
You Personally					
Your Family					
Members of Your Community					

6. How have environmental and health risks from oil and gas extraction and production been communicated to you in the past? (Please check all that apply)

Conversations with other community members

☐

Brochures

☐

Public meetings

☐

Communications from Saudi Aramco's Environmental Protection Department

☐

Communications from Jubail Industrial City Royal Commission

☐

No communication has ever been made

☐

Other. Please describe: _____

7. What have you learned about risks from any communications with the Saudi Aramco's Environmental Protection Department?

8. What have you learned about risks from any communications with the Jubail Industrial Royal Commission Environmental Protection Department?

9. Have you ever experienced any environmental / health hazard resulting from oil and gas extraction and production in Eastern Province of Jubail? (Please check only one)

Yes

☐

No

☐

Please describe this experience or experiences:

10. Over the past year, what are some of the health symptoms that you have noticed within affected communities that might be attributed to exposure to soil, air, and/or water pollution due to Saudi Aramco Oil Company extraction and production activities? (Please check all that apply)

Nausea	☐
Shortness of breath	☐
Headaches or migraines	☐
Eye irritation (burning or itchy eyes)	☐
Nose irritation (itchy, burning, or runny nose)	☐
Throat irritation	☐
Odor	☐
Skin Rash	☐
Sore or blisters	☐
Diarrhea	☐
Disorientation	☐
Cancer	☐

No symptoms noticed

☐

Other symptoms, please specify: _____

11. Within the past five years, have you ever voiced concerns to government officials regarding the negative impacts of oil and gas extraction? (Please check one box)

Yes

☐

No

☐

Please describe the concerns expressed:

12. How satisfied are you with the response of government officials within the oil and gas regulatory bodies in reacting effectively and providing solutions to the oil and gas production and extraction impacts that you've voiced your concerns regarding? (Please check one box)

Very satisfied

☐

Satisfied

☐

Somewhat satisfied

☐

Dissatisfied

☐

Very dissatisfied

☐

Not applicable ☐

Don't know ☐

13. How comfortable are you about expressing your concerns about the impacts of oil and gas production and extraction to public officials? (Please check one box)

Very comfortable ☐

Comfortable ☐

Somewhat comfortable ☐

Not comfortable ☐

Don't know ☐

14. How responsive were oil and gas representatives in cases of emergency or any perceived risks, including transportation incidents, contact with equipment, fires, explosions, exposure to harmful substances, falls. etc.? (Please check one box)

Very immediate ☐

Immediate ☐

Somewhat immediate ☐

Not immediate ☐

Don't know

☐

15. Based on your understanding of the risks involved in oil and gas extraction, please choose your level of agreement with each statement. (Please check one response per statement)

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Oil and gas from extraction to production is the biggest source of pollution in the Eastern Province of Jubail.					
Pollution from oil and gas extraction and production activities is hazardous to human health.					
Oil and gas extraction and production have negative impacts on agriculture.					
Oil and gas extraction and production have negative impacts on water quality and water resources.					

16. From your perspective, what are the benefits resulting from oil and gas production and extraction activities to the communities in the Eastern Province of Jubail? (Please check all that apply)

A more robust economy

☐

Employment opportunities

☐

City development process

☐

Attractive to other business

☐

Infrastructure stability (roads, bridges, etc.)

☐

Scholarship to residents

☐

Not aware

☐

Others. Please specify: _____

Respondent Information

17. Year of birth : 19_____

18. Gender :

Male

☐

Female

☐

19. Nationality :

Saudi Arabian

☐

Other

☐

If other, please specify: _____

20. Education level:

Primary education

☐

High school diploma

☐

Technical school

☐

Bachelor's degree

☐

Graduate school

☐

21. Occupational Status:

Employed

☐

Unemployed

☐

Retired

☐

Stay at home spouse

☐

Other/please specify: _____

Thank you for taking the time to participate in this study. Your assistance in providing this information is very much appreciated.

APPENDIX II

OIL AND NATURAL GAS RISK PERCEPTION SURVEY:

FOR SAUDI ARAMCO REPRESENTATIVES

This survey is a means of data collection for my research as a PhD student. All information gathered in this survey will be kept confidential. The only data released to the public will be in a form where individual responses cannot be identified. Kindly complete the survey in all truthfulness.

1. In your opinion, what type of impacts do oil and gas extraction activities have on the surrounding communities? (Please check all that apply)

Impact	Very Negative	Negative	Somewhat Negative	Neutral	Somewhat Positive	Positive	Very Positive	Don't Know
Environment, Air								
Environment, Water								
Environment, Soil								
Community Well-being								

2. Based on the impacts listed in the previous question, are there adequate policies in place to combat any negative effects to the environment or community members resulting from the extraction activities of oil and gas? (Please check one box and explain)

Yes ☐ Explain how? _____

No ☐ Explain why? _____

3. What methods are used by regulatory bodies incorporated under the Royal Commission for Jubail and Yanbu (RCJY) ensure that oil and gas companies operate or carry out the extraction activities within the confines of the laws? (Please check all that apply)

Inspections ☐

Citations ☐

Fines ☐

Sanctions ☐

Other methods. Please specify:

4. Please describe the legal basis for at least one of the methods identified in question #3 above.

5. In your opinion, how would you rate the practices that are applied in retorting and refining procedures utilized by the Saudi Aramco Oil Company based on OSHA standard? (Please check one response for each)

Procedure for Saudi Aramco	Maximum Practice	Below Maximum but Above Minimum Practice	Minimum Practice	Below Minimum Practice
Retorting				
Refining				

6. What different risks associated with oil and gas extraction do you have experience in dealing with in your job? (Please check all that apply)

Risks	No Experience	Have Personal Experience	Don't Know
Fires and Explosions			
Physical Injury Incidents			

If there are other risks that you have experience with, please specify:

7. How responsive do you think oil and gas representatives have been in cases of emergency or any perceived risks, including transportation incidents, contact with equipment, fires, explosions, exposure to harmful substances, falls. etc.? (Please check one box)

Very immediate	☐
Immediate	☐
Somewhat immediate	☐
Not immediate	☐
Don't know	☐

8. How have environmental and health risks from oil and gas extraction and production been communicated to community residents? (Please check all that apply)

Conversations with other community members

☐

Brochures

☐

Public meetings

☐

Communications from Saudi Aramco's Environmental Protection Department

☐

Communications from Jubail Industrial City Royal Commission

☐

To my knowledge, no communications have been made

☐

Other communications, please describe:

9. What do you think that the general public has learned about risks from these communications regarding oil and gas extraction and production activities?

10. How are environmental and health risks from oil and gas extraction and production communicated to field workers? (Please check all that apply)

Conversations with other field workers

☐

Brochures

☐

Public meetings

☐

Communications from Saudi Aramco's Environmental Protection Department

☐

Communications from Jubail Industrial City Royal Commission

☐

To my knowledge, no communications have been made

☐

Other communications, please describe:

11. Over the past year, what are some of the human health symptoms that you have noticed within affected communities that might be attributed to exposure from soil, air, and/or water pollution due to Saudi Aramco Oil Company extraction and production activities? (Please check all that apply)

Nausea ☐

Shortness of breath ☐

Headaches or migraines ☐

Eye irritation (burning or itchy eyes) ☐

Nose irritation (itchy, burning, or runny nose) ☐

Throat irritation ☐

Odor ☐

Skin Rash ☐

Sore or blisters ☐

Diarrhea ☐

Disorientation ☐

Cancer ☐

No symptoms noticed ☐

Other symptoms, please specify: _____

12. Please rate the following issues pertaining to the training and practices by oil and gas extraction workers. (Please check the appropriate rating for each statement)

Statement	Excellent	Good	Average	Poor	Don't Know
Employer provided training on environmental health and safety issues concerning oil and gas extraction procedures.					
Employee knowledge of the extraction and production processes.					
Employee utilization of their environmental health and safety training on the job.					

13. Based on your understanding of the risks involved in oil and gas extraction, please choose your level of agreement with each statement. (Please check one response per statement)

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Oil and gas from extraction to production is the biggest source of pollution in the Eastern Province of Jubail.					
Pollution from oil and gas extraction and production activities is hazardous to human health.					
Oil and gas extraction and production have negative impacts on agriculture.					
Oil and gas extraction and production have negative impacts on water quality and water resources.					

Respondent Information

14. **Year of birth:** 19_____

15. **Gender:**

Male

☐

Female

☐

16. **Nationality:**

Saudi Arabian

☐

Other

☐

If other, please specify: _____

17. **Education level:**

Primary education

☐

High school diploma

☐

Technical school

☐

Bachelor's degree

☐

Graduate school

☐

**Thank you for taking the time to participate in this study. Your assistance in providing this
information is very much appreciated.**

APPENDIX III

Table 37- Number of responses for each question in resident survey (total number answering the survey N=42)

Survey questions to residents		Number of people answering the question
Q1. Are you currently an employee or have you been employed in the past by oil and gas companies? (Please check one box)		42
Q2. What impact do oil and gas extraction activities have on your community? (Please check one for each impact)	Air	41
	Water	41
	Soil	37
	Well-being	38
Q3. What different risks associated with oil and gas extraction are you aware of? (Please check one for each risk)	Fires	42
	Physical injuries	41
Q4. How much do you worry about exposure to pollution related to the extraction of oil and natural gas? (Please check one for each pollution)	Air	42
	Water	42
	Land	41
Q5. What is the likelihood that pollution resulting from oil and gas activities has caused health problems for you, your family, or members of your community? (Please check one response for each)		42
Q6. How have environmental and health risks from oil and gas extraction and production been communicated to you in the past? (Please check all that apply)		42
Q7. What have you learned about risks from any communications with the Saudi Aramco's Environmental Protection Department?		20
Q8. What have you learned about risks from any communications with the Jubail Industrial Royal Commission Environmental Protection Department?		14
Q9. Have you ever experienced any environmental / health hazard resulting from oil and gas extraction and production in Eastern Province of Jubail? (Please check only one)		42
Q10. Over the past year, what are some of the health symptoms that you have noticed within affected communities that might be attributed to exposure to soil, air, and/or water pollution due to Saudi Aramco Oil Company extraction and production activities? (Please check all that apply)		42
Q11. Within the past five years, have you ever voiced concerns to government officials regarding the negative impacts of oil and gas extraction? (Please check one box)	Yes or No	6
	Please describe the concerns expressed	2

Q12. How satisfied are you with the response of government officials within the oil and gas regulatory bodies in reacting effectively and providing solutions to the oil and gas production and extraction impacts that you've voiced your concerns regarding? (Please check one box)	41
Q13. How comfortable are you about expressing your concerns about the impacts of oil and gas production and extraction to public officials? (Please check one box)	41
Q14. How responsive were oil and gas representatives in cases of emergency or any perceived risks, including transportation incidents, contact with equipment, fires, explosions, exposure to harmful substances, falls. etc.? (Please check one box)	42
Q15. Based on your understanding of the risks involved in oil and gas extraction, please choose your level of agreement with each statement. (Please check one response per statement)	40
Q16. From your perspective, what are the benefits resulting from oil and gas production and extraction activities to the communities in the Eastern Province of Jubail? (Please check all that apply)	42
Q17. Year of birth:19____	36
Q20. Educational level	42
Q21. Occupation	42

Table 38- Number of responses for each question in Saudi Aramco representatives survey (total number answering the survey N=11).

Survey questions to Saudi Aramco EPD representatives		Number of people answering the question
Q1. What impact do oil and gas extraction activities have on your community? (Please check one for each impact)	Air	11
	Water	11
	Soil	11
	Well-being	11
Q2. Based on the impacts listed in the previous question, are there adequate policies in place to combat any negative effects to the environment or community members resulting from the extraction activities of oil and gas? (Please check one box and explain)		10
Q3. What methods are used by regulatory bodies incorporated under the Royal Commission for Jubail and Yanbu (RCJY) ensure that oil and gas companies operate or carry out the extraction activities within the confines of the laws? (Please check all that apply)		9
Q4. Please describe the legal basis for at least one of the methods identified in question #3 above.		3
Q5. In your opinion, how would you rate the practices that are applied in retorting and refining procedures utilized by the Saudi Aramco Oil Company based on OSHA standard? (Please check one response for each)	Retorting	8
	Refining	11
Q6. What different risks associated with oil and gas extraction do you have experience in dealing with in your job? (Please check all that apply)	Fires and Explosions	11
	Physical Injury Incidents	10
	If there are other risks that you have experience with, please specify.	4
Q7. How responsive do you think oil and gas representatives have been in cases of emergency or any perceived risks, including transportation incidents, contact with equipment, fires, explosions, exposure to harmful substances, falls. etc.? (Please check one box)		11
Q9. What do you think that the general public has learned about risks from these communications regarding oil and gas extraction and production activities?		8

Survey questions to Saudi Aramco EPD representatives		Number of people answering the question
Q10. How are environmental and health risks from oil and gas extraction and production communicated to field workers? (Please check all that apply)		11
Q11. Over the past year, what are some of the human health symptoms that you have noticed within affected communities that might be attributed to exposure from soil, air, and/or water pollution due to Saudi Aramco Oil Company extraction and production activities? (Please check all that apply)the appropriate rating for each statement)		11
Q12. Please rate the following issues pertaining to the training and practices by oil and gas extraction workers. (Please check the appropriate rating for each statement)	Employer provided training on environmental health and safety issues concerning oil and gas extraction procedures.	11
	Employee knowledge of the extraction and production processes.	11
	Employee utilization of their environmental health and safety training on the job.	11
Q13. Based on your understanding of the risks involved in oil and gas extraction, please choose your level of agreement with each statement. (Please check one response per statement)	Oil and gas from extraction to production is the biggest source of pollution in the Eastern Province of Jubail.	10
	Pollution from oil and gas extraction and production activities is hazardous to human health.	10
	Oil and gas extraction and production have negative impacts on agriculture.	11
	Oil and gas extraction and production have negative impacts on water quality and water resources.	11
Q14. Year of birth		10
Q15. Gender		11
Q16. Nationality		11
Q17. Education level		11