OZONE AIR POLLUTION AND STAGE-OF-CHANGE STATUS FOR ALTERNATIVE TRANSPORTATION USAGE AMONG COLLEGE STUDENTS

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BY

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To the Dean of the Graduate School:

I am submitting herewith a dissertation written by Lynn M. Ott entitled "Ozone Air Pollution and Stage-of-Change Status for Alternative Transportation Usage Among College Students." I have examined this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy with a major in Health Studies.

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ABSTRACT

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OZONE AIR POLLUTION AND STAGE-OF-CHANGE STATUS FOR ALTERNATIVE TRANSPORTATION USAGE AMOUNG COLLEGE STUDENTS

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Non-attainment of EPA standards for ozone (O_3) is the most common air pollution problem facing large cities in the U.S. In 1999, approximately 184.5 million U.S. residents lived in areas with unhealthful 0_3 levels. Minority and disadvantaged populations are disproportionately represented in these areas. Motor vehicle exhaust is responsible for 49% of emissions of O_3's precursor, NOx. Reduction of auto emissions will be necessary in order to attain healthful O_3 levels. Part of the solution will involve increased usage of more sustainable transportation sources. This study used a self-report survey, developed by the researcher, which utilized Prochaska's Stage of Change Theory, and the Health Belief Model, to assess stage-of-change status, barriers, and incentives for usage of walking, bicycling, carpooling, and public transit for commuting purposes, and to determine health beliefs regarding ozone air pollution. The survey was administered to 103 male and 99 female college students between the ages of 18 to 65. Chi-square analysis revealed the majority of participants were in the precontemplaton stage for usage of each alternative transportation method with no differences by the selected demographics. Carpooling had the highest percent of participants in the advanced stages of change (planning, action and maintenance). Ordinal regression analysis revealed that low income, the incentive of saving money on transportation costs, and the belief that air pollution will affect future health were significant predictors of advanced stage of change status.

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CHAPTER I

INTRODUCTION

Rationale

Air pollution has become a major environmental health problem affecting both developed and developing countries throughout the world (World Health Organization [WHO], 1999). The consequence has been that air pollution is causing human health problems as well as damage to vegetation, crops, wildlife, materials, buildings and even the climate (Elsom, 1992). In the U.S., the largest sources of air pollution, in order of importance, are: 1) transportation, mainly automobiles and trucks; 2) electric power plants that burn coal or oil; and 3) industry, for which the major sources include steel mills, metal smelters, oil refineries, and paper mills (Nadakavudaren, 2000). The most common air pollution problem resulting from these emission sources is ground-level ozone (O_3). According to the United States Environmental Protection Agency (EPA) (1999a), non-attainment of EPA requirements for O_3 is the most common air pollution problem facing large cities in the U.S. It is estimated that in 1999, 184.5 million people in the U.S. lived in areas that are in non-attainment of healthful O_3 levels (United States Department of Transportation [DOT], 2002).

O_3 is a colorless, odorless gas that occurs naturally in relatively high concentrations in the stratosphere, which lies approximately 10-30 miles above the earth's surface (EPA, 1999b). This stratospheric ozone layer is essential to the maintenance of life on earth, protecting the earth's inhabitants from the sun's harmful ultraviolet (UV) radiation (Elsom, 1992). While O_3 also occurs naturally in very small amounts at ground level in the troposphere, in urban areas throughout the U.S., tropospheric O_3 levels are rising to unhealthful levels sometimes reaching over 10 times the natural level (EPA, 1999b; Nadakavukaren, 2000). In affected urban areas, O_3 air pollution reaches its highest level between the months of May and September when temperatures are high and sunlight abundant (ALA, 1998). O_3 forms at ground level when volatile organic compounds (VOC's) combine with nitrogen dioxides (NOx) in the presence of heat and light (Nadakavukaren, 2000; Texas Natural Resource Conservation Commission [TNRCC], 1999). NOx is formed via the burning of fossil fuels at high temperatures, and is the primary precursor to O_3. NOx and VOC's, are emitted into the air by motor vehicles, electrical power plants and other industrial plants.

Ground-level O_3 negatively affects human health as well as the health of plants, and ecosystems. The adverse health effects resulting from exposure to O_3 are numerous, and researchers estimate that one in three people in the U.S. are at risk for experiencing these adverse health effects (EPA, 1999b). The ALA (1999a) estimates the number of air pollution related deaths in the U.S. to range from 50,000 to 100,000 per year. When O_3 air pollution reaches unhealthful levels, emergency room visits due to asthma and other respiratory diseases increase for both children and adults (Burnett, Smith-Doiron, Stieb, Cakmak, & Brook, 1999; Cody, Clifford, Birnbaum, & Lioy, 1992; White, Etzel, Wilcox, & Lloyd, 1994). As reported by Kundro (1999), Health

Canada found that the risk of death as a result of O_3 exposure increased by 1% for every 10 part per billion (ppb) increase in O_3 concentration. The risk of respiratory problems requiring hospital admission increased 8% for every 10 ppb increase.

Lung damage resulting from over-exposure to O_3 may occur without the presence of noticeable symptoms. Regardless of symptomotology or lack thereof, long-term exposure to O_3 continues to harm the lungs, speeding up the reduction of lung function that is a natural part of the aging process (EPA, 1999b; NASA, 2002). Certain populations have been identified as being at particular risk for adverse health effects resulting from O_3 exposure. Children, individuals who work or exercise outdoors in the summer, individuals with unusual susceptibility to O_3, and individuals suffering from bronchitis, asthma or emphysema are at special risk during periods of high ozone levels (ALA, 1998; EPA, 1999b).

In the past, efforts to reduce air pollution have consisted primarily of "command and control" programs that involve enforcement of government regulations designed to reduce toxic emissions. Such programs have proven highly effective in reducing industrial, point source pollution and causing auto manufacturers to produce cleaner burning automobiles (DOT, 2002; EPA, 1998; EPA, 1999a; Nadakavukaren, 2000). While these government controls continue to effectively lower industrial emissions and reduce pollutants emitted from vehicles, O_3's precursor, NOx, continues to be emitted into the air at increasing levels. The EPA (1998) reports that since 1970, NOx emissions have increased by approximately 10%. This increase in NOx emissions is attributable to increased usage of motor vehicles and increased usage of higher polluting vehicles. The DOT(2002) reports that vehicle miles driven in the U.S. has increased 140% since 1970. Presently, 49% of NOx emissions in the U.S. come from motor vehicles: 27% from utility plants: and 19% from industrial, commercial, and residential sources (EPA, 1998). Because vehicle exhaust is the leading cause of the build up of O_3 air pollution in U.S. cities, reduction of auto emissions will be necessary in order to reach attainment of EPA air quality standards for ground-level 0_3.

Problems underlying ever increasing auto emissions of NOx and subsequent development of ground-level ozone air pollution are complex and multifaceted, requiring solutions that are more complex and wider in scope than traditional command and control methods. Underlying conditions which dictate the need to increase single-occupancy driving need to be addressed in order to make alternatives more amenable. Such factors include but are not limited to business practices that encourage non-sustainable transportation practices, community planning and development, housing development patterns and individual transportation choices. Individual choices pertaining to transportation sources and usage play a central role in rise of O_3 and will need to play a critical role in cleaning up our air.

In the past, scientists and policymakers have virtually ignored the behavioral components of environmental problems (Gardner & Stern, 1996; McKinney & Schoh, 1998). More recently, experts have voiced a strong need for involvement from the social sciences such as sociology and psychology, in order to apply their expertise in helping bring about more sustainable behavior (Gardner & Stern, 1996; McKinney & Schoch, 1998). In response to this need for effective social action, the EPA has developed new strategies to assist communities and individuals to embrace more environmentally friendly behaviors (EPA, 2000). The EPA's "Community-Based Environmental Protection" program (CBEP) is an excellent example of this type of program. CBEP helps communities develop multifaceted strategies to address behaviorally based environmental problems that cannot be solved with traditional command and control policies. CBEP seeks solutions to these more complex environmental problems by addressing the underlying factors that contribute to environmentally unfriendly behaviors.

A multi-faceted approach such as this could be quite effective in addressing issues underlying the problem of ever increasing single-occupancy vehicle usage. Such programs would work with the community to remove the barriers to using alternative transportation. These barriers may include but are not limited to increased time required when using alternative transportation, safety concerns regarding mass transit, problems of convenience, employment issues, the high cost of living in cities were people work, and increased crime in inner cities (Gardner & Stearns, 1996). The DOT is aware of many of these barriers and has several programs in place to help make the use of alternative transportation more amenable to the needs of the public (DOT, 1999; DOT, 2002). Both the EPA and the DOT warn however that programs aimed at providing alternatives to single-occupancy vehicle usage can only be effective if the public actually utilizes such alternatives. Therefore, the DOT (1999; 2002) and the EPA (2000) strongly encourage aggressive marketing approaches and public education and outreach programs aimed at increasing the public's knowledge of O_3 air pollution and increasing the use of alternative transportation.

Moving towards decreasing usage of single-occupancy vehicles and increasing usage of more environmentally friendly modes of transportation in order to reduce O_3 air pollution is a social change strongly supported by health professionals as well. Organizations such as the ALA and APHA are highly involved in advocacy work aimed at increasing air quality standards and promoting changes that will bring about decreases in O_3 air pollution. Health educators can also play a vital role in bringing about social changes that will help communities move towards more sustainable transportation choices. The field of health education has been highly successful in applying human behavior theories to the understanding of various health-related behaviors as well as using these theories to guide development of programs that have proven highly effective in bringing about behavior change (Glanz, Lewis, & Rimer, 1997). Many of these same theories could serve as effective tools in developing a deeper understanding of individuals' environmental behaviors and in developing programs to assist in bringing about more sustainable behavior. In particular, such theories could be highly effective in developing programs that will encourage individuals to utilize sustainable transportation choices. Currently, there is a lack of empirical research in which social theory has been applied to addressing the underlying problems which lead to O_3 air pollution and the use of non-sustainable transportation.

Research in which social theory is applied to reducing air pollution is important because in order to develop effective programs, it is first necessary to understand the attitudes, beliefs, and readiness of individuals regarding use of alternative transportation. The Transtheoretical Model (TTM) has been successfully used in health education research to guide in determining individual and population readiness for change. The Transtheoretical Model (TTM) was developed by James Prochaska as a result of studies on addictive behaviors (Glanz et al., 1997). These studies showed that behavior change occurs not as an isolated event but rather a multistage process as individuals progress through a series of six stages of change: precontemplation, contemplation, preparation, action, maintenance, and termination (Prochaska & DiClemente, 1983). Interventions are then developed in order to assist individuals in moving from their current stage into the next stage of change and such interventions are guided by what Prochaska called "processes of change." Different processes of change are applied based on the individual's stage-of-change status. For example, if a person were in the precontemplation stage, consciousness-raising would be an appropriate intervention for facilitating movement into the contemplation stage (Glanz et al., 1997; Prochaska, 1992). While the TTM was developed to assist individuals in overcoming addictions, it has proven to be quite effective when applied to a broad range of health behaviors such as exercise (Chrisler, 1994), cardiovascular rehabilitation (Hellman, 1997), and numerous others (Glanz et al., 1997). This model can also be useful in determining individuals' stage of change pertaining to sustainable transportation behaviors. Once a target population's stage of change is determined, appropriate educational and behavioral programs can be developed to assist in moving individuals along the change continuum. When using the TTM for this purpose, the goal of intervention would to move individuals to the maintenance stage, in which sustainable transportation behaviors are consistently practiced, since termination of these behaviors would be undesirable.

The health belief model (HBM) has been effectively used to explain beliefs associated with health-related behaviors, and as a guiding framework for designing health education programs (Glanz et al., 1997). Developed by Hockbaum, Leventhal, Kegeles and Rosenstock, the HBM states that an individual will take action to control for an ill-health condition if the individual believes he or she is susceptible to the condition, the condition would have serious consequences, that a particular action will be beneficial, and the benefit of such action outweighs the costs of such action (Rosenstock, 1974; Strecher & Rosenstock, 1997). The HBM can be a powerful tool to guide assessment of beliefs regarding the health effects of O_3 air pollution and the benefits and barriers to the use of alternative transportation. Such cost-benefit analysis has been highly effective in developing programs designed to increase other sustainable behaviors such as recycling and energy conservation (McKenzie-Mohr & Smith, 1999). Determining a population's stage of change, along with the barriers and benefits of change as set forth by the two aforementioned theoretical models, will lay an excellent foundation upon which effective program development can take place.

Statement of the Purpose

The purpose to this study was to explore attitudes and beliefs regarding ozone air pollution and alternative transportation usage among community college students in a northern California city, which suffers from a severe ozone air pollution problem. The researcher sought to determine beliefs regarding the primary source of ozone air pollution and beliefs about the health effects of ozone air pollution. In addition the researcher explored the relationship between selected demographics and stage-of-change status of the population in regards to usage of various forms of alternative transportation including walking, bicycling, carpooling, and public transportation.

Hypotheses

The following five null hypotheses were tested for this study:

Null Hypothesis 1: There are no statistically significant differences in stage-of-change status regarding alternative transportation usage among students of a northern California college related to age, gender, income level, ethnicity, educational level, college major, and educational background.

Null Hypothesis 2: There are no statistically significant differences in perceived barriers to alternative transportation usage among students of a northern California college related to age, gender, income level, ethnicity, educational level, college major, and educational background.

Null Hypothesis 3: There are no statistically significant differences in the perceived benefits of using alternative transportation among students of a northern California college related to age, gender, income level, ethnicity, educational level, college major, and educational background.

Null Hypothesis 4: There are no statistically significant differences in health beliefs regarding air pollution among students of a northern California college related to age, gender, income level, ethnicity, educational level, college major, and educational background.

Null Hypotheses 5: There is no statistically significant relationship between stage-of-change status, perceived barriers, perceived benefits, and health beliefs regarding air pollution reduction among students of a northern California college.

Delimitations

The following delimitations were identified in this study:

1. All participants were students at American River College.

Limitations

The following limitations are identified in this study:

1. The study population was limited to students attending American River College, a community college in northern California.
2. Generalizability may be limited due to the use of a convenience sample as subjects in this study.
3. All participants were capable of reading and speaking the English language.

Assumptions

The following assumptions have been made pertaining to the implementation of this study:

1. Students who participated in the study were able to read and understand all items in the Sustainable Transportation Survey.
2. Student participants answered all items truthfully and to the best of their ability.

Definition of Terms

The following terms have been defined for use in this study:

1. Ground-level ozone – Ground-level ozone, an air pollutant, develops when nitrogen dioxide combines with volatile organic compounds in the presence of heat and sunlight (Nadakavukaren, 2000).

2. Incentive – Something that encourages a particular behavior, may include actual benefits of performing the behavior.

3. National Ambient Air Quality Standards (NAAQS) – National regulations indicating the maximum levels allowable, in a given geographical area, for each of the 6 criteria pollutants (Nadakavukaren, 2000).

4. Ozone (O_3) – A gas composed of three atoms of oxygen, O_3 occurs naturally in the stratosphere 10-30 miles above the earth's surface in order to protect life on earth from the sun's harmful UV rays (EPA, 1999).

5. Nitrogen Oxides (NOx) – a generic term for a group of gases which contain both nitrogen and oxygen (EPA, 1998a)

6. Processes of change – Developed by Prochaska and DiClemente (1983), processes of change can be defined as "covert and overt activities that people use to progress through the six stages-of-change. Processes of change provide important guides for intervention programs" (Glanz et al., 1997, p. 63).

7. Stages-of-change – A series of six stages an individual moves through during the behavior change process. Prochaska and DiClemente (1983) define these stages as follows:

a) Precontemplation – An individual has no intention of taking action to change the behavior in the foreseeable future.

b) Contemplation – An individual is acutely aware of the cons of changing the particular behavior and intends to change the behavior within the next six months.

c) Preparation – An individual intends to take action within the next month, and often has a plan for doing so.

d) Action – An individual has made specific behavioral changes within the last six months.

e) Maintenance –An individual is sustaining the behavior and is working to prevent relapse. Maintenance may last from six months to five years.

f) Termination –An individual is abstaining from a substance or behavior, and has no temptation to return to the pre-change behavior. Not applicable to positive behavior change, since termination would involve discontinuing the desirable behavior.

8. Sustainable behavior – Behaviors by which an individual meets his or her needs without degrading the environment for future generations (McKinney & Schoch, 1998).

9. Sustainability – "Meeting the needs of today without reducing the quality of life for future generations" (McKinney & Schoch, 1998).

10. Transtheoretical Model (TTM) – A model that defines specific stages of change that one experiences as he or she changes a particular behavior. The model was

developed by James Prochaska and Robert DiClemente (Prochaska & DiClemente, 1983).

Importance of the Study

Traditional "command and control" methods for reducing various environmental pollutants are not sufficient for controlling the nation's O_3 air pollution problem. Such methods are highly effective in controlling "point source" pollutants, i.e., those that are released from specific locations such as power plants or industrial sites (Nadakavukaren, 2000). Reduction of "non-point source" pollutants, those that enter the environment from broad, undefined locations such as motor vehicle exhaust, remain a formidable challenge. Command and control methods are currently being implemented and are highly effective in reducing emissions of O_3's precursors, NOx and VOCs, from industrial sites. However, NOx emissions from motor vehicles, a nonpoint source pollutant, have increased 10% since 1970 despite legislation requiring cleaner burning motor vehicles (EPA, 1998). This increase in NOx emissions is attributable to increases in usage of motor vehicles and increased usage of SUV's and trucks (DOT, 2002).

The EPA and the DOT recognize that reducing O_3 air pollution will require reducing dependency on single occupancy vehicles, and they are using a multifaceted approach to developing programs to accomplish this. Such programs involve development and implementation of new transportation technologies, increasing use and convenience of current alternative transportation resources, and developing educational and incentive programs to encourage the public to utilize these alternatives (DOT, 2002;

EPA, 2000). Far more money and effort have gone into development of new technologies, resulting in a current need for educational and incentive programs aimed at encouraging the public to utilize sources of alternative transportation.

Development of effective educational and incentive programs will require an understanding of the public's current attitudes, perceptions, and beliefs regarding O_3 air pollution and its health effects. It will also require an understanding of the relationship between various population demographics and stage of change regarding usage of various types of alternative transportation, as well as perceived barriers and benefits of utilizing various sources of alternative transportation. It is the hope of this researcher that this study will contribute to the acquisition of such knowledge in order that effective health education programs can be developed.

CHAPTER II

REVIEW OF THE LITERATURE

This chapter contains a review of the literature. Topics discussed include a historical perspective on O_3 air pollution, characteristics and health effects of O_3, and strategies to reduce tropospheric O_3.

Historical Perspective on Ozone Air Pollution

Evidence that air pollution has been troublesome to humans can be traced back to the days when primitive man sat around smoky, indoor fires. According to Brimblecombe (1987), archaeological evidence suggests that early humans experienced respiratory discomfort as a result of these indoor fires. In developing countries today, indoor air pollution resulting from indoor fires, used for cooking and heat, continues to pose a health threat to susceptible individuals (WHO, 1999). In the early days of Rome, authors referred to the "oppressive fumes of Rome" in their writings (WHO, 1999). In the 1300's air pollution from the burning of coal was recognized as a serious problem. As a result, King Edward I placed a ban on the burning of "sea-coal." Stiff penalties were administered to those violating this order, with third offenses being punishable by death (Martin, 1975). Coal burning in London resumed, however, and London became known for its thick, sooty air (Nadakavukaren, 2000). It was not until 1819 that London once again began taking measures to reduce air pollution (Elsom, 1992).

While air pollution has been troublesome to humans since the beginning of time, the dawn of industrialization brought about rapid increases in air pollution throughout the industrialized world. In the early 1800's, the rapid growth and development of energy intensive industries and the influx of people into large cities, accompanied by record levels of fossil fuel consumption, had a dramatic effect on the air quality in growing cities. The mounting problem of air pollution resulted in health problems, public complaints and political action aimed at air pollution reduction. Early efforts to curb smoke emissions in U.S. cities consisted primarily of local legislation (Elsom, 1992). For example, in 1867, the city of St. Louis passed an ordinance mandating that all industrial smokestacks be 20 feet higher than neighboring buildings in order to reduce high levels of smoke in the air (Nakakavukaren, 2000). In 1881, the cities of Chicago and Cincinnati passed municipal legislation that prohibited industrial emission of thick smoke. By 1912, 23 of 28 U.S. cities with populations over 200,000 had programs aimed at reducing dense smoke in the air (Elsom, 1992).

Despite these early efforts to reduce air pollution, the problem continued to worsen, resulting in several episodes that had a profound effect on human health. One such incidence occurred on October of 1948 when the city of Donora, Pennsylvania, experienced a temperature inversion which trapped air pollutants from industrial plants in the valley, forming a dense layer of smoke and soot. The incidence had a tragic effect on the health of the town's small population of 12,300, resulting in 20 deaths and 5,910 persons becoming ill (Elsom, 1992; Nadakavukaren, 2000; Schrenk, Heinmann, Clayton, Gafafer, &Wexler, 1949; WHO, 1999). New York has experienced similar events on several occasions. In November of 1953, New York experienced a sudden rise in levels of particulate matter and sulphur dioxide that resulted in the death of approximately 250 people. Similar incidences occurred in New York in 1962, 1963 and 1966 (Greenburg, Field, Reed, & Erhard, 1962).

Up until the early 1940's, air pollution problems consisted primarily of particulate matter released into the atmosphere, appearing in the form of thick, dense smoke. Early air pollution legislation occurred on a local level and was aimed primarily at reducing smoke. As public awareness of air pollution grew, efforts to reduce dense, smoky emissions began to show encouraging results. The visible air quality in cities throughout the U.S. showed significant improvement in the late 1950's and early 1960's as industries began burning natural gas and oil as opposed to coal (Nadakavukaren, 2000).

As smoky air pollution conditions decreased, however, new forms of air pollution began to emerge. These new pollutants, most of which are by-products of fossil fuel burning, have become the primary air pollutants in large cities throughout the world today (Nadakavukaren, 2000; WHO, 1999). This new type of air pollution was first recognized in the early 1940's, as the Los Angeles basin in southern California began to experience long, frequent episodes of brownish, hazy air that differed from the smoke normally associated with air pollution. This unusual air pollution was originally named "smog" and was mistakenly believed to be a combination of smoke and fog. Because of the health problems occurring as a result of "smog," the California Air Pollution Control Act of 1947, aimed at reducing smoke and sulphur dioxide emissions, was enacted and certain plants producing heavy, visible emissions were forced to close (Elsom, 1992). These actions did little to reduce the "smog" in Los Angeles, however, because they were not aimed at the true sources of the problem, fossil fuel burning motor vehicles and industrial plants (Nadakavukaren, 2000). What was once called "smog" later became known as photochemical pollution. The most abundant and harmful pollutant contained in photochemical pollution is ozone (O_3) (EPA, 1999b; McKinney & Schoch, 1998; Nadakavukaren, 2000). While Los Angeles was among one of the first cities to experience O_3 air pollution, during the 1960's and 1970's cities throughout the U.S. and the industrialized world began to experience rapidly rising levels of O_3, the main constituent of photochemical smog (Elsom, 1992).

Currently, in industrialized countries, including the United States, the primary sources of air pollution are a result of the development of industry and sources of motorized transportation. In the U.S., the largest sources of air pollution, in order of importance, are: 1) transportation, mainly automobiles and trucks; 2) electric power plants that burn coal or oil; and 3) industry, for which the major sources include steel mills, metal smelters, oil refineries, and paper mills (Nadakavudaren, 2000). The most common air pollution problem resulting from these emission sources is ground-level O_3. It is estimated that in 1997, approximately 43% of the U.S. population lived in areas shown to have unhealthful levels of O_3 air pollution (Healthy People 2010, 2000). According to the United States Environmental Protection Agency (EPA) (1999a), non-attainment of EPA requirements for O_3 is the most common air pollution problem facing large cities in the U.S.

Characteristics of Ozone

Ozone is a colorless, odorless gas that naturally occurs in relatively high concentrations in the stratosphere that lies approximately 10-30 miles above the earth's surface (EPA, 1999b). The stratospheric level of the earth's atmosphere lies directly above the troposphere, which extends from sea level to approximately 8-9 miles above the earth's surface. It is in the troposphere that nearly all forms of life on earth reside (Nadakavukaren, 2000). Within the stratosphere lies a highly concentrated level of ozone, commonly referred to as the ozone layer. The highest concentrations of O_3 within the stratosphere occur between 11-15 miles above the earth's surface (Elsom, 1992; Nadakavukaren, 2000). This stratospheric ozone is created when high-energy ultra-violet (UV) radiation splits normal oxygen molecules (O_2) into atomic oxygen (O), thus freeing the two atomic oxygen atoms to combine with other O_2 molecules to form ozone molecules (O_3). UV radiation is also easily absorbed by O_3 molecules. When this occurs, O_3 molecules are split into O_2 and O, freeing the atomic oxygen to possibly combine and create either another new O_2 molecule, or join with an existing O_2 molecule to form a new molecule of O_3. Thus, free of human interference, the stratospheric ozone layer is continually maintaining a dynamic equilibrium between ozone production and ozone destruction that maintains the earth's protective ozone layer (McKinney & Schoch, 1998).

The stratospheric ozone layer is essential to the maintenance of life on earth for two important reasons. The ozone layer protects life on earth from the sun's harmful UV radiation as O_3 molecules absorb radiant energy, split into O_2 and O, and release heat. This process is beneficial to the earth's inhabitants because it absorbs a large portion of biologically damaging UV radiation which in excess can cause skin cancers, cataracts, disruption in growth and function of plant life – including photosynthesis, and other serious ecological disruption (Dickey, 1999). In addition, the ozone layer helps maintain stable climate conditions in the troposphere where life resides (McKinney & Schoch, 1998).

While O_3, as it occurs naturally in the stratosphere, is necessary to maintenance of life on earth, O_3 is a harmful air pollutant when it forms at ground level in the troposphere, causing damage to human health, vegetation and common materials (EPA, 1999b). O_3 occurs naturally in very small amounts at ground-level; however, in large cities and their surrounding areas throughout the U.S. ozone often rises to unhealthy levels, sometimes reaching to over 10 times the natural level (McKinney & Schoch, 1998), causing it to be one of the most serious air pollution problems facing the U.S. today. O_3 air pollution forms at ground-level when nitrogen oxides (NOx) combine with volatile organic compounds (VOCs) in the presence of heat and sunlight (Nadakavukaren, 2000). In affected urban areas, O_3 air pollution reaches its highest level between the months of May and September, when temperatures are high and sunlight is abundant (ALA, 1998). NOx and VOCs, the precursors of O_3, are emitted into the air by motor vehicles, electrical power plants and other industrial plants.

VOCs are chemicals that are emitted into the air in small amounts from natural sources. Most VOC emissions, however, are the result of motor vehicle emissions, chemical manufacturing, dry cleaners, and other industrial and consumer usages of chemical solvents (EPA, 1998a). NOx is formed when fossil fuels are burned at high temperatures. According to the EPA (1998a), the main source of these NOx emissions is burning of fossil fuels by motor vehicles and power plants. Motor vehicles are by far the largest offenders, being responsible for 49% of all NOx emissions. Electrical power plants are responsible for 27% of all NOx emissions; industry produces 19%, and 5% of NOx emissions come from other sources. Not only are NOx emissions the primary precursor in the formation of ground-level O_3, they are a precursor to acid rain, cause deterioration in water quality, and contribute to global warming. The EPA (1998b) estimates that in 1997, over 23 million tons of NOx were released into the air in the U.S., making NOx the only criteria air pollutant emitted directly in the air that is showing a significant increase in the U.S. All other criteria air pollutants are on the decline.

Effects of Tropospheric Ozone Exposure

Because the O_3 molecule is highly reactive, it acts as a powerful oxidant (McKinney & Schoch, 1998). Consequently, ground-level ozone negatively affects human health as well as the health of plants, and ecosystems. In order to understand the health effects of various levels of O_3 in the troposphere, the EPA, NIEHS, and other scientists and health professionals rely primarily on epidemiological and toxicological studies. One goal of these studies is to establish the dose-response relationship for various pollutants and for combinations of pollutants. The EPA and the WHO use these studies to determine the health effects of different levels of exposure and to determine a dose at which no health effect is detectable (WHO, 1999). In the U.S., the EPA also uses these studies to set National Ambient Air Quality Standards (NAAQS) for the six criteria air pollutants that the EPA has deemed harmful to human health. The sole purpose of the NAAQS is to reduce these six criteria air pollutants to levels which pose no threat to human health, while at the same time allowing a margin of safety in order to protect more vulnerable individuals such as children and the elderly (EPA, 1999a; Nadakavukaren, 2000). From these studies, WHO (1999) has concluded that humans begin experiencing adverse effects from O_3 when levels reach concentrations of .10 to .25 parts per million (ppm). WHO (1999) in its "Air Quality Guide," recommends that countries work towards not exceeding maximum one-hour O_3 concentrations of 0.06 ppm or a maximum 8 hour average concentration of 0.03 ppm. For approximately 22 years, the EPA (1999a) had set the federal air quality standard for O_3 at .12 ppm averaged over one hour. An area is in "attainment" with the O_3 NAAQS if the area does not exceed this level more that one day per year over a period of three years. However, research has continued to demonstrate adverse health effects in healthy children and adults at levels lower than the national standard for O_3. Research has also shown that a standard based on several hours rather than an hourly peak is more protective of public health. In response to these research findings, in 1997, the EPA (2002) announced a new, stricter ozone standard of 0.08 ppm averaged over an eight-hour period. In the year 2000, this new standard began to be phased-in.

Human Health Effects

The adverse health effects resulting in exposure to ground-level ozone are numerous, and researchers estimate that one in three people in the U.S. are at risk for experiencing one or more of these health effects (EPA, 1999b). The ALA estimates the number of air-pollution-related deaths in the U.S. to range from 50,000 to 100,000 per year. Hospitalizations and emergency visits for respiratory related illness also show a significant rise on days when ozone levels are high. Dickey (1999) states that hospitalizations for asthma, pneumonia and COPD increase 6-10% for each 50 parts per billion (ppb) increase in peak ozone levels. Burnett et al. (1999) performed a 15-year study in Toronto, Canada, examining the association of daily levels of gaseous air pollutants and particulate matter with daily hospitalizations due to asthma, obstructive lung disease, respiratory infection, heart failure, ischemic heart disease, cerebral vascular disease and peripheral vascular disease. After factoring out confounding factors such as temperature, day of week, climate, and humidity, results showed that O_3 air pollution made a significant contribution to hospital admissions. Interestingly, three auto-related pollutants made a significant contribution to hospital admissions, with NOx, ozone's precursor, making the largest contribution.

Because O_3 is a very strong oxidant, it causes adverse health effects to the respiratory system, exposed mucous membranes and even the immune system. While exposure to O_3 affects individuals differently, symptoms may include one or more of the following: shortness of breath, chest pain, wheezing, coughing, headache, nausea, malaise, and eye irritation. Individuals may experience any variety of these symptoms at O_3 levels found in most large urban areas throughout the U.S. (ALA, 1999; Dickey, 1999; Hammer et al, 1974). Hammer et al. (1974) studied a sample of healthy student nurses in Los Angeles in order to determine the association between hourly threshold levels of O_3 and a variety of health effects caused by O_3. Threshold levels for various symptomotologies were .05 ppm for headaches, .15 ppm for eye irritation, .27 ppm for coughs, and .29 ppm for chest discomfort.

Respiratory health effects are the most common result of exposure. Because O_3 is highly reactive, it causes damage to lung tissue, increases lung sensitivity to other irritants, reduces the lung's ability to fight respiratory infection, and reduces lung function (Dickey, 1999; EPA, 1999a; Nadakavukaren, 2000; NASA, 2002). O_3 expresses its oxidative qualities by interacting with biomolecules in the lungs, forming ozonides that then become free radicals. Free radicals then interact with various parts of the lung, causing inflammation and damage throughout (Dickey, 1999). As O_3 reacts with the lung's biomolecules and incoming O_2 in the airways, chemical bonds form and reform in different ways, causing inflammation in the membrane lining of the airways. The airways react by covering affected areas with fluid and by contracting muscles. These actions cause a reduction in the diameter of the airways resulting in decreased lung capacity.

Another important consequence of over-exposure is a reduction in the airway's ability to provide a protective barrier against infectious agents and other irritants (Dickey, 1999; NASA, 2002; Nadakavukaren, 2000). O_3 damages the cilia which line the lung's airways. This cilia lining is important to lung function because in protects the lungs by removing foreign particles. Unhealthful levels of O_3 damage this delicate cilia lining by slowing down or stopping the cilia's activity altogether. At higher levels of O_3 exposure, patches of the lung's cilia may die and disappear altogether.

Fortunately, this damage to ciliated cells is reversible (Nadakavukaren, 2000; NASA 2002). As O_3 travels more deeply into the lungs, it reaches the aveoli, were the exchange of oxygen and carbon dioxide takes place. Damage occurs as ozone inhibits activity of the macrophages that reside in the alveoli. This assault on alveolar macrophages further reduces the lung's ability to protect itself from pathogenic organisms, increasing susceptibility to infectious, airborne respiratory diseases such as colds, bronchitis, flu, and pneumonia (EPA, 1999b; Dickey, 1999; Nadakavukaren, 2000; NASA, 2002).

Alveolar cells are particularly sensitive to O_3, which damages the walls of the alveoli, causing tiny lesions. As these lesions heal, scar tissue develops causing the lung tissue to become thicker and stiffer, further reducing lung capacity. While the O_3 related lesions in the alveoli are reversible, subsequent scar tissue remains and is believed to be partially responsible for long-term reduction of lung function when exposure occurs over a long period of time (Nadakavukaren, 2000; NASA, 2002).

EPA scientists liken ozone's effect on the lining of the lung to the effect of sunburn on the skin. Just as sunburn causes burnt skin cells to slough off, so damaged cells in the lung's lining slough off and are replaced. Permanent damage may occur if this process continues to take place over a long period of time because this activity causes pre-mature aging of the lungs, much like sunburn causes pre-mature aging of the skin (EPA, 1999b; NASA, 2002).

Lung damage resulting from over-exposure to O_3 may occur without the presence of noticeable symptoms. On the other hand, symptoms may appear initially and then disappear as exposure continues. Regardless of symptomotology or lack thereof, O_3 exposure continues to cause harm to the lungs, speeding up the reduction of lung function that is a natural part of the aging process (EPA, 1999b; NASA, 2002).

Lung function, or vital lung capacity, is the volume of air that is drawn in with a full breath. Lung function is typically determined by measuring the speed and/or volume of air that is expelled from fully inflated lungs (NIEHS, 2000). Short-term exposure to low concentrations of O_3 has been found to cause both a significant reduction in lung function and inflammation in the lung lining of healthy children and adults during exercise. In controlled laboratory studies of healthy volunteers exposed to 80 ppb of O_3 during 6.5 hours of moderate exercise, the NIEHS (2000) observed a 5-10% reduction in the lung capacity of participants. O_3 concentration in this study is a level commonly found during warm summer months in most parts of the world. Adams and Schelegle (1983) found similar results when they exposed 10 long distance runners to O_3 concentrations of 0 ppm, .20 ppm, and .30 ppm during six-hour increments of exercise that resembled their regular training. When exposed to 0_3 during training, the athletes experienced declines in lung function as well as shortness of breath, coughing and throat irritation.

While the health effects of short-term exposure to ozone, such as occurs in laboratory studies, are reversible, lung damage resulting from long-term exposure may not be. Animal toxicology studies show that chronic exposure to concentrations of .20ppm or less of O_3 can cause changes in the small airways that are similar to changes that occur in the lungs of an individual in the early stages of chronic obstructive lung disease (Elsom, 1992). NEIHS (2000) found that when laboratory animals experienced chronic exposure to O_3 levels commonly found in U.S. cities, they developed permanent scarring in the lungs that resulted in long-term reduction of lung capacity. It appears that long-term exposure to O_3 effects human lungs in the same manner. When Detels et al. (1987) followed a cohort of 1,000 healthy, nonsmoking residents of Glendora, California, between 1977 and 1983, they found that over the years, participants experienced a decrease in FEV which is comparable to FEV declines observed in smokers. The researchers concluded that these participants are experiencing an accelerated decline in lung function that is likely due to chronic exposure to O_3.

Individual responses to O_3 exposure vary from individual to individual for reasons we do not entirely understand. Nevertheless, certain populations have been identified as being at particular risk for adverse health affects. These groups include 1) people with pre-existing respiratory disease, 2) adults who participate in physical outdoor activity, 3) people with an unusual susceptibility to ozone, and 4) children (ALA, 1998; EPA, 1999b). People with pre-existing respiratory diseases such as asthma, chronic bronchitis or emphysema are more vulnerable to O_3's damaging effects because their lungs are already functioning below normal capacity. Such diseases cause narrowing of the airways and reduction of lung surface area available for gas-exchange, often resulting in changes in inhalation patterns (WHO, 1999). When exposed to O_3, the additional reduction in lung function becomes more difficult to tolerate and individuals will experience health effects earlier and at lower O_3 concentrations than healthy adults. Furthermore, the adverse effects of O_3 exposure in some of these patients is believed to increase sensitivity to other irritants such as allergens, pathogenic organisms, and environmental pollutants (Dickey, 1999). The EPA (1999b) estimates that in the U.S., 6.4 million children and adults with asthma and other respiratory diseases live in communities with unhealthful levels of ozone.

Reduced lung function resulting from O_3 exposure is also a particular problem for healthy adults who participate in vigorous outdoor activity during the O_3 season. Such individuals include outdoor workers, athletes and others who exercise outdoors. The ALA (1999a) reports that laboratory studies on healthy adults and children reveal that participating in heavy exercise when O_3 exposure is below .12 ppm causes reduction in lung function. Because these individuals are participating in vigorous activity, they have an increased respiratory rate resulting in the intake of higher levels of O_3. This, combined with the fact that O_3 levels are significantly higher outdoors, results in this group being exposed to far higher doses of O_3 than those who are inactive outdoors or those who remain indoors. Symptoms that may appear in these individuals during activity include taking more shallow breaths at a more rapid rate (ALA, 1998; EPA, 1999b).

More recently, a new sub-group of the population has been identified as being unusually susceptible to O_3. These otherwise healthy individuals experience above average health effects from ozone exposure for reasons yet to be discovered. This subgroup, referred to as "responders," comprise approximately 5-20% of the US population. The ALA (1998) reports that in laboratory studies, "responders" experience significantly greater losses in lung function than healthy non-responders.

Perhaps most disturbing is the fact that children represent a population at particular risk for both short and long-term health effects resulting from O_3 exposure. According to the ALA (1999), approximately 27.1 million U.S. children under the age of 13, and over 1.9 million children with asthma, reside in communities in which O_3 levels exceed the new .08 ppm eight hour standard. Of these children, minority children are disproportionately represented. It is estimated that 69.2% of Hispanic children, 67.7% of Asian children and 61.3% of African American children live in areas that are in non-attainment of current O_3 standards, while only 50.8% of white children live in non-attainment areas.

Several factors combine which cause children to be especially susceptible to O_3. Children have higher metabolic rates and higher breathing rates than adults in relation to their weight and lung surface area. This results in children breathing in more air and taking in higher doses of pollution in proportion to their body weight and lung surface area as compared to adults (EPA, 1996; NASA, 2000). This is important because lung damage from air pollution is highly influenced by the ratio of pollution dose per pound of body weight (ALA, 1999). In addition, because children are still growing, their respiratory system and immune system defenses are not fully developed, making them more vulnerable to the effects of pollution. The airways of children are also more narrow than adults; thus, levels of O_3 that cause only minor inflammation may result in significant lung obstruction in a child, especially a young child. Couple these biological factors with the fact that children spend significantly greater time exercising outdoors in the summer than adults and it can easily be seen that children are a highly vulnerable population (ALA, 1999; EPA, 1999b; NASA, 2000). Studies of the lung function of children clearly show that children experience lung function declines at low levels of exposure. Lippman (1989) observed significant levels of lung impairment in children exercising outdoors when O_3 concentrations were .113 ppm. More recent findings show that children experience lung function decline when exposed to O_3 levels equal to and below the new stricter U.S. health standard of .08 ppm over eight hours (ALA, 1999). Of further concern is the fact that while children are more likely to experience reduced lung function upon exposure, they are also less likely to recognize and/or report the biological warning signs such as wheezing or shortness of breath. They are also far less likely than adults to remedy the situation by reducing exercise or moving indoors (ALA, 1999; NASA, 2000).

While the EPA specifically identifies the aforementioned four groups as being at increased risk for health effects, it is important to acknowledge other factors which influence susceptibility to the health effects of O_3. Age is one such factor. Just as young children have decreased resistance to the effects of O_3, the elderly are also at increased susceptibility. As aging occurs, lung function and physiological defense mechanisms begin to decline leaving the elderly more vulnerable to air pollution. The elderly are also more likely to have other health conditions that result in their being more vulnerable (WHO, 1999).

Socioeconomic factors also influence susceptibility. People with a poor standard of living may experience one or more factors that increase their susceptibility. These factors may include poor nutritional status, overcrowding, and decreased access to quality medical care. These problems are likely to be further compounded by the fact that poor people are more likely to live in less expensive neighborhoods, close to polluting industrial sites. Minority and disadvantaged populations are disproportionately represented in areas with high ground-level O_3 levels. Industrial and electricity generating facilities are major sources of O_3 precursors, and these facilities are disproportionately concentrated in areas with high percentages of minorities (ALA, 1998b).

Economic Effects

The negative effects of O_3 air pollution are not limited to human health, each year ozone air pollution's damaging effect on plants and materials results in the loss of billions of dollars. Much of this economic loss is due to decreased agricultural yields. An interesting characteristic of O_3 air pollution is its ability to travel hundreds of miles downwind from its point of origination, adversely affecting the crops and wild plant species that lie in its path (Elsom, 2002; NASA, 2002). O_3 is thought to be responsible for about 90% of all air pollution related damage to crops, reducing yields by up to 6-7% each year, resulting in approximately 5 billion dollars in losses to U.S. farmers each year. In California alone it is estimated that ground-level O_3 air pollution is responsible for agricultural losses of about one billion dollars per year (Elsom, 2002; McKinney & Schoch, 1998).

Once again, it is O_3's highly oxidative nature that is responsible for a large portion of its damage to plant life. When O_3 is absorbed by the plant, oxidation increases, producing compounds which interfere with the energy production in the mitochondria. The result of this reduction in energy production is three-fold. The plant will be less effective in utilizing water efficiently, photosynthesis will slow, and the plant will produce fewer numbers of flowers and fruits. Plants weakened by high concentrations of O_3 suffer further insult as they become more susceptible to disease, pests and drought (Elsom, 2002; Nadakavukaren, 2000; NASA, 2002). O_3's damage to plants also has a direct effect on soil productivity. When plants metabolize carbon dioxide (CO_2) they send carbon to the roots to be deposited in the soil were it is utilized by soil building microbes and increases nitrogen production in the soil. Exposure to high levels of O_3 reduce the plant's ability to metabolize CO_2, resulting in less carbon being sent from the atmosphere to the soil, lower levels of microbial activity, reduced soil enrichment and subsequent loss of soil fertility (NASA, 2002). Plant damage resulting from O_3 levels occurs at low concentrations. An O_3 concentration of only .05 ppm for 4 hours, far lower than our current O_3 standard, appears to be the threshold at which damage occurs in sensitive plants (Elsom, 1992). Crops that are especially sensitive to ozone damage include soybeans, spinach, tomatoes, pinto beans, peanuts, tobacco, and cotton (NASA, 2002). Farmers growing these crops in areas with high O_3 exposure must add nitrogen to the soil in order to boost productivity. Interestingly, nitrogen runoff into local waterways, resulting from poor fertilization practices, also has damaging effects on both human health and the health of aquatic ecosystems (Nadakavukaren, 2000).

Strategies to Reduce Tropospheric Ozone Levels

Command and Control Methods

In the past, efforts to reduce air pollution have consisted primarily of "command and control" programs that involve enforcement of government regulations designed to reduce toxic emissions. In 1963, the first Clean Air Act (CAA) was passed and in 1970, and 1990, amendments to the CAA were passed which gave the EPA the responsibility and legal authority to set healthful air pollution standards, to put limits on point source and mobile emissions, and to enforce these new standards. Passage of the Clean Air Act amendments set in motion the first national comprehensive program for reducing air pollution, resulting in the development of National Ambient Air Quality Standards for the six criteria pollutants determined by the EPA to be unhealthful. The six criteria pollutants include CO, NO_2, O_3, SO_2, PM 10, and lead (EPA, 1999a, 2000b). As a result of the Clean Air Act amendments of 1970 and 1990, air quality in the U.S. has shown significant improvement. Between 1970 and 1993, lead emissions from industrial sources decreased by 91%, and the move from leaded to unleaded gas reduced lead emissions even further (EPA, 1999a). SO_2, a pollutant emitted primarily by coal burning power plants, has also shown significant declines. Most areas in the U.S. are currently in attainment of lead and SO_2 NAAQS. Because motor vehicles release more harmful pollutants into the air than any other single emission source, an integral part of the CAAA has been setting emissions standards for vehicles. In metropolitan areas, it is estimated that 90-95% of CO concentrations and 80-90% of NOx and VOC's come from motorized vehicles (Nadakavukaren, 2000). This action has also proven highly successful as newer automobiles are continuing to emit fewer and fewer pollutants. Today, new automobiles emit 90% less CO, 80-90% fewer hydrocarbons (VOC's which are precursors to ozone development) and 70% less NOx compared to cars manufactured in 1970 (DOT, 2002; Nadakavukaren, 2000). In essence, since 1970, emissions of CO, PM10, SO2 and VOC have decreased significantly (EPA, 1998). These improvements in air quality and emission reduction show that government regulation and control is highly effective in reducing industrial, point source pollutants and in providing incentive for manufacturers to produce cleaner burning automobiles.

Despite these improvements, however, ground-level O_3 air pollution remains the most difficult air pollution problem to control. Furthermore, it is currently estimated that in 1999, 62 million people in the U.S. lived in areas that are in non-attainment of the old one-hour ozone standard and 122.5 million people live in areas that are in non-attainment of the newer eight-hour ozone standard (DOT, 2002). While the government controls continue to effectively lower industrial emissions and reduce pollutants emitted from vehicles, O_3's precursor, NOx, continues to be emitted into the air at increasing levels. The EPA (1998) reports that since 1970, as the aforementioned air pollutant emissions showed decline, NOx emissions increased approximately 10%. This increase in NOx emissions is attributable to increases in usage of motor vehicles and increased usage of higher polluting vehicles. Since 1970, vehicle miles traveled in the U.S. have increased 140% (DOT, 2002). The EPA estimates that Americans drive more than 2 trillion miles per year, a figure that has more that doubled since 1980. Furthermore, increasing numbers of individuals are choosing to drive vehicles that are not required to meet CAAA requirements. Such vehicles include sport utility vehicles, minivans and light-duty trucks. A loophole in the CAAA exempts these vehicles from the same emission standards that regular cars must meet, and it is estimated that these vehicles emit 2-3 times as much pollution as regular automobiles. Presently, purchases of sport utility vehicles, minivans and light-duty trucks comprise one-half of new vehicle purchases in the U.S. (Nadakavukaren, 2000). Another factor that contributes to increases in NOx emissions is the fact that increasing percentages of U.S. workers are commuting to work in single occupancy vehicles. In 1980, 6% of U.S. workers traveled to work on mass transit, 20% carpooled and 64% drove alone. In 1990, only 5% or workers utilized public transit, carpooling usage dropped to 13% and 73% of individuals drove to work alone (Gardner & Stearns, 1996). Increases in miles driven in single-occupancy vehicles accompanied by increases in growth and demand for travel have counteracted the benefits of cleaner burning cars and gasoline (DOT, 2000).

Utilizing Behavior Change Theory to Develop Effective Interventions

Problems underlying ever increasing auto emissions of NOx and subsequent development of ground-level ozone air pollution are complex and multifaceted, requiring solutions that are more complex and wider in scope than traditional command and control methodologies. Underlying conditions that dictate the need to increase single-occupancy driving need to be addressed in order to make alternatives more amenable. New technologies need to be developed, alternatives need to be more accessible and convenient, employers need to be supportive, housing and development patterns need to be altered, and the public needs to be convinced to utilize transportation alternatives. Such is the case with many environmental problems that are behaviorally based. The EPA has recognized that many environmental problems have deep underlying factors that must be addressed in order for long-term solutions to take place. Such underlying issues may include but are not limited to community development patterns, economic factors and social factors (EPA, 2000). In response to this, the EPA has developed new strategies to assist communities and individuals to embrace more environmentally friendly behaviors. The EPA's "Community-Based Environmental Protection" program (CBEP) (EPA, 2000) is an excellent example of the type of program that could be highly effective in addressing issues associated with increased automobile usage (EPA, 2000). CBEP helps communities develop multifaceted strategies to address behaviorally based environmental problems that cannot be solved with traditional command and control policies. CBEP seeks solutions to these more complex environmental problems by addressing the underlying factors that contribute to environmentally unfriendly behaviors. Effective programs can then be developed which integrate sustainable environmental practices with the economic and social objectives of the community (EPA, 2000).

A multifaceted approach such as this could be quite effective in addressing issues that underlie the problem of ever increasing single-occupancy vehicle usage. Many factors other than air quality determine individual transportation choices, and barriers to using alternatives to single-occupancy commutes or living closer to worksites are numerous. Barriers may include but are not limited to increased time required when using alternative transportation, safety concerns pertaining to mass transit, problems of convenience, employment issues, high cost of living in cities were people work, and increased crime in inner cities (Gardner & Stearns, 1996). The DOT is aware of many of these barriers and has several programs in place to help make the use of alternative transportation more amenable the needs of the public. For example, the "Congestion Mitigation and Air Quality Improvement Program" (CMAQ) (DOT, 2000) provides funding for surface transportation programs that improve air quality by reducing auto emissions in urban areas that are in non-attainment of O_3. Between 1992 and 1997, 43% of CMAQ funds were received by transit programs to improve convenience, safety, and appeal of mass transit and to reduce miles driven in single-occupancy vehicles. Other programs funded by CMAQ are aimed at reducing O_3 by developing programs that improve traffic flow and reduce congestion, increase convenience and usage of ride-sharing, increase use of vehicle emission inspection and maintenance programs and utilize education and outreach programs to increase public knowledge (DOT, 2002). The DOT is also working to develop "Intelligent Vehicle and Highway Systems" (IVHS), which if put into effect will result in sweeping changes in transportation as we know it today. The EPA and DOT recommend development of programs that will increase usage of alternative transportation and decrease motor vehicle usage. The DOT warns, however, that programs aimed at providing alternatives to single-occupancy vehicle usage can only be effective if the public actually utilizes such alternatives. Therefore, the DOT (1999; 2000) and the EPA strongly encourage aggressive marketing approaches and public education and outreach programs aimed at increasing the public's knowledge of O_3 air pollution and the development of programs that will increase usage of alternative transportation.

Moving towards decreasing usage of single-occupancy vehicles and towards more environmentally friendly modes of transportation in order to reduce O_3 air pollution is a social change supported by health professionals as well. Organizations such as the ALA and the APHA are highly involved in advocacy work aimed at increasing air quality standards and promoting changes that will bring about decreases in O_3 air pollution. (ALA, 1999; APHA, 2002). Health educators can also play a vital role in bringing about social changes that will result in more sustainable transportation practices. The field of health education has been highly successful in applying human behavior theories to the understanding of various health-related behaviors as well as using these theories to guide development of programs that have proven highly effective in bringing about behavior change (Glanz, Lewis, & Rimer, 1997). Many of these same theories could serve as effective tools in developing a deeper understanding of environmentally related behaviors and in developing programs to assist in bringing about more sustainable behavior. In particular, such theories could be highly effective in developing programs that will encourage individuals to utilize sustainable transportation choices. In order to develop effective programs, however, it is first necessary to determine the cognitive and behavioral factors that influence transportation behaviors and alternative transportation usage. These factors include the attitudes, beliefs, and readiness of individuals in regards to O_3 air pollution reduction and alternative transportation usage. Theories commonly utilized in the field of health education can be highly instrumental in guiding the assessment of these factors.

The health belief model (HBM) has been effectively used to explain beliefs associated with health related behaviors, and as a guiding framework for designing health education programs (Glanz et al., 1997). Developed by Hockbaum, Leventhal, Kegeles, and Rosenstock, the HBM explains behavior at the level of beliefs and decision-making (Rosenstock, 1974). Strecher and Rosenstock (1997) propose that an individual will take action to control for an ill-health condition if the individual believes the following: (a) he or she is susceptible to the condition; (b) the condition would have serious consequences; (c) taking a particular action will be beneficial; (d) the benefit resulting from the action outweighs the perceived negative costs such as inconvenience and financial burden; and (e) environmental cues can be effective in stimulating action (Glanz et al, 1997). Studies in which the HBM model have been applied to programs aimed at encouraging various health behaviors are numerous. The HBM has been shown to be a useful tool in understanding behaviors related to participation in immunization programs (Hockbaum, 1958), adherence to cardiac rehabilitation programs (Fleury, 1992; Oldridge & Streiner, 1990), HIV protective behaviors (Allard, 1989; Hingson, Strunin, Berlin & Heeren, 1990) and many other health related behaviors. The HBM can also be a powerful tool to guide assessment of beliefs regarding health effects of O_3 air pollution and the benefits and barriers to the use of alternative transportation. Cost-benefit analyses have been highly effective in developing programs designed to increase other sustainable behaviors such as recycling and energy conservation (McKenzie-Mohr & Smith, 1999). Once barriers and benefits of change are determined, program planners can work to decrease barriers and increase incentives for the desired behavior (McKenzie-Mohr & Smith, 1999).

Another pertinent aspect of developing effective programs to increase usage of alternative transportation consists of determining were the target population is at in relation to the decisional and behavioral processes involved in changing transportation behaviors. The Transtheoretical Model (TTM), developed by James Prochaska delineates five "stages of change" individuals move through, and 10 "processes of change" they may use to move through the five stages as they integrate more healthful behaviors into their lives (Prochaska & DiClemente, 1983). The theory was developed as a result of studies on addictive behaviors. These studies showed that behavior change occurs not as an isolated event but rather a multistage process as individuals progress through the five stages of change: precontemplation, contemplation, preparation, action, maintenance, and termination (Prochaska & DiClemente, 1983; Glanz et al., 1997). The "processes of change" consist of strategies that people utilize in order to progress through the five stages of change (Prochaska & DiClemente, 1983).

During the first stage of change, "precontemplation," the individual is not considering making change and may even be unaware that a certain behavior is problematic. If the individual has considered change, there is no intention of changing behavior in the foreseeable future. On the other hand, individuals in this stage may have tried to change the behavior in the past without success, resulting in a lack self-efficacy needed to attempt further change (Glanz et al., 1997; Prochaska & DiClemente, 1984). The second stage, "contemplation," involves awareness of the problem. The individual is seriously considering change yet has made no specific plan to take action. The individual possesses an understanding of the pros and cons associated with the target behavior and may be weighing these pros and cons as they contemplate change. If the cons seem too large, individuals may remain stuck in this stage until the cost/benefit balance shifts.

Prochaska and DiClemente (1984) identify the third stage as "preparation." During the preparation stage, the individual intends to take action in the near future, which is considered to be within the next six months. Individuals in this stage typically have a plan of action and have already taken steps to move themselves towards the desired behavior. Individuals in this stage are well served by programs that will move them into action. "Action" is the fourth stage of change identified by Prochaska and DiClemente (1984), and it is in this stage that individuals are actually modifying the behavior they have been preparing to change. Making these overt behavioral changes involves a great deal of energy and commitment. When the individual successfully implements the behavioral change for a period of six months they move from the action stage to the "maintenance" stage. In this stage, the individual continues the desired behavior and works to prevent relapse. The individual remains in the maintenance stage as they continue the new behavior. In this stage, the behavior becomes more habitual, requiring less attention and energy (Prochaska & DiClemente, 1983; Prochaska & DiClemente, 1984).

Individuals do not necessarily move through these stages in a linear manner, but instead may "relapse" into earlier stages. Prochaska and DiClemente (1984) identify relapse as a natural aspect of the change process, one that hopefully results in learning and greater success as the individual again begins progressing through the stages of change. Individuals may relapse several times as they cycle through earlier stages before successfully maintaining the desired behavior.

Determining what stage of change a particular target population is at in regards to a particular target behavior is an important aspect of designing effective health education programs. Interventions are then developed in order to assist individuals in moving from their current stage into the next stage of change. Such interventions can be guided by what Prochaska called "processes of change." The processes of change are applied based on the individual's stage-of-change status. For example, if a person is in the precontemplation stage, consciousness-raising would be an appropriate intervention for facilitating movement into the contemplation stage. In the contemplation and planning stages, interventions may utilize the processes of self-reevaluation, dramatic relief and/or self-liberation in order to facilitate movement into the subsequent stage. (Glanz et al., 1997; Prochaska, 1992). While the TTM was developed to assist individuals in overcoming addictions, it has proven to be quite effective when applied to a broad range of health behaviors such as exercise (Armstrong & Sallis, 1993; Chrisler, 1994; Pinto, 1995), cardiovascular rehabilitation (Hellman, 1997; Laitakari, 1998), drunk driving prevention (Polacsek et al., 2001), and worksite wellness program participation (Herrick & Stone, 1997), to name only a few. This model can also be useful in determining individuals' stages of change pertaining to sustainable transportation behaviors. Once a target population's stage of change is determined, appropriate educational and behavioral programs can be developed to assist in moving individuals along the change continuum. When using the TTM for this purpose, the goal of intervention would to move individuals to the maintenance stage, in which sustainable transportation behaviors are consistently practiced.

Summary

Air pollution has been troublesome to human health since the beginning of time when primitive man sat in caves around smoky fires (Brimblecombe, 1987). Air pollution problems reached serious proportions with the dawn of industrialization. In the early 1940's, photochemical air pollution first showed up in Los Angeles. The main constituent of photochemical pollution is O_3 and this troublesome pollutant has now reached unhealthful levels in cities throughout the United States and the industrialized world. The EPA (1999a) reports that, currently, O_3 air pollution is the most prevalent air pollution problem facing large cities in the United States. In 1997, it was estimated that approximately 47% of the U.S. population lived in areas shown to have unhealthful levels of O_3 air pollution (Healthy People 2010, 2000).

O_3 is a colorless, odorless gas which occurs naturally in the stratosphere and protects life on earth from the sun's harmful ultraviolet rays (Elsom, 1992; EPA, 1999b). At ground level, in the troposphere, high levels of O_3 pose health risks to humans and plant life. Damage to respiratory health is the most common health effect of over-exposure, and includes damage to lung tissue, increased lung sensitivity to other irritants, reduction in the lung's ability to fight respiratory infection, and reduction in lung function. Populations most vulnerable to the health effects of ozone air pollution include children, individuals who exercise outdoors during the summer, individuals with chronic respiratory disease and a sub-group of healthy adults referred to as "responders." The elderly, minorities and individuals of lower socioeconomic status are also disproportionately affected by ground-level O_3 air pollution (ALA, 1999; ALA, 1998; Dickey, 1999; EPA, 1996; EPA, 1999b; NASA, 2000).

Currently, automobiles are the largest contributor to the formation of ground-level ozone and the EPA and DOT are working to increase usage of alternative sources of transportation in order to reduce levels of O_3 air pollution. Health educators can be highly instrumental in developing programs that will increase usage of alternative transportation. Such programs can be instrumental in removing barriers to alternative transportation usage and in promoting change. The HBM and the TTM are models that can serve as highly effective tools in assessing barriers to alternative transportation usage and readiness to change. This information can then be highly useful in the development of effective program planning.

CHAPTER III

METHODOLOGY

The purpose of this study was to examine the differences between selected demographics, perceived barriers, and stages of change pertaining to alternative transportation usage, among college students in a northern California city that suffers from severe ozone air pollution. In this chapter, the methodology used in conducting the study is presented, including the research instrument, study sample, data collection, and treatment of the data.

Research Instrument

A self-report survey instrument was developed by the researcher for use in this research study (Appendix A). The survey questionnaire, entitled "Sustainable Transportation Survey," consisted of 33 items which were used to collect information on participant demographics, stages of change, perceived barriers and benefits, and health beliefs pertaining to O_3 air pollution reduction and the use of alternative transportation.

Instrument Development Resources

A combination of resources served as the foundation upon which the instrument was developed. Stage of change and demographic survey questions were partially adapted from Adams's (1999) 16-item survey designed to obtain data regarding demographics, stage of change, and barriers pertaining to participation in a regular exercise program

In order to assure that the instrument designed for the present sustainable transportation study was appropriate for analyzing attitudes and behaviors associated with development of environmentally sustainable behaviors, the researcher also utilized information from the field of environmental psychology. McKenzie-Mohr and Smith (1999) have drawn upon the principles of social psychology to develop a community-based social marketing approach to increasing sustainable behavior. Their approach emphasizes the importance of identifying internal and external barriers and benefits to sustainable behavior and then developing programs which address these issues. In their book, they outline methodologies, procedures, and recommendations for development of survey instruments aimed at assessing attitudes, beliefs, perceived costs, and perceived benefits associated with sustainable behaviors. Furthermore, they recommend four types of questions that should be adapted for use in a sustainable attitude and behavior instrument in order to assess barriers and benefits of change. They formulated these questions based on research in the field of social psychology and environmental psychology (Mann & Smith, 1993). McKenzie-Mohr suggest that in formulating questions to assess barriers and benefits of change, the instrument should seek to determine what makes it difficult to do the behavior, what negatives are associated with the behavior, what positives are associated with doing the behavior, and what makes it easy to do the behavior. The recommendations set forth by McKenzie-Mohr and Smith (1999) were heavily utilized to guide in the formulation of instrument questions aimed at determining attitudes, beliefs, perceived barriers, and perceived benefits regarding the use of alternative transportation. In addition, the Health Belief

Model (Glanz et al., 1997) was used to guide in the development of items that assessed health beliefs regarding air pollution. The Health Belief Model, developed by Hochbaum, Leventhal, Kegels, and Rosenstock (Rosenstock, 1974) states that an individual will take action to control for an ill-health condition if the individual believes that he or she is susceptible to the condition, the condition would have serious consequences, taking a particular action will be beneficial, and the benefit resulting from the action outweighs the perceived negative costs associated with the behavior. These concepts contained in the Health Belief Model were used to guide in the development of questions pertaining to beliefs regarding (a) the short- and long-term health effects of exposure to ozone air pollution, (b) the primary source of ozone air pollution, and (c) whether increased usage of alternative transportation can improve levels of ozone air pollution.

Instrument Design

The first 10 items in the 33-item questionnaire solicited demographic information, including age, gender, living situation, number of children, ethnicity, income level, highest educational level, college major, and number of courses and credit hours completed in biology, environmental health, and environmental science in high school and college. Item 11 assessed participant beliefs about the primary source of ozone air pollution, and items 12 through 17 determined participants' driving habits. If a respondent did not drive a motor vehicle, they were asked to skip items 14 through 17 and proceed with item 18, which assessed alternative transportation preferences.

Stage of change pertaining to usage of various types of alternative transportation as a means of commuting to and from work or school was determined in items 19 through 22. The stages of change that were measured in this study, as defined by Prochaska's Transtheoretical Model (Prochaska & DiClemente, 1984), included precontemplation, contemplation, preparation, action, and maintenance. Stage was assessed for each of the following alternative transportation choices: public transit, carpooling and/or vanpooling, bicycling, and walking. For each of these transportation choices, stage of change was determined by asking respondents to indicate which choice most closely fit their attitude. Individuals who selected the first response choice, which indicated they had not been practicing that mode of transportation as a method of commuting to or from school or work on a regular basis, and did not intend to begin practicing that mode for commuting purposes any time in the future, were considered to be in the "precontemplation" stage. Those who selected the second response choice, which stated they had not been using that mode of transportation regularly but were thinking about using it regularly within the next six months, were considered to be in the contemplation stage. The third response choice stated that they had not been using the alternative transportation method regularly but were planning to start using it regularly within the next month. Individuals marking this choice were considered to be in the planning stage. An individual was considered to be in the action stage if they chose the fourth choice, which stated they had been using the alternative transportation method regularly for less than six months. If they marked the last choice, which indicated they had been using the mode of transportation regularly for six months or more, they were considered to be in the maintenance stage.

Items 23 through 28 assessed benefits and barriers to using each of the aforementioned modes of alternative transportation. For each of those transportation modes, the participants were presented with (1) a list of five to seven factors from which they indicated those factors they felt would *discourage* their use of that mode of transportation (e.g., “I have concerns about my personal safety”), and (2) a list of five to seven factors from which they could indicate those factors that they felt would *encourage* their use of that mode (e.g., “I would save money on transportation costs”). For both the discouragement and encouragement questions for each mode, an open-ended response choice (“Other”) was provided, for which they were asked to indicate their own factor. In addition, for the encouragement questions for each mode, a “nothing could encourage me” response choice was also provided. Respondents were instructed to select all factors that they felt applied to them.

In items 29 through 33, health beliefs pertaining to the effects of air pollution on health were assessed. Through items 29 through 32, individuals were asked if they believe air pollution currently affects their health, and whether or not they believe it will affect their health in the future. They were also asked if they believe the health of their family or friends is currently affected by air pollution or will be affected in the future. The last question assessed whether or not participants believe that the air pollution problem can be improved by increasing alternative transportation usage.

Validity and Reliability

Content validity was determined by having the instrument examined by a panel of experts (three professors) in the field of health education. Changes were made per their recommendations, which included the addition of income and ethnicity items in the demographic section of the instrument. Test-retest reliability was determined by administering the instrument to a group of 14 college students, and then administering the instrument again to the same group 10 days following the first administration. Participants in this test-retest pilot group consisted of 7 male and 7 female student volunteers enrolled in an introductory health science course at American River College. Ages ranged from 17 to 43 years old. Ethnicity of participants was well diversified and consisted of four Hispanics, four Whites, two African Americans, two Pacific Islander/Phillipinos, one Armenian, and one Asian. Ten participants held high school diplomas or GEDs and four of the participants held associate degrees. During the first administration, participants were asked to complete the survey and provide feedback regarding readability and understandability of survey items. Based on the feedback received from this pilot study, minor modifications were made to six items. Modifications at this point consisted of correcting typographical errors. The pilot group found the instrument to be clear and easily understandable.

The original instrument was re-administered 10 days later to the same pilot study group. Chi-square analyses were performed on the first and second administrations of nominal data survey items. Results indicated that there was no significant difference between participant responses on the first and second administrations of the survey. Spearman Rho correlations were performed on all continuous variable items in the survey. Results indicated correlations above .70 on all items tested. In conclusion, test-retest reliability results indicated that participant responses were stable between the first and second administrations and that no items appeared problematic.

Study Sample

After completion of the validity and reliability testing and revision of the instrument, the final version of the survey questionnaire was administered to a larger convenience sample of students. The study sample consisted of 202 students attending general education classes at American River College in northern California (see Table 1). A total of 103 males and 99 females representing a wide variety of college majors participated in the study. Ages ranged from 16 to 76 years of age. Permission to survey the students was granted by the Department of Research and Grants at American River College. In addition, approval to perform the study was granted by Texas Woman's University's Institutional Review Board. Participants were recruited from general education undergraduate classes at American River College. Classes from which students were recruited included five sections of an introductory health science course, three sections of an elementary mathematics course, two sections of an introductory biology course for non-biology majors, one section of a conservation biology course, and one section of an introductory biology course for biology majors. The topic of air pollution or atmospheric degradation had not been discussed in any of these classes prior to the administration of the survey.

Table 1. Participant Demographics

Demographic		N	%
Gender	Male	102	52.3
	Female	99	47.7
Age	18-24	131	67.2
	25-34	34	17.4
	35-49	22	11.3
	50-65	8	4.1
Ethnicity	African American	14	7.2
	Asian	19	9.7
	Hispanic	21	10.8
	White	120	61.5
	Other	17	8.7

Participants were first given a brief explanation of the general nature of the study by the researcher. The students were informed that their participation was strictly voluntary, that they were free to decline taking the survey, and that declining would in no way reflect poorly on their class performance or their grade. Students were further instructed to not take a survey if they did not wish to participate and instead to feel free to work on something else at their desk. They were also informed that any survey information collected from them would be strictly anonymous, since they would be asked to refrain from putting their name or other identifying information on the survey questionnaire. Lastly, participants were told how to contact the researcher if they desired to obtain further information regarding the study or the results of the study. Completion of the survey questionnaire took approximately 15 minutes.

Data Analysis

Data collected in the study were analyzed using the *Statistical Package for Social Sciences* (SPSS). Descriptive statistics were computed to describe the study participants in regard to demographics, stage of change, beliefs about the primary source of ozone air pollution, beliefs about the health effects of ozone air pollution, and perceived barriers and benefits pertaining to usage of various modes of alternative transportation. Chi-square analysis were conducted to determine if there were differences in the dependent variables of stages of change, perceived barriers, perceived benefits, and health beliefs that were related to the independent variables of age, gender, ethnicity, income level, educational level, and environmental coursework. Ordinal regression analyses were performed in order to determine whether any of the barriers, incentives, or beliefs were predictive of stage of change status.

CHAPTER IV

RESULTS

In this chapter, the results of analysis of the data collected from the sustainable transportation survey are provided. First, using descriptive statistics, the responses of the survey participants regarding the primary source of ozone pollution, and patterns of motor vehicle and alternative transportation usage, are presented. Secondly, the results of the chi-square analyses to determine if differences exist in stage-of-change status for the alternative transportation modes of public transit, carpooling, walking, and bicycling by selected demographics are provided. Third, results of the chi-square analyses to determine differences in perceived barriers and incentives to alternative transportation by selected demographics are presented. Lastly, the results of ordinal regression analyses to identify predictors of stage of change for the four modes of alternative transportation from among the selected demographics, respondents' perceived barriers and incentives, and their health beliefs regarding air pollution are provided.

Backward ordinal regression procedures were used to predict stage of change for the four modes of alternative transportation (public transit, bicycling, walking, and carpooling). Since a large majority of the respondents were in the two early stages of change (precontemplation and contemplation), to increase the predictive validity of the regression models, the number of empty response cells was decreased by collapsing the last three stage-of-change categories into one: preparation/action/maintenance.

For all of these modes except carpooling, the following variables were used as potential predictors in the initial model: selected demographics (age, gender, number of children, ethnicity, income, education, number of credits taken in environmental coursework), barriers and incentives for use of public transportation, health beliefs related to air pollution, and beliefs regarding the impact of alternative transportation on reducing air pollution. Since the barriers and incentives items for carpooling were inadvertently omitted form the survey instrument, the ordinal regression procedure for that alternative transportation mode did not include barrier and incentive variables in the model.

Transportation Practices

To determine the transportation practices of the study sample, descriptive statistics were performed (see Table 2). Nearly all of the survey participants (93.3%) reported driving a motor vehicle on a regular basis, with 45.6% driving an average of 1-2 hours per day on weekdays and 44.6% driving an average of 1-2 hours per day on weekends. The majority of the respondents (71.3%) said they drove to commute to and from school. The most frequently utilized form of alternative transportation was walking (26.7%), followed by carpooling (25.1%), bicycling (17.9%), and public transit (9.7%). A sizeable proportion of participants indicated they would consider using alternative transportation: 46.2% indicated that they would consider bicycling as a means of alternative transportation, 43.6% would consider public transit, 41% would consider walking, and 31% would consider telecommuting. Only 16.9% of respondents reported that they would not consider using any form of alternative transportation.

Table 2. Transportation Practice

	N	%
Vehicle access	186	95.4
Drive regularly	182	93.3
Weekday driving hours		
Less than 1 hour per day	46	23.6
1-2 hours per day	89	45.6
3-4 hours per day	36	17.4
Over 4 hours per day	15	7.7
Weekend driving hours		
Less than 1 hour per day	47	24.1
1-2 hours per day	87	44.6
3-4 hours per day	37	19.0
Over 4 hours per day	12	6.2
Primary driving purpose		
Commuting/work/school	139	71.3
Running errands	17	8.7
Social activities	8	4.1
Sports activities	2	1.0
Visiting family and friends	3	1.5
Transporting children	1	.5
Other	1	.5
Alternative transportation usage		
Walk	52	26.7
Bicycle	35	17.9
Public transit	19	9.7
Carpool	49	25.1
Other	2	1.0
Alternative transportation you would consider using		
Walk	80	41.0
Bicycle	90	46.2
Public transit	85	43.6
Telecommute	62	31.8
Other	16	8.2
Would not consider alternative	33	16.9

Beliefs Regarding Ozone Pollution

Primary Source of Ozone Air Pollution

Descriptive statistics for beliefs regarding the primary source of ozone air pollution are presented in Table 3. For beliefs regarding the primary source of air pollution, 60% of respondents believed that motor vehicles are the primary source, 34.4%

Table 3. Perceptions of Primary Source of Air Pollution

	N	%
Motor Vehicles	117	60.0
Industrial Emissions	67	34.4
Agricultural Practices	5	2.6
Total	189	97.0

believed that industrial emissions are the primary source, and 2.6% believed that agricultural practices are the primary source.

Health Effects of Air Pollution

Of the total respondents, 59.3% indicated that they believe air pollution currently affects their health (see Table 4). Differences by ethnicity approached statistical significance (p=.058), with 92.9% of African-Americans believing that air pollution is currently affecting their health, compared to 47.4% of Asians and 53.8% of Whites. It is also interesting to note that somewhat greater percentages of respondents in the older age categories and those with higher levels of education (e.g., 100% of those holding a master's degree) held this belief. However, none of these differences were found to be statistically significant.

The vast majority of respondents (78.9%) believed that air pollution would affect their health in the future. By income level, only 50% of respondents with annual incomes over $100,000 believed air pollution would affect their health in the future, while higher percentages (70% to 90.9%) of those in the lower income categories indicated this belief. Chi-square analysis revealed that these differences were statistically significant at the p=.05 level (X^2=19.86, df=10, p=.031). As was found above regarding the current affect on health, African-Americans, those in the older age categories, and those with higher

Table 4. Beliefs Regarding Ozone Air Pollution by Demographics

	Air pollution affects my health now		Air pollution will affect my health in the future		Air pollution affects others health now		Air pollution will affect others health in future		alt trans will improve air quality	
	N	%	N	%	N	%	N	%	N	%
Age										
18-24	70	53.4	100	76.3	76	58.0	103	78.6	100	76.3
25-34	22	66.7	25	75.8	24	72.7	26	78.8	27	81.8
34-49	17	77.3	20	90.9	18	81.8	20	90.0	20	90.9
50-65	6	75.0	8	100.0	7	87.5	7	87.5	6	75.0
Gender								*		
Male	64	63.4	77	76.2	66	65.3	77	76.2	77	76.2
Female	51	54.8	76	81.7	59	63.4	79	84.9	76	81.7
Children										
0	79	56.0	109	77.3	86	61.0	111	78.7	109	77.3
1-2	22	68.8	25	78.1	25	78.1	26	81.3	27	84.4
3-4	10	76.9	12	92.3	9	69.2	11	84.6	11	84.6
5+	3	42.9	6	85.7	4	57.1	7	100.0	5	71.4
Ethnicity										
Af Am	13	92.9	14	100.0	13	92.9	14	100.0	11	78.6
Asian	9	47.4	16	84.2	11	57.9	17	89.5	14	73.7
Hispanic	16	76.2	18	85.7	14	66.7	18	85.7	19	90.5
White	64	53.8	88	73.9	73	61.3	88	73.9	94	79.0
Other	11	64.7	14	82.4	11	64.7	15	88.2	12	70.6
Annual Income				*						
0- 10,000	28	54.9	41	80.4	31	60.8	43	84.3	41	80.4
10+-20,000	24	64.9	27	73.0	24	64.9	29	78.4	33	89.2
20+-30,000	17	56.7	21	70.0	20	66.7	21	70.0	23	76.7
30+-50,000	22	66.7	30	90.9	24	72.7	30	90.0	29	87.9
50+-100,000	17	54.8	27	87.1	19	61.3	25	80.6	19	61.3
100,000+	5	50.0	5	50.0	5	50.0	6	60.0	7	70.0
Education										
HS/GED	85	57.8	112	76.2	92	62.6	114	77.6	113	76.9
AA	22	61.1	31	86.1	24	66.7	31	86.1	30	83.3
BA/BS	6	66.7	8	88.9	7	77.8	9	100.0	8	88.9
MA	2	100.0	2	100.0	2	100.0	2	100.0	2	100.0
Env Courses										
0	36	62.1	44	75.9	37	63.8	45	77.6	44	75.9
1-4	37	54.4	53	77.9	40	58.8	51	75.0	56	82.4
5-9	28	60.9	37	80.4	31	67.4	39	84.8	35	76.1
10+	14	63.6	19	86.4	17	77.3	21	95.5	18	81.8
Total	115	59.3	153	78.9	125	64.4	156	80.4	153	78.9

* Significant at the p=.05 level

levels of education had somewhat greater percentages of respondents who believed air pollution would have future health effects, as did those who had three or more children. However, none of these differences were found to be statistically significant.

About two-thirds of the participants (64%) believed that air pollution currently affects the health of their family and/or friends. Again, African-Americans, those in the older age categories, and those with higher levels of education had somewhat greater percentages of respondents who held this belief, as well as those who had taken 10 or more environmental content courses. However, none of these differences were found to be statistically significant.

A large majority (80.4%) of respondents believe that air pollution will affect the health of their family and/or friends in the future. For gender, a higher percentage of females (84.9%) reported this belief compared to males (76.2%). Chi-square analysis revealed that this difference was statistically significant at the p=.05 level (X^2=6.25, df=2, p=.044). As was found for some of the other beliefs concerning the health effects of air pollution, African-Americans, those in the older age categories, those with higher levels of education, those with incomes below $100,000, and those who had taken 10 or more environmental content courses had somewhat greater percentages of respondents who held this belief about the effect on family/friends in the future. However, none of these differences were found to be statistically significant.

Alternative Transportation Usage and Air Quality

The vast majority (78.9%) of respondents believed that air quality could be improved by citizens increasing usage of alternative transportation such as public transit, carpooling, bicycling, and walking. By income level, higher percentages of respondents with household incomes under $50,000 per year (76.7% to 89.2%) indicated this belief compared with 61.3% to 70.0% of those in higher income categories. Chi-square analysis revealed that these differences were statistically significant at the p=.01 level (X^2=22.93, df=10, p=.01).

Public Transit Usage

Stage-of-Change Status

Results revealed that the vast majority of the respondents in the sample (81.8%) were in the precontemplation stage for usage of public transit as a means of alternative transportation, with 9.9% in the contemplation stage, 3.1% in the planning stage, 1.0% in the action stage, and 4.2 % in the maintenance stage (see Table 5). While the distributions for stage-of-change status by age, gender, number of children, ethnicity, income, education, and number of environmental courses completed were very similar for the most part, some interesting differences were observed.

Respondents who had 3-4 children, were African-American, or had an income level of $0-$10,000 had moderately higher percentages (at 15.4%, 18.6%, and 13.7%, respectively) who were in advanced stages of change (i.e., preparation, action, or maintenance). Those who had taken 10 or more environmental courses had the lower percentages in the precontemplation and contemplation stages. However, no statistically significant differences were found for any of the selected demographics.

Table 5. Stage-of-Change Status for Public Transit Usage by Demographics

	Precontemplation		Contemplation		Planning		Action		Maintenance	
	N	%	N	%	N	%	N	%	N	%
Total	157	81.8	19	9.9	6	3.1	2	1.0	8	4.2
Age										
18-24	105	80.8	13	10.0	2	1.5	2	1.5	8	6.2
25-34	28	84.8	3	9.1	2	6.1	0	0	0	0
34-49	17	81.0	2	9.5	2	9.5	0	0	0	0
50-65	7	87.5	1	12.5	0	0	0	0	0	0
Gender										
Male	81	81.8	11	11.1	4	4.0	1	1.0	2	2.0
Female	76	81.7	8	8.6	2	2.2	1	1.1	6	6.5
Children										
0	113	80.7	16	11.4	3	2.1	2	1.4	6	4.3
1-2	27	87.1	1	3.2	2	6.5	0	0	1	3.2
3-4	9	69.2	2	15.4	1	7.7	0	0	1	7.7
5 +	7	100.0	0	0	0	0	0	0	0	0
Ethnicity										
Af Am	10	71.4	0	0	2	14.3	0	0	2	14.3
Asian	14	77.8	2	11.1	1	5.6	0	0	1	5.6
Hispanic	16	80.0	2	10.0	1	5.0	1	5.0	0	0
White	98	82.4	14	11.8	2	1.7	1	0.8	4	3.4
Other	15	88.2	1	5.9	0	0	0	0	1	5.9
Annual Income										
0-10,000	36	70.6	8	15.7	2	3.9	1	2.0	4	7.8
10+-20,000	30	83.3	2	5.6	1	2.8	0	0	3	8.3
20+-30,000	26	89.7	3	10.3	0	0	0	0	0	0
30+-50,000	26	78.8	3	9.1	3	9.1	0	0	1	3.0
50+-100,000	29	93.5	2	6.5	0	0	0	0	0	0
100,000 +	8	80.0	1	10.0	0	0	1	10.0	0	0

Table 5 (continued)

	Precontemplation		Contemplation		Planning		Action		Maintenance	
	N	%	N	%	N	%	N	%	N	%
Education										
HS/GED	121	82.9	11	7.5	5	3.4	2	1.4	7	4.8
Assoc	28	77.8	7	19.4	0	0	0	0	1	2.8
Bach	6	75.0	1	12.5	1	12.5	0	0	0	0
Mast	2	100.0	0	0	0	0	0	0	0	0
Environ Courses										
0	48	84.2	5	8.8	2	3.5	0	0	2	3.5
1-4	55	82.1	3	4.5	3	4.5	2	3.0	4	6.0
5-9	39	84.8	5	10.9	0	0	0	0	2	4.3
10 +	15	68.2	6	27.3	1	4.5	0	0	0	0

Barriers to Usage of Public Transit

The most frequently identified barrier to using public transportation was "public transit takes too much additional time out of my schedule" (see Table 6), with 62.5% identifying this as a barrier, followed by "can't come and go exactly when I please" (54.2%), "public transit lines are not easily accessible for me" (39.6%), and "concerns about my personal safety" (38.5%). The two other barriers, "seems that public transit is for lower-class individuals" and "other," were indicated by less than 10% of the total respondent sample. Among these six barriers, some differences were found for the selected demographics.

For the "can't come and go as I please" barrier, there was little variation in the percentage of responses across most of the selected demographics, except for age group. The youngest respondents (18- to 24-year-olds) had the highest percentage (61.5%) for whom this was a barrier, and the oldest respondents (50- to 65-year-olds) had the lowest percentage (28.6%). Chi-square analysis revealed that this difference was statistically significant at the p=.01 level (X^2=12.26, df=3, p=.007).

For the "I have concerns about my personal safety" barrier, Asians (42.1%), Whites (40%), and Others (42.1%) were more likely to indicate personal safety concerns than Hispanics (15%) and African Americans (7.7%). Chi-square analysis revealed that this relationship was statistically significant at the p=.05 level (X^2=15.15, df=4, p=.003). In addition, a far higher percentage of females (59.1%), as compared to males (19.2%), indicated personal safety concerns. This difference was also statistically significant at the p=.001 level (X^2=32.31, df=1, p<.001). For educational level, the percentage of

Table 6. Barriers and Incentives for Public Transit Usage

	Barriers												Incentives									
	Too much time		Safety concerns		Not easily accessible		Can't come and go		For lower class		Other		Save money on transport.		Help reduce air pollution		Financial incentives		Other		Nothing could encourage	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Total	120	62.5	74	38.5	76	39.6	104	54.2	19	9.9	17	8.9	94	49.0	5	49.5	76	39.6	15	7.9	34	17.7
Age								**						*								
18-24	81	62.3	56	43.1	57	43.8	80	61.5	14	10.8	11	8.5	70	53.8	67	51.5	50	38.5	10	7.8	25	19.2
25-34	20	60.6	10	30.3	9	27.3	10	30.3	3	9.1	3	9.1	9	27.3	12	36.4	11	33.3	5	15.2	7	21.2
34-49	15	68.2	6	27.3	7	31.8	12	54.5	1	4.5	3	13.6	12	54.5	13	59.1	12	54.5	0	0	1	4.5
50-65	4	57.1	2	28.6	3	57.1	2	28.6	1	14.3	0	0	3	42.9	3	42.9	3	42.9	0	0	1	14.3
Gender				***																		
Male	60	60.6	19	19.2	39	39.4	50	50.5	10	10.1	6	6.1	46	46.5	43	43.4	39	39.4	5	5.1	17	17.2
Female	60	64.5	55	59.1	37	39.8	54	58.1	9	9.7	11	11.8	48	51.6	52	55.9	37	39.8	10	10.8	17	18.3
Children																						
0	83	59.3	54	38.6	59	42.1	79	56.4	15	10.7	10	7.2	65	46.4	65	46.4	52	37.1	10	7.2	28	20.0
1-2	22	71.0	12	38.7	10	32.3	18	58.1	3	9.7	4	12.5	20	64.5	18	58.1	15	48.4	3	9.4	4	12.9
3-4	8	61.5	7	53.8	5	38.5	4	30.8	1	7.7	2	15.4	4	30.8	8	61.5	7	53.8	1	7.7	1	7.7
5+	7	100.0	1	14.3	1	14.3	3	42.9	0	0	1	14.3	5	71.4	4	57.1	2	28.6	1	14.3	0	0
Ethnicity				**																		
Af Am	10	76.9	1	7.7	2	15.4	8	61.5	0	0	3	21.4	7	53.8	9	62.2	5	38.5	2	14.3	0	0
Asian	12	63.2	8	42.1	7	36.8	5	26.3	1	5.3	0	0	10	52.6	9	47.4	5	26.3	0	0	3	15.8
Hispanic	8	40.0	3	15.0	12	60.0	9	45.0	2	10.0	2	10.0	10	50.0	7	35.0	7	35.0	1	5.0	4	20.0
White	76	63.9	48	40.3	46	38.7	69	58.0	14	11.8	11	9.3	56	47.1	59	49.6	47	39.5	11	9.4	24	20.2
Other	12	70.7	11	64.7	7	41.2	9	52.9	2	11.8	1	5.9	9	52.9	9	52.9	10	58.8	1	5.9	2	11.8

Table 6 (continued)

	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
0-10,000	31	60.8	21	41.2	24	47.1	26	51.0	5	9.8	2	3.9	26	51.0	26	51.0	19	37.3	5	10.0	8	15.7
10+-20,000	24	66.7	12	33.3	11	30.6	21	8.3	3	8.3	1	2.8	18	50.0	22	61.1	12	33.3	1	2.8	7	19.4
20+-30,000	17	56.7	12	40.0	9	30.0	10	33.3	4	13.3	5	16.5	14	46.7	12	40.0	11	36.7	2	6.7	6	20.0
30+-50,000	21	65.6	11	34.4	12	37.5	21	65.6	2	6.3	5	15.6	16	50.0	14	43.8	15	46.9	2	6.3	6	18.8
50+-100,000	20	64.5	11	35.5	12	38.7	17	54.8	3	9.7	3	9.7	14	45.2	15	48.4	13	41.9	3	9.7	5	16.1
100,000+	7	70.0	6	60.0	8	80.0	7	70.0	2	20.0	1	10.0	5	50.0	5	50.0	5	50.0	1	10.0	2	20.0
Education				***														*				
HS/GED	85	58.2	50	34.2	58	39.7	77	52.7	14	9.6	13	8.9	67	45.9	71	48.6	48	32.9	10	6.9	32	21.9
AA	27	77.1	23	65.7	15	42.9	23	65.7	5	14.3	2	5.7	18	51.4	19	54.3	23	65.7	4	11.4	2	5.7
BA/BS	6	66.7	0	0	3	33.3	3	33.3	0	0	2	22.2	8	88.9	4	44.4	4	44.4	1	11.1	0	0
MA	2	100.0	1	50.0	0	0	1	50.0	0	0	0	0	1	50.0	1	50.0	1	50.0	0	0	0	0
Env crs																		*				
0	33	57.9	21	36.8	19	33.3	24	42.1	24	42.1	4	6.9	25	43.9	27	47.4	15	26.3	7	12.1	13	22.8
1-4	44	65.7	22	32.8	24	35.8	42	62.7	42	67.7	8	11.9	32	47.8	29	43.3	25	37.3	3	4.5	15	22.4
5-9	30	65.2	21	45.7	21	45.7	26	56.5	26	56.5	3	6.5	24	52.2	26	56.5	24	52.2	3	6.7	5	10.9
10+	13	59.1	10	45.5	10	45.5	12	54.5	12	54.5	2	9.5	13	59.1	13	59.1	12	54.5	2	9.5	1	4.5

* Significant at the .05 level
** Significant at the .01 level
*** Significant at the .001 level

respondents who indicated the personal safety barrier was higher for associate degree holders (65.7%) and master degree holders (50%) compared to high school diploma holders (34.2%). No bachelor degree holders identified this barrier. Chi-square analysis revealed that this difference was statistically significant at the p=.001 level (X^2=17.80, df=3, p<.001).

Of those who listed "other barriers," two frequently listed barriers were that public transportation did not go were they needed to go, and that if they take public transportation they would be burdened by having too many things to carry. There was no significant difference for either of these barriers by any of the selected demographics.

Incentives for Usage of Public Transit

The most frequently reported incentive for public transportation usage was "I would save money on transportation costs," with 49.0% of respondents identifying this incentive, followed by "I would be doing my part to help reduce air pollution" (49.5%), "financial incentives" (39.6%), "nothing could encourage me to use public transit" (17.7%), and "other" (7.9%) (see Table 6). Among these incentives, some differences were found for the selected demographics. For the incentive "I would save money on transportation costs," there was a difference found for the age demographic. By age group, respondents 18-24 years old (53.8%) and 34-49 years old (54.5%) had the highest percentage for whom this was an incentive, while respondents 25-34 years old (27.3%) had the lowest percentage. Chi-square analysis revealed that this difference was statistically significant at the p=.05 level (X^2=7.83, df=3, p=.05). For the incentive "I would be doing my part to help reduce air pollution," 55.9% of females and 43.9% of males identified this as an incentive. Chi-square analysis revealed that this difference by gender approached statistical significance (p=.084). For financial incentives, chi-square analysis revealed statistically significant differences by both educational level and environmental coursework. By educational level, a higher percentage of associate degree holders (65.7%) and master's degree holders (50%) identified this incentive compared to under 45% of bachelor's degree and high school degree holders. Chi-square analysis revealed that this difference was statistically significant at the p=.05 level (X^2=12.92, df=3, p=.013). For environmental coursework, over 50% of persons with five or more environmental courses reported this as an incentive compared to less that 38% of respondents with fewer than four environmental courses. Chi-square analysis revealed that this difference was statistically significant at the p=.05 level (X^2=9.45, df=3, p=.024).

For the incentive item "nothing could encourage me to use public transit" respondents with high school diplomas (21.9%) had the highest percentage of respondents identifying this response choice, followed by individuals with associate degrees (5.7%). No individuals with bachelor's or master's degrees indicated that nothing could encourage their use of public transit. This difference approached statistical significance (p=.055). For "other" incentives for using public transit, the most commonly listed incentives dealt with accessibility, with several respondents stating that they would be more encouraged to use public transportation if pick-up points were more easily accessible and if it dropped them off closer to work or school.

Predictors for Stage of Change for Use of Public Transportation

For use of public transportation as alternative transportation, the final ordinal regression iteration resulted in only one variable – income level – being included in the model (see Table 7). Income of $0-10,000 was a statistically significant predictor (p=.019) of stage of change for this mode of alternative transportation. Based on the estimated probability of response (see Table 8), respondents whose incomes were in the $0-10,000 category were more likely than those with incomes in the $10,001-20,000 or $20,000 or higher categories to be in advanced stages of change, with a 14% likelihood of this very low income group being in either the planning, action, or maintenance stages

Table 7. Stage of Change for Use of Public Transit - Parameter Estimates

	Estimate	Std. Error	Wald	df	P
Stage of Change					
Precontemplation	1.862	.288	41.685	1	.000
Contemplation	2.781	.347	64.363	1	.000
Annual Income					
0-10,000	.979	.419	5.465	1	.019
10+-20,000	.297	.525	.321	1	.571
20,001+	0			0	

Pearson X^2 Goodness of Fit=9.642, df=9, p=.380; Nagelkerke Pseudo R^2=.123

Table 8. Stage of Change for Use of Public Transit - Estimated Probability of Response

	Precontemplation	Contemplation	Prep/Action/Maintenance
Annual Income			
0-10,000	.71	.15	.14
10+-20,000	.83	.10	.08
20,001+	.87	.08	.06

of change, compared to 8% and 6% likelihoods, respectively, for those in the other two higher income groups. The Nagelkerke Pseudo R-Square indicates that this predictive model accounts for approximately 12% of the variance in stage of change for public transportation.

Walking

Stage-of-Change Status

Results for stage of change status for walking as a means commuting showed the majority (75.3%) of respondents were in the pre-contemplation stage, with only 10% in the contemplation stage, 5.8% in the planning stage, 3.7% in the action stage, and 5.3% in the maintenance stage (see Table 9). While similar distributions for stage-of-change status were observed for each of the selected demographics, some differences were found. By ethnicity, African Americans had the highest proportion of respondents in the contemplation stage (30.8)%, and Hispanics had the highest proportions of respondents in the planning (10%) and maintenance stage (10%). For level of education, 6.9% of individuals with a high school education were in the maintenance stage, while no individuals with higher levels of education reported being in the maintenance stage. While these small variances were found in stage-of-change status for walking by the demographics of ethnicity and educational level, these differences were not statistically significant.

Table 9. Stage-of-Change Status for Walking

	Precontemplation		Contemplation		Planning		Action		Maintenance	
	N	%	N	%	N	%	N	%	N	%
Total	143	75.3	19	10.0	11	5.8	7	3.7	10	5.3
Age										
18-24	99	76.7	10	7.8	6	4.7	5	3.9	9	7.0
25-34	25	75.8	5	15.2	3	9.1	0	0	0	0
34-49	14	66.7	3	14.3	2	9.5	1	4.8	1	4.8
50-65	5	71.4	1	14.3	0	0	1	14.3	0	
Gender										
Male	76	77.6	9	9.2	5	5.1	3	3.1	5	5.1
Female	67	72.8	10	10.9	6	6.5	4	4.3	5	5.4
Children										
0	109	77.9	12	8.6	6	4.3	6	4.3	7	5.0
1-2	18	62.1	5	17.2	4	13.8	0	0	2	6.9
3-4	10	76.9	2	15.4	1	7.7	0	0	0	0
5 +	5	71.4	0	0	0	0	1	14.3	1	14.3
Ethnicity										
Af Am	7	53.8	4	30.8	1	7.7	0	0	1	7.7
Asian	15	83.3	1	5.6	1	5.6	1	5.6	0	0
Hispanic	14	70.0	2	10.0	2	10.0	0	0	2	10.0
White	89	75.4	12	10.2	5	4.2	5	4.2	7	5.9
Other	16	94.1	0	0	1	5.9	0	0	0	0
Annual Income										
0-10,000	37	72.5	4	7.8	4	7.8	3	5.9	3	5.9
10+-20,000	22	62.9	5	14.3	1	2.9	2	5.7	5	14.3
20+-30,000	24	82.8	3	10.3	1	3.4	0	0	1	3.4
30+-50,000	24	75.0	4	12.5	3	9.4	1	3.1	0	0
50+-100,000	26	83.9	2	6.5	2	6.5	0	0	1	3.2
100,000 +	8	80.0	1	10.0	0	0	1	10.0	0	0

Table 9 (continued)

	Precontemplation		Contemplation		Planning		Action		Maintenance	
	N	%	N	%	N	%	N	%	N	%
Education										
HS/GED	106	73.1	14	9.7	9	6.2	6	4.1	10	6.9
Assoc	30	85.7	3	8.6	1	2.9	1	2.9	0	0
Bach	6	75.0	1	12.5	1	12.5	0	0	0	0
Mast	1	50.0	1	50.0	0	0	0	0	0	0
Environ Courses										
0	44	78.6	5	8.9	2	3.6	1	1.8	4	7.1
1-4	46	69.7	7	10.6	6	9.1	4	6.1	3	4.5
5-9	36	78.3	5	10.9	0	0	2	4.3	3	6.5
10 +	17	77.3	2	9.1	3	13.6	0	0	0	0

Barriers for Walking

The most frequently reported barrier to walking for commuting purposes was "I live too far," which was indicated by 71.4% of respondents, followed by "too much additional time" (56.8%), "bad weather" (55.2%), Looking messy (24%), "personal safety concerns (22.9%), "other" (4.2%), and "walking is for lower-class individuals (2.1%) (see Table 10). For these seven barriers, some differences were found for the selected demographics.

For the "I live too far to walk" barrier, the proportion of respondents identifying this barrier increased as age decreased, with 77.7% of the younger participants (18-24 years old) identifying this as a barrier while only 14.3% of older participants (50-65 years old) indicated this was a barrier to them. Chi-square analysis revealed that this difference was statistically significant at the p=.001 level (X^2=15.64, df=3, p=.001). While just over one-half of respondents identified "walking takes too much time" and "bad weather" as barriers, little variance was found by any of the selected demographics.

The "bad weather" barrier was identified by higher percentages of females (61.3%) and respondents with household incomes over $100,000 per year (70%); however, these differences were not statistically significant. For the "looking messy" barrier, there was little variation in the percentage of responses across most of the selected demographics, except by gender. A higher proportion of females (31.2%) indicated this barrier than males (17.2%). Chi-square analysis revealed that this difference was statistically significant at the p= .05 level (X^2=5.17, df=1, p=.023). For

Table 10. Barriers for Walking

	Too much time		Safety concerns		Bad weather		Looking messy		For lower class		Live too far		Other	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Age											***			
18-24	81	62.3	31	23.8	76	58.5	35	26.9	2	1.5	101	77.7	6	4.7
25-34	17	51.5	8	24.2	15	45.5	5	15.2	1	3.0	22	66.7	0	0
34-49	8	36.4	3	13.6	14	63.6	5	22.7	0	0	13	59.1	2	9.1
50-65	3	42.9	2	28.6	1	14.3	1	14.3	0	14.3	1	14.3	0	0
Gender			***				*						*	
Male	60	60.6	10	10.1	49	49.5	17	17.2	3	3.0	68	68.7	1	1.0
Female	49	52.7	34	36.6	57	61.3	29	31.2	1	1.1	69	74.2	7	7.5
Children														
0	83	59.3	29	20.7	76	54.3	33	23.6	3	2.1	102	72.9	5	3.6
1-2	13	41.9	7	22.6	18	58.1	7	22.6	0	0	22	71.0	1	3.1
3-4	8	61.5	6	46.2	9	69.2	5	38.5	1	7.7	9	62.2	2	15.4
5+	4	57.1	2	28.6	3	42.9	1	14.3	0	0	4	57.1	0	0
Ethnicity														
Af Am	6	46.2	2	15.4	7	53.8	2	15.4	0	0	7	53.8	1	7.1
Asian	10	52.6	4	21.1	6	31.6	3	15.8	0	0	13	68.4	0	0
Hisp	9	45.0	2	10.0	9	45.0	2	10.0	0	0	16	80.0	0	0
White	70	58.8	26	21.8	67	56.3	30	25.2	3	2.5	84	70.6	5	4.2
Other	11	64.7	8	47.1	13	76.5	7	41.2	1	5.9	14	82.4	2	11.8
Income														
0-10k	28	54.9	13	25.5	25	49.0	10	19.6	1	2.0	38	74.5	2	3.9
10,001-20k	22	61.1	5	13.9	23	63.9	11	30.6	0	0	25	69.4	0	0
20,001-30k	13	43.3	7	23.3	13	43.3	5	16.7	2	6.7	19	63.3	2	6.7
30,001-50k	18	56.3	9	28.1	20	62.5	8	25.0	0	0	24	75.0	0	0
50,001-100k	21	6.7	5	16.1	18	58.1	8	25.8	1	3.2	22	71.0	3	9.7
100k +	5	50.0	4	40.0	7	70.0	3	30.0	0	0	8	80.0	1	10.0
Educ														
HS/GED	88	60.3	29	19.9	76	52.1	32	21.9	2	1.4	104	71.2	5	3.4
AA	17	48.6	13	37.1	24	68.6	11	31.4	0	0	27	77.1	2	5.7
BA/BS	3	33.3	2	22.2	5	55.6	2	22.2	1	11.1	5	55.6	1	11.1
MA	1	50.0	0	0	1	50.0	1	50.0	1	50.0	1	50.0	0	0
Env crs														
0	31	54.4	11	19.3	29	50.9	12	21.1	1	1.8	38	66.7	1	1.7
1-4	41	61.2	14	20.9	37	55.2	11	16.4	0	0	50	74.6	2	3.0
5-9	25	54.3	14	30.4	28	60.9	14	30.4	1	2.2	32	69.6	4	8.7
10+	12	54.5	5	22.7	12	54.5	9	40.9	2	9.1	17	77.3	1	4.8
Total	190	56.8	44	22.9	106	55.2	46	24.0	4	2.1	137	71.4	8	4.2

* Significant at the p=.05 level
*** Significant at the p=.001 level

the "personal safety concerns" barrier, more females (36.6%) than males (10.1%) identified this barrier. Chi-square analysis revealed that this difference was statistically significant at the p=.001 level (X^2=19.00, df=1, p<.001). This was also a small variance by ethnicity, with 47.1% of Others, 21.8% of Whites, and 21.1% of Asians identifying this as a barrier, compared to only 15.4% of African Americans and 10.0% of Hispanics, but this difference was not statistically significant.

For the "other" barrier item, the barriers most frequently indicated were physical limitations, needing to carry items with them, and needing to shuttle children from place to place. For gender, a higher proportion of females (7.5%) indicated "other" barriers to walking compared to males (1.0%). Chi-square analysis revealed that this difference was statistically significant at the p=.05 level (X^2=5.10, df=1, p=.024).

Incentives for Walking

The incentive for walking indicated by the highest percentage of respondents (60.9%) was "walking would be good exercise and I would be more physically fit," followed by "saving money on transportation costs" (44.8%), "doing my part to reduce air pollution" (39.6%), "financial incentives" (25.5%), "nothing could encourage me to walk" (20.8%), and "other" (5.2%) (see Table 11). Among these six incentives, some differences were found for the selected demographics.

For the "walking would be good exercise" incentive, 70.0% of those in the 18- to 24-year-old age group indicated that exercise was an incentive to walk, as compared to 42% of 25 to 34 year-olds, 45.5% of 34- to 49-year-olds, and only 28.6% of 50 to 65 year-olds. Chi-square analysis revealed this difference to be statistically significant at the

Table 11. Incentives for Walking

	Save money		Help reduce Air pollution		Financial incentives		Good Exercise		Other		Nothing could encourage	
	N	%	N	%	N	%	N	%	N	%	N	%
Age								**				*
18-24	64	49.2	54	41.5	34	26.2	91	70.0	9	7.0	22	16.9
25-34	11	33.3	10	30.3	7	21.2	14	42.4	1	3.0	13	39.4
34-49	8	36.4	11	50.0	7	31.8	10	45.5	0	0	3	13.6
50-65	3	42.9	1	14.3	1	14.3	2	28.6	0	0	2	28.6
Gender								*		*		
Male	43	43.4	33	33.3	27	27.3	52	52.5	2	2.0	22	22.2
Female	43	46.2	43	46.2	22	23.7	65	69.9	8	8.6	18	19.4
Children				*								
0	61	43.6	49	35.0	35	25.0	89	63.6	8	5.8	26	18.6
1-2	14	45.2	13	41.9	10	32.3	16	51.6	1	3.1	10	32.3
3-4	5	38.5	9	69.2	3	23.1	6	46.2	0	0	3	23.1
5+	5	71.4	5	71.4	1	14.3	6	85.7	1	14.3	1	14.3
Ethnicity												
Af Am	9	62.2	7	53.8	3	23.1	8	61.5	0	0	1	7.7
Asian	9	47.4	9	47.4	8	42.1	16	84.2	0	0	0	0
Hisp	8	40.0	5	25.0	2	10.0	10	50.0	0	0	3	17.6
White	50	42.0	46	38.7	30	25.2	69	58.0	9	7.6	31	26.1
Other	9	52.9	8	47.1	4	23.5	12	70.6	1	5.9	4	45.8
Income												
0-10k	27	52.9	23	45.1	13	25.5	35	68.6	4	7.8	10	19.6
10,001-20k	18	50.0	17	47.2	8	22.2	23	63.9	2	5.6	8	22.2
20,001-30k	13	43.3	12	40.0	7	23.3	15	50.0	0	0	6	20.0
30,001-50k	15	46.9	10	31.3	9	28.1	19	59.4	1	3.1	6	18.8
50,001-100k	11	35.5	10	32.3	9	29.0	21	67.7	2	6.5	5	16.1
100k +	1	10.0	3	30.0	1	10.0	2	20.0	0	0	5	50.0
Educ						*						
HS/GED	63	43.2	59	40.4	30	20.5	89	61.0	9	6.2	28	19.3
AA	19	54.3	12	34.3	14	40.0	22	62.9	0	0	9	28.1
BA/BS	4	44.4	4	44.4	5	55.6	4	44.4	1	11.1	1	11.1
MA	0	0	1	50.0	0	0	2	100.0	0	0	1	50.0
Env crs								*				
0	26	45.6	22	38.6	9	15.8	37	64.9	3	5.2	13	22.8
1-4	29	43.3	24	35.8	21	31.3	42	62.7	3	4.5	12	17.9
5-9	26	56.5	21	45.7	15	32.6	31	67.4	3	6.5	7	15.9
10+	5	22.7	9	40.9	4	18.2	7	31.8	1	4.8	8	36.4
Total	86	44.8	76	39.6	49	25.5	117	60.9	10	5.2	40	20.8

* Significant at the .05 level
** Significant at the .01 level

p=.01 level (X^2=14.53,df=3, p=.002). For gender, more females (69.2%) indicated that exercise was an incentive for walking compared to males (52.5%). Chi-square analysis revealed that this difference was statistically significant at the p=.05 level, (X^2=6.08, df=1, p=.014). Participants with 10 or more courses discussing environmental issues (31.8%) were least likely to indicate exercise as an incentive, compared to respondents with no environmental courses (64.9%), 1-4 environmental courses (62.7%), and 5-9 courses (67.4%). Chi-square analysis revealed that this difference was statistically significant at the p=.05 level (X^2=9.11, df=3, p=.028). By income, respondents in the income categories ranging from $0-100,000 per year (50-68.6%) were more likely to identify exercise as an incentive for walking than individuals with household incomes over $100,000 per year (20%). Chi-square analysis revealed that this difference approached statistical significance (p=.062).

For the "I would save money on transportation costs" incentive, no significant differences were found for the selected demographics. For the "I would be doing my part to reduce air pollution" incentive, differences were found by number of children. Of the total respondents, 71.4% of individuals with 5 or more children, 69.2% of individuals with 3-4 children, and only 35.0% of individuals with zero children indicated this incentive. Chi-square analysis revealed that this difference was statistically significant at the p=.05 level (X^2=9.03, df=3, p=.029). A larger proportion of females (46.2%) indicated that reducing air pollution acted as an incentive compared to males (33.3%). Chi-square analysis revealed that this difference approached statistical significance (p=.068). For the "financial incentives" option, no differences were found for the selected demographics. For the "nothing could encourage me to walk" option, a difference by age group was found, with 39.4% of respondents in the 25- to 34-year-old age category and 28.6% of individuals in the 50 to 65 year-old age category indicating that nothing could encourage them to walk as means of alternative transportation, compared to 16.9% of respondents in the 18- to 24-year-old age category and 13.6% of respondents in the 34- to 49-year-old age category. Chi-square analysis revealed these differences to be statistically significant at the p=.05 level (X^2=9.04, df=3, p=.029). Only 5.2% of respondents indicated that "other" incentives could encourage them to walk, with the most frequently identified incentives under this item being an increased feeling of personal safety and shorter distances to destinations. Females (8.6%) reported the "other" incentive item more frequently than males (2%). Chi-square analysis revealed that this difference was statistically significant at the p=.05 level (X^2=4.21, df=1, p=.04)

Predictors for Stage of Change for Walking

For use of walking as alternative transportation, the final ordinal regression iteration resulted in five variables being included in the model (see Table 12). Income of $0-10,000 was a statistically significant predictor (p=.05), as was the income category of $10,001-20,000 (p=.01), for stage of change for this mode of alternative transportation. Based on the estimated probability of response (see Table 12), respondents whose incomes were in the $0-10,000 and $10,001-20,000 categories had a 22% likelihood and 25% likelihood, respectively, to be in advanced stages of change (planning/action/ maintenance) compared to only a 9% likelihood for those with incomes over $20,000.

Table 12. Stage of Change for Walking - Parameter Estimates

	Estimate	Std. Error	Wald	df	p
Stage of Change					
Precontemplation	1.312	.838	2.451	1	.117
Contemplation	2.162 .	.853	6.421	1	.011
Annual Income					
0-10,000	.968	.454	4.551	1	.033
10+-20,000	1.280	.498	6.594	1	.010
20,001+	0			0	
Live too far to walk					
Yes	-1.474	.404	13.317	1	.000
No	0			0	
$ Savings Incentive					
Yes	.941	.398	5.603	1	.018
No	0			0	
0_3 affect on your future health					
Yes	14.706	.832	312.544	1	.000
No	0			0	
O_3 affect on others future health					
Yes	-14.397	.000		1	
No	0			0	

Pearson X^2 Goodness of Fit=22.658, df=32, p=.889; Nagelkerke Pseudo R^2=.215

Table 13. Stage of Change for Use of Walking - Estimated Probability of Response

	Precontemplation	Contemplation	Prep/Action/Maintenance
Income			
0-10	.63	.15	.22
10-20	.59	.16	.25
20,001+	.82	.09	.09
Bar walk far			
Yes	.80	.10	.10
No	.53	.17	.30
Inc walk save			
Yes	.62	.15	.23
No	.82	.09	.09
Your future health			
Yes	.72	.12	.16
No	.83	.08	.09
Family's future health			
Yes	.72	.12	.16
No	.79	.10	.11

Other statistically significant predictors were the incentives of "save money on transportation costs" (p=.01), the beliefs that "air pollution will affect your health in the future" (p=.001) and that "air pollution will affect the health of your friends or family in the future" (p=.001), and the barrier of "live too far from work and/or school" (p=.001). For the first three variables, those who answered "yes" for these items were more likely to be in the advanced stages of change, with likelihoods of 23%, 16%, and 16%, respectively, of falling into the planning/action/maintenance category compared to likelihoods of 9%, 9%, and 11%, respectively, for those who did not have these perceptions. On the contrary, those for whom living to far from work/school was a barrier had only a 10% likelihood of being in that advanced-stage category, compared to a 30% likelihood for those who did not identify that as a barrier. The Nagelkerke Pseudo R-Square indicates that this predictive model accounts for approximately 22% of the variance in stage of change for walking as an alternative mode of transportation

Bicycling

Stage-of-Change Status

Results showed that the majority of respondents in the sample (71.2%) were in the precontemplation stage for bicycling as a means of alternative transportation, with 20.4% in the contemplation stage, 4.2% in the planning stage, 3.7% in the action stage, and .5% in the maintenance stage (see Table 14). While the distributions for stage of change status by the selected demographics were very similar for the most part, some interesting differences were observed. By age, those in the youngest age category (18-24 years) had the highest proportion of respondents in the contemplation stage (23.8%), the action stage

Table 14. Stage-of-Change Status for Bicycling by Demographics

	Precontemplation		Contemplation		Planning		Action		Maintenance	
	N	%	N	%	N	%	N	%	N	%
Age										
18-24	86	66.2	31	23.8	6	4.6	6	4.6	1	0 .8
25-34	27	81.8	5	15.2	0	0	1	3.0	0	0
34-49	17	81.0	2	9.5	2	9.5	0	0	0	0
50-65	6	85.7	1	14.3	0	0	0	0	0	0
Gender										
Male	65	66.3	23	23.5	4	4.1	5	5.1	1	1.0
Female	71	76.3	16	17.2	4	4.3	2	2.2	0	0
Children										
0	96	68.6	32	22.9	5	3.6	6	4.3	1	.7
1-2	21	70.0	6	20.0	3	10.0	0	0	0	0
3-4	12	92.3	0	0	0	0	1	7.7	0	0
5 +	6	85.7	1	14.3	0	0	0	0	0	0
Ethnicity										
Af Am	10	76.9	3	23.1	0	0	0	0	0	0
Asian	14	77.8	3	16.7	1	5.6	0	0	0	0
Hispanic	12	60.0	5	25.0	0	0	2	10.0	1	5.0
White	87	73.1	21	17.6	7	5.9	4	3.4	0	0
Other	11	64.7	5	29.4	0	0	1	5.9	0	0
Annual Income										
0-10,000	36	70.6	10	19.6	4	7.8	1	2.0	0	0
10-20,000	22	61.1	10	27.8	2	5.6	2	5.6	0	0
20-30,000	25	86.2	2	6.9	0	0	2	6.9	0	0
30-50,000	24	75.0	6	18.8	2	6.3	0	0	0	0
50-100,000	22	71.0	7	22.6	0	0	1	3.2	1	3.2
100,000 +	5	50.0	4	40.0	0	0	1	10.0	0	0

Table 14 (continued)

	Precontemplation		Contemplation		Planning		Action		Maintenance	
	N	%	N	%	N	%	N	%	N	%
Education										
HS/GED	103	70.5	29	19.9	7	4.8	6	4.1	1	.7
Assoc	28	80.0	6	17.1	0	0	1	2.9	0	0
Bach	5	62.5	2	25.0	1	12.5	0	0	0	0
Mast	0	0	2	100.0	0	0	0	0	0	0
Environ Courses										
0	43	76.8	11	19.6	0	0	2	3.6	0	0
1-4	46	68.7	14	20.9	4	6.0	3	4.5	0	0
5-9	35	76.1	7	15.2	2	4.3	1	2.2	1	2.2
10 +	12	54.5	7	31.8	2	9.1	1	4.5	0	0

(4.6%) and the maintenance stage (.8%). Males also showed higher percentages than females in the contemplation stage (23.5% versus 17.2%, respectively), and in the action stage (5.1% versus 2.2%, respectively). By ethnicity, Hispanics had the highest percentage in the action (10%) and maintenance (5%) stages. However, these differences were not statistically significant.

Barriers to Bicycling

The most frequently identified barrier for walking was "I live too far from work or school," with 63.7% of respondents identifying this barrier, followed by "bad weather" (55.4%), "too much time" (43%), "looking messy when arriving to work or school" (31.1%), "personal safety concerns" (29%), "other" (3.6%), and "bicycling is for low-class individuals" (1%) (see Table 15). Among these seven barriers, some differences were found for the selected demographics.

For the distance barrier, little variance was found for the selected demographics, except by age. Participants in the youngest age category (18-24 years) identified the distance barrier most frequently (71.5%), compared to 51% of those over the age of 34. Chi-square analysis showed this difference to be statistically significant at the p=.05 level (X^2=10.64, df=3, p=.014). For the "personal safety concerns" barrier, some variation was found across the selected demographics by ethnicity, gender, and number of children. For ethnicity, 64.7% of participants in the "Other" ethnicity category (primarily American Indians and Pacific Islanders) reported the safety concerns barrier, followed by 31.6% of Asians, 26.1% of Whites, 20% of Hispanics, and only 14.3% of African

Table 15. Barriers for Bicycling

	Too Much time		Personal Safety		Looking Messy		Bad Weather		For lower class		Live too far		Other	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Age												*		
18-24	56	43.1	34	26.2	44	33.8	78	60.0	1	.8	93	71.5	3	2.3
25-34	18	54.5	9	27.3	5	15.2	15	45.5	1	3.0	15	45.5	2	6.1
34-49	8	36.4	8	36.4	9	40.9	11	50.0	0	0	11	50.0	1	4.5
50-65	1	12.5	5	62.5	2	25.0	3	37.5	0	0	4	50.0	1	12.5
Gender				*										*
Male	46	46.0	22	22.0	28	28.0	54	54.0	0	0	63	63.0	1	1.0
Female	37	39.8	34	36.6	32	34.4	53	57.0	2	2.2	60	64.5	6	6.5
Children				*										
0	59	42.1	35	25.0	44	31.4	80	57.1	1	.7	94	67.1	5	3.6
1-2	15	46.9	11	34.4	9	28.1	17	53.1	1	3.1	17	53.1	0	0
3-4	6	46.2	8	61.5	5	38.5	7	53.8	0	0	7	53.8	1	7.7
5+	3	42.9	2	28.6	2	28.6	3	42.9	0	0	4	57.1	1	14.3
Ethnicity				**										
Af Am	7	50.0	2	14.3	3	21.4	7	50.0	1	7.1	5	35.7	1	7.1
Asian	10	52.6	6	31.6	3	15.8	7	36.8	0	0	11	57.9	0	0
Hispanic	6	30.0	4	20.0	4	20.0	10	50.0	0	0	16	80.0	0	0
White	50	42.0	31	26.1	41	34.5	67	56.3	1	.8	77	64.7	5	4.2
Other	9	52.9	11	64.7	8	47.1	13	76.5	0	0	12	70.6	1	5.9
Annual Income														
0- 10,000	21	41.2	13	25.5	12	23.5	25	49.0	1	2.0	30	58.8	4	7.8
10,001-20,000	15	41.7	9	25.0	13	36.1	21	58.3	0	0	22	61.1	0	0
20,001-30,000	14	46.7	11	36.7	7	23.3	13	43.3	0	0	19	63.3	1	3.3
30,001-50,000	15	45.5	9	27.3	12	36.4	20	60.6	0	0	23	69.7	1	3.0
50,001-100,k	14	45.2	8	25.8	11	35.5	20	64.5	1	3.2	21	67.7	1	3.2
100k+	3	30.0	5	50.0	4	40.0	6	60.0	0	0	7	70.0	0	0
Educ				*										
HS/GED	64	43.8	35	24.0	41	28.1	80	54.8	2	1.4	95	65.1	4	2.7
AA	12	33.3	17	47.2	14	38.9	20	55.6	0	0	3	63.9	2	5.6
BA/BS	6	66.7	3	33.3	4	44.4	5	55.6	0	0	4	44.4	1	11.6
MA	1	50.0	1	50.0	1	50.0	2	100.0	0	0	1	50.0	0	0
Env crs														
0	25	43.1	19	32.8	14	24.1	29	50.0	0	0	33	56.9	2	3.4
1-4	32	47.8	17	25.4	19	28.4	38	56.7	1	1.5	44	65.7	2	3.0
5-9	15	32.6	12	26.1	16	34.8	25	54.3	1	2.2	30	65.2	2	4.3
10+	11	50.0	8	36.4	11	50.0	15	68.2	0	0	16	72.7	1	4.5
Total	83	43.0	56	29.0	60	31.1	107	55.4	2	1.0	123	63.7	7	3.6

* Significant at the .05 level
** Significant at the .01 level

Americans. Chi-square analysis revealed these differences to be statistically significant at the p=.01 level (X^2=13.45, df=4, p=.009). A higher percentage of females (36.6%) identified this as a barrier compared to males (22%). Chi-square analysis revealed that this difference was statistically significant at the p=.05 level (X^2=4.96, df=1, p=.026). For number of children, 61.5% of respondents with 3-4 children identified safety as a barrier compared to 25% of respondents with no children. Chi-square analysis revealed that this difference was statistically significant at the p=.05 level (X^2=8.19, df=3, p=.042).

The "bicycling is for low-class individuals" and "other" barriers were identified by less than 4% of participants. For "other" barriers to bicycling, the most frequently indicated barrier was difficulty carrying needed supplies on the bicycle. For gender, a higher percentage of females indicated "other barriers" compared to males. Chi-square analysis revealed that this difference was statistically significant at the p=.05 level, (X^2=4.07, df=1, p=.043).

Incentives for Bicycling

The incentive for bicycling indicated by the highest percentage of participants was "bicycling would be good exercise" (63.9%) (see Table 16), followed by "saving money on transportation costs" (52.6%), "doing my part to reduce air pollution" (41.8%), "more off-road bicycling trails" (34.5%), "financial incentives" (31.4%), "nothing could encourage me to bicycle" (14.4%), and "other" (2.1%). Among these seven incentives, some differences were found for the selected demographics.

For the "exercise" incentive, the percentage of respondents identifying this incentive decreased as age increased, with 69.5% of the 18- to 25-year-olds identifying the exercise incentive compared to 25% of 50- to 65-year-olds. Chi-square analysis revealed this difference to be statistically significant at the p=.05 level (X^2=9.01, df=3, p=.029). A higher percentage of females (74.2%) identified exercise as an incentive compared to males (54.5%). Chi-square analysis revealed that this difference was statistically significant at the p=.01 level (X^2=8.18, df=1, p=.004). A higher percentage of respondents with five or more children (85.7%) compared to those with no children (68.1%) indicated that exercise was an incentive for bicycling. Chi-square analysis revealed that this difference was statistically significant at the p=.05 level (X^2=8.20, df=3, p=.042).

For the "save money on transportation cost" incentive, no significant differences were found among the selected demographics. For the "reducing air pollution" incentive, there was little variation in the percentage of responses across most of the selected demographics, except for ethnicity and gender. Over 40% of African Americans, Asians, Whites, and Others identified reducing air pollution as an incentive compared to only 14.3% of Hispanics. Chi-square analysis revealed that this difference was statistically significant at the p=.05 level (X^2= 9.94, df=4, p=.041). A higher percentage of females (48.4%) identified this incentive compared to males (35.6%). Chi-square analysis revealed that this difference approached statistical significance (p=.072).

For the "financial incentives" option, there was little variation in the percentage of responses across most of the selected demographics. By educational level, over 50% of

Table 16. Incentives for Bicycling

	Save money on transportation		Help reduce air pollution		Financial incentives		Good exercise		More offroad bike trails		Other		Nothing could encourage	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Age								*					*	
18-24	73	55.7	57	43.5	44	33.6	91	69.5	50	38.2	4	3.1	14	10.7
25-34	13	39.4	9	27.3	6	18.2	20	60.6	8	24.2	0	0	9	27.3
34-49	12	54.5	12	54.5	9	40.9	11	50.0	7	31.8	0	0	2	9.1
50-65	4	50.0	3	37.5	2	25.0	2	25.0	2	25.0	0	0	3	37.5
Gender								**			0	0		
Male	53	52.5	36	35.6	35	34.7	55	54.5	30	29.7	2	2.0	15	14.9
Female	49	52.7	45	48.4	26	28.0	69	74.2	37	39.8	2	2.2	13	14.0
Children								*						
0	72	51.1	55	39.0	47	33.3	96	68.1	53	37.6	4	2.8	17	12.1
1-2	18	56.3	14	43.8	10	31.3	14	43.8	7	21.9	0	0	8	25.0
3-4	5	38.5	8	61.5	3	23.1	8	61.5	4	30.8	0	0	2	15.4
5+	6	85.7	4	57.1	1	14.3	6	85.7	3	42.9	0	0	0	0
Ethnicity				*										
Af Am	8	57.1	8	57.1	4	28.6	7	50.0	3	21.4	0	0	2	14.3
Asian	10	52.6	8	42.1	5	26.3	15	78.9	7	36.8	0	0	3	15.8
Hispanic	11	52.4	3	14.3	4	19.0	9	42.9	4	19.0	0	0	3	14.3
White	61	51.3	51	42.9	40	33.6	78	65.5	41	34.5	3	2.5	19	16.0
Other	10	58.8	10	58.8	6	35.3	13	76.5	10	58.8	1	5.9	0	0
Annual Income														
0- 10k	29	56.9	26	51.0	15	29.4	36	70.6	16	31.4	1	2.0	8	15.7
10,001- 20k	23	62.2	18	48.6	12	32.4	24	64.9	15	40.5	2	5.4	3	8.1
20,001- 30k	14	46.7	9	30.0	6	20.0	19	63.3	9	30.0	0	0	5	16.7
30,001- 50k	19	57.6	11	33.3	1	36.4	21	63.6	11	33.3	0	0	5	15.2
50,000- 100k	12	38.7	11	35.5	10	32.3	17	54.8	11	35.5	0	0	5	16.1
100k+	3	30.0	4	40.0	4	40.0	5	50.0	4	40.0	0	0	2	20.0
Educ						**								
HS/GED	72	49.0	57	38.8	37	25.2	95	64.6	51	34.7	4	2.7	20	13.6
AA	23	63.9	17	47.2	19	52.8	22	61.1	11	30.6	0	0	8	22.2
BA/BS	6	66.7	5	55.6	5	55.6	6	66.7	3	33.3	0	0	0	0
MA	1	50.0	2	100.0	0	0	1	50.0	2	100.0	0	0	0	0
Env crs														
0	30	51.7	24	41.4	12	20.7	39	67.2	19	32.8	2	3.4	11	19.0
1-4	34	50.0	23	33.8	22	32.4	39	57.4	23	33.8	1	1.5	7	10.3
5-9	27	58.7	22	47.8	17	37.0	32	69.6	17	37.0	0	0	7	15.2
10+	11	50.0	12	54.5	10	45.0	14	63.6	8	36.4	1	4.5	3	13.6
Total	102	52.6	81	41.8	61	31.4	124	63.9	67	34.5	4	2.1	28	14.4

* Significant at the .05 level
** Significant at the .01 level

associate and bachelor's degree holders identified this incentive compared to only 25.2% of high school diploma holders and 0% of master's degree holders. Chi-square analysis revealed that this difference was statistically significant at the p=.01 level (X^2=13.63, df=3, p=.003). For the "more off-road trails" and "other" incentives items, little variance was found for any of the selected demographics. For "other," common incentives listed included increased safety, living closer to work or school, owning a bicycle, and having a place to clean up upon arrival.

For the "nothing could encourage me to bicycle" incentive item, there was little variation in the percentage of responses across most of the selected demographics, except for age level. A higher percentage of those in the oldest age category (37.5% of those 50-65 years of age) indicated that nothing could encourage them to bicycle compared to those in the youngest age category (11% of those 18-24 years of age). Chi-square analysis revealed that this difference was statistically significant at the p=.05 level (X^2=9.85, df=3, p=.02).

Predictors for Stage of Change for Bicycling

For use of bicycling as alternative transportation, the final ordinal regression iteration resulted in two variables being included in the model (see Table 17). The statistically significant predictors for this model were the barrier item "bicycling takes too much time" (p=.05) and the incentive item of "nothing could encourage me to bicycle as a means of commuting" (p=.01). Based on the estimated probability of response (see Table 18), respondents who indicated that bicycling took too much time out of their schedule were more likely than those who did not perceive this as a barrier to be in the early stages of change for bicycling, with those for whom time was a barrier having a 79% likelihood of being in the precontemplation stage of change compared to a 65% likelihood of those who did not identify this as a barrier. Those in the group who indicated that nothing could encourage them to use a bicycle as an alternative mode, not surprisingly, had a much higher likelihood (96%) of being in the precontemplation group compared to the other respondents who did not have this perception (67%). The Nagelkerke Pseudo R-Square indicates that this predictive model accounts for approximately 11% of the variance in stage of change for use of bicycle as an alternative mode of transportation.

Table 17. Stage of Change for Use of Bicycle - Parameter Estimates

	Estimate	Std. Error	Wald	df	p
Stage of Change					
Precontemplation	.459	.206	4.964	1	.026
Contemplation	2.011	.285	49.889	1	.000
Time Barrier					
Yes	-.656	.343	3.665	1	.056
No	0			0	
No incentive to Bike					
Yes	-2.490	1.037	5.763	1	.016
No	0			0	

Pearson X^2 Goodness of Fit=2.332, df=4, p=.675; Nagelkerke Pseudo R^2=.108

Table 18. Stage of Change for Bicycling - Estimated Probability of Response

	Precontemplation	Contemplation	Prep/Action/Maintenance
Time bar bike			
Yes	.79	.15	.06
No	.65	.24	.11
No inc bike			
Yes	.96	.03	.01
No	.67	.23	.10

Carpooling

Stage-of-Change Status

Results revealed that the majority of the respondents (63.9%) were in the precontemplation stage for usage of carpooling as a means of alternative transportation, with 15.2% in the contemplation stage, 2.6% in the planning stage, 7.9% in the action stage and 10.5% in the action stage (see Table 19). While distributions for stage-of-change status by the selected demographics were very similar for the most part, some interesting differences were observed. Respondents between the ages of 18-34, Asians, and those with household incomes over $50,000 annually had the highest proportion of respondents in the maintenance stage of change.

Predictors for Stage of Change for Carpooling

For use of carpooling as a source of alternative transportation, ordinal regression indicated that none of the variables included in the modes were statistically significant predictors of stage of change for that model

Table 19. Stage-of-Change Status for Carpooling by Demographics

	Precontemplation		Contemplation		Planning		Action		Maintenance	
	N	%	N	%	N	%	N	%	N	%
Age										
18-24	73	56.2	22	16.9	4	3.1	13	10.0	18	13.8
25-34	27	81.8	4	12.1	0	0	0	0	2	6.1
34-49	15	71.4	3	14.3	1	4.8	2	9.5	0	0
50-65	7	100.0	0	0	0	0	0	0	0	0
Gender										
Male	61	62.2	13	13.3	3	3.1	10	10.2	11	11.2
Female	61	65.6	16	17.2	2	2.2	5	5.4	9	9.7
Children										
0	85	60.7	23	16.4	4	2.9	13	9.3	15	10.7
1-2	21	70.0	3	10.0	1	3.3	1	3.3	4	13.3
3-4	10	76.9	2	15.4	0	0	0	0	1	7.7
5 +	5	71.4	1	14.3	0	0	1	14.3	0	0
Ethnicity										
Af Am	11	84.6	1	7.7	0	0	1	7.7	0	0
Asian	7	38.9	4	22.2	0	0	3	16.7	2	22.2
Hispanic	14	70.0	2	10.0	1	5.0	2	10.0	1	5.0
White	77	64.7	16	13.4	4	3.4	9	7.6	13	10.9
Other	13	76.5	3	17.6	0	0	0	0	1	5.9
Annual Income										
0-10,000	31	60.8	7	13.7	1	2.0	7	13.7	5	9.8
10-20,000	23	63.9	6	16.7	2	5.6	1	2.8	4	11.1
20-30,000	20	69.0	5	17.2	1	3.4	2	6.9	1	3.4
30-50,000	23	71.9	7	21.9	0	0	1	3.1	1	3.1
50-100,000	18	58.1	4	12.9	0	0	3	9.7	6	19.4
100,000 +	5	50.0	0	0	1	10.0	1	10.0	3	30.0

Table 19 (continued)

	Precontemplation		Contemplation		Planning		Action		Maintenance	
	N	%	N	%	N	%	N	%	N	%
Education										
HS/GED	92	63.0	18	12.3	5	3.4	14	9.6	17	11.6
Assoc	23	65.7	8	22.9	0	0	1	2.9	3	8.6
Bach	6	75.0	2	25.0	0	0	0	0	0	0
Mast	1	50.0	1	50.0	0	0	0	0	0	0
Environ Courses										
0	34	60.7	9	16.1	1	1.8	7	12.5	5	8.9
1-4	43	64.2	9	13.4	2	3.0	5	7.5	1	11.9
5-9	29	63.0	9	19.6	1	2.2	3	6.5	4	8.7
10 +	16	72.7	2	9.1	1	4.5	0	0	3	13.6

CHAPTER V

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to explore attitudes and beliefs regarding ozone (O_3) air pollution and alternative transportation usage among community college students in a northern California city that suffers from a severe O_3 air pollution problem. The researcher explored the relationship between selected demographics and stage-of-change status of the population in regards to usage of various forms of alternative transportation, including walking, bicycling, carpooling, and public transportation. In addition, the researcher examined the barriers and incentives to usage of public transit, walking, and bicycling as alternatives for commuting to and from school and/or work. The researcher also sought to determine beliefs regarding the primary source of ozone air pollution and beliefs about the health effects of ozone air pollution.

The sample consisted of 202 students at a northern California community college. Participants included 103 males and 99 females, ranging in age from 18 to 65 years, and representing a wide variety of college majors. Student participation was voluntary and anonymous. Demographic information, stages of change, perceived barriers and benefits, and health beliefs pertaining to use of alternative transportation were measured using a self-report survey instrument developed by the researcher.

Chi-square analyses were performed in order to examine the differences in stage-of-change status, perceived barriers, and perceived incentives for the modes of alternative transportation by the selected demographics (age, gender, income, number of children, ethnicity, educational level, and environmental coursework). In addition, chi-square analysis was used to assess differences in beliefs regarding the source of O_3 air pollution, as well as the current and future health effects of air pollution. Ordinal regression analyses were performed to determine which factors among the demographics, barriers, incentives, and beliefs made the largest contribution to stage of change status for use of public transit, carpooling, walking, and bicycling.

Discussion

Results from this study indicated that 93.3% of respondents drive a motor vehicle on a regular basis. Of the respondents that drive regularly, 71.3% report that commuting to and from work and/or school constituted the majority of their time spent driving. A little over half of the participants reported believing that air pollution currently affects their health (59%), with a higher proportion of non-whites (African Americans, 92.9%; Hispanics, 76.2%, and Others, 64.7%) reporting this belief compared to 53.8% of Whites. These findings appear to correspond well with actual exposure to O_3, coinciding with reports from the American Lung Association (ALA) (1999) that 61.3% of African American children and 69.2% of Hispanic children live in non-attainment areas for O_3 air pollution compared to 50.8% of white children. Furthermore, the ALA (1998b) reports that minorities are also more likely to live close to industrial sites and power plants that emit pollutants into the air.

A far greater proportion of respondents indicated the belief that air pollution will affect their health in the future (78.9%), with a greater proportion of persons earning under $100,000 per year reporting this belief. For age, the proportion of respondents reporting the belief that air pollution will affect their health in the future increased as age increased, with 87.5% of respondents between the ages of 50-65 reporting this belief. Once again, these findings are reflective of actual vulnerability to air pollution. The WHO (1999) reports that as aging occurs, lung function and physiological defense mechanisms decline, leaving the older individuals more vulnerable to air pollution.

While the vast majority of respondents reported believing that air pollution would affect their health in the future, fewer of them (60%) believed that motor vehicle usage is the primary contributor to the development of ground-level O_3. Interestingly, 78.9% of respondents believed that air quality could be improved by citizens increasing their usage of alternative transportation. These findings suggest that while the majority of respondents may understand that motor vehicle usage contributes to air pollution, a significant proportion may be unaware of the extent of the problem, causing the researcher to question whether participants understand that motor vehicles emit more pollutants into the air than any other single emission source or that motor vehicles are responsible for nearly one-half of all NOx emissions.

Most of the respondents (81.8%) were in the precontemplation stage for usage of public transit for commuting purposes. Of those in the more advanced stages of change (preparation, action, or maintenance), the highest percentages were found for African Americans (28.6%), those between 18 and 24 years old (9.2%), and those earning under 20,000 per year (24.8%). Of these demographics, having an annual income of $10,000 or less was a predictor of stage-of-change status for public transit usage. The most frequently identified barrier for using public transit was that it took too much additional time out of their schedule. Lack of freedom to come and go as desired was another barrier identified by the majority of respondents. Personal safety was a concern for a substantial percentage of females, Asians, and Whites. Saving money on transportation costs and financial incentives were identified as incentives to use public transit by slightly over one-half of the respondents.

Like public transit, the vast majority of respondents (75.3%) were in the precontemplation stage for walking, with few respondents in the action and maintenance stages, at 3.7% and 5.3%, respectively. Several factors served as predictors of advanced stage-of-change status for walking, including earning less than $20,000 per year, the incentive of saving money on transportation costs, and the belief that air pollution will affect personal health and the health of others in the future. As with public transit, walking appears to be utilized out of financial necessity. Furthermore, individuals who walk may believe that air pollution will affect their health in the future because walking gives them greater exposure to foul air, and they are therefore more likely to feel its effects.

For barriers to walking, living too far from school or work was identified by a large majority of respondents (71.4%) and was a significant predictor for being in the early stages of change for this alternative transportation mode. Personal safety concerns and looking messy when arriving to work were barriers more frequently identified by females compared to males. The perception that walking would be good exercise and would help them to be more physically fit was an incentive for walking as an alternative transportation mode for over 60% of respondents, with participants in the younger age categories identifying this incentive more than those over 50 years of age, and females identifying this incentive more frequently than males.

As with walking and public transit, the vast majority of respondents (71.2%) were in the precontemplation stage for bicycling. Interestingly, of all the modes of transportation examined, bicycling showed the highest proportion of respondents in the contemplation stage (20.4%). Higher proportions of males and Hispanics were represented in the advanced stages (action and maintenance).

As with walking, the exercise and physical fitness aspect was once again identified by the highest percentage of respondents as an incentive for bicycling, with a greater proportion of females identifying this as an incentive compared to males. It is interesting to note that the proportion of respondents indicating this incentive decreased as age increased. Non-whites were more likely than whites to indicate that doing one's part to reduce air pollution was an incentive for bicycling.

Living too far from work or school was indicated as a barrier to bicycling by the majority of respondents (63.7%). Personal safety concerns was indicated as a barrier by a higher proportion of females compared to males, and a higher proportion of whites compared to non-whites. Two barriers, "bicycling takes too much additional time out of my schedule" and "nothing could encourage me to bicycle as a means of commuting" were predictive of being in the precontemplation for bicycling.

Of the modes of transportation examined, a higher proportion of respondents were in advanced stages of action (7.9%) and maintenance (10.5%) for carpooling as compared to public transit, walking, and bicycling. There was little variation for stage of change status by the selected demographics. However, for ethnicity, a higher percentage of Asians and Whites, 38.9% and 21.9% respectively, were in the advanced stages (preparation, action and maintenance). For income, higher percentages of individuals earning over $50,000 per year (69.1%) or under $20,000 per year (37.4%) reported being in the action and maintenance stages for carpooling.

It is unfortunate that the investigator inadvertently did not include barriers and incentives for carpooling since this appears to be a promising mode of alternative transportation. However there were some interesting patterns that emerged. For gender, a higher proportion of females expressed personal safety concerns for public transit, walking, and bicycling. While safety concerns for carpooling were not examined in this study, it is interesting to note that there was a higher proportion of females in the action and maintenance stages for carpooling (5.4% and 9.7%, respectively) compared to public transit (1.1% and 6.5%, respectively), walking (4.3% and 5.4%, respectively), and bicycling (2.2% and 0%, respectively). It may be possible that females are more likely to utilize carpooling because they perceive it as safer. It is the feeling of the researcher that there is a need for a study that would examine incentives and barriers to carpooling as well as predictors of stage of change status.

In essence, these findings indicate certain patterns regarding use of alternative transportation. Clearly, while the vast majority of respondents are in the precontemplation stage for usage of each of the four alternative transportation modes, money is an issue. Personal income is a contributor to respondents being in advanced stages of change for both public transit and walking, with individuals with annual household incomes under $20,000 disproportionately represented in the advanced stages. Likewise, for walking, saving money on transportation costs was predictive of being in the advanced stages of change. While not statistically significant predictors, saving money on transportation costs and financial incentives were also the most frequently identified incentives for public transit usage. Furthermore, for carpooling, a higher proportion of respondents with household incomes over $50,000 per year, reported being in the action (19.7%) and maintenance (49.4%) stages.

While the vast majority of respondents indicated that exercise was an incentive for bicycling and walking, living too far from work or school was a barrier for the majority of respondents. In fact, living too far from work or school and was found to be predictive of being in the precontemplation stage for walking.

Conclusions

Five null hypotheses were delineated for investigation in this study. The first null hypothesis stated that there are no differences in stage of change status regarding alternative transportation usage among students of a northern California college that are related to age, gender, income level, ethnicity, educational level, and environmental coursework. Based on the results of this study, this null hypothesis was not rejected.

The second null hypothesis stated that there are no differences in perceived barriers to alternative transportation usage among students of a northern California college related to age, gender, income level, ethnicity, educational level, and environmental coursework. Based on the results of this study, this null hypothesis was rejected. Statistically significant differences among several of these demographics were found for a number of the barriers. For barriers to use of public transportation, differences were found by gender, ethnicity, and education for "personal safety concerns," and by age for "can't come and go as I please." For barriers to walking, differences were found by gender for "personal safety concerns," "looking messy when arriving to work or school," and "other"; by education for "walking is for lower class individuals,"; and by age for "live too far." For barriers to bicycling, differences were found by gender, number of children, ethnicity, and education for "personal safety concerns," by age for "live too far;" and by gender for "other."

The third null hypothesis stated that there are no differences in the perceived benefits of using alternative transportation among students of a northern California college related to age, gender, income level, ethnicity, educational level, and environmental coursework. Based on the results of this study, this null hypothesis was rejected. Statistically significant differences among several of these demographics were found for a few of the incentives. For incentives for use of public transportation, differences were found by age for "saving money on transportation costs" and by education and number of environmental courses taken for "financial incentives." For incentives for walking, differences were found by number of children for "helping reduce air pollution," by education for "financial incentives"; by gender, age, and number of environmental courses taken for "good exercise"; by gender for "other"; and by age for "nothing could encourage me." For incentives for bicycling, differences were found for the following incentives by ethnicity for "help reduce air pollution,"; by gender and children for "bicycling would be good exercise," by education for "financial incentives," and by age for "nothing could encourage me to bicycle."

The fourth null hypothesis stated that there are no differences in health beliefs regarding air pollution among students of a northern California college related to age, gender, income level, ethnicity, educational level, and environmental coursework. Based on the results of this study, this null hypothesis was rejected. Statistically significant differences were found by ethnicity for "air pollution currently affects my health"; by gender for "air pollution will affect my health in the future"; and by income for "air pollution will affect the health of my family and/or friends in the future."

The fifth null hypothesis stated that there is no relationship between stage of change status, perceived barriers, perceived benefits, and health beliefs regarding air pollution reduction among students of a northern California college. Based on the results of this study, this null hypothesis was rejected. Income was found to be a statistically significant predictor of stage of change status for both public transportation and walking. Predictors for stage status for walking also included "financial incentives," "save money on transportation costs," "live too far," "air pollution will affect my health in the future" and "air pollution will affect the health of my family and/or friends in the future." For bicycling, "bicycling takes too much time," and "nothing could encourage me to bicycle" were predictive of stage of change status for bicycling.

Implications

From this study, several implications related to program development and education can be made. Clearly, this study shows that the vast majority of respondents are in the precontemplation stage for alternative transportation usage. A look at the barriers that exist for various methods of alternative transportation indicate that programs aimed at increasing usage of alternative transportation will need to be multifaceted in nature, involving cooperative efforts from employers, community planners, community developers, and the public. For example, it is clear that distance between home and work and/or school destinations acts as a barrier for walking and bicycling for the majority respondents for walking and bicycling as transportation modes. Furthermore, respondents report that public transit takes to much time and limits their ability to come and go as they please. Females, Whites, and Asians report personal safety concerns pertaining to the use of public transit.

Reducing these barriers cannot be done through educational programs alone. Solutions will need to involve employers, the business community, developers, and city planners who work together to remove barriers and increase incentives for utilization of alternative transportation. For example, developers, city planners, and employers need to work together to make it feasible and desirable for employees to live closer to work, since living too far to utilize alternative transportation appears to be a barrier to the majority of individuals. Furthermore, transportation alternatives need to be less time consuming, since taking extra time for alternative transportation is also a major barrier to its use. One way this might occur in the city in which this study took place is to increase coverage of the public transit such that it reaches out to a larger area, with pick-up and drop-off occurring a minimum of each hour as opposed to two to three times per day. Public transit could also be further developed such that commuters can actually get in and out of work more quickly utilizing public transit, as opposed to sitting in their cars in traffic. Solutions such as this might increase usage of public transit by reducing the time barrier and increasing commuter's ability to come and go as they please.

In order to increase use of alternative transportation, commuters will need to view it as time-saving and convenient. Furthermore, city and government officials need to work to make public transit safer and/or dispel the misbelief that it is not safe. This might begin with a study on the safety of the public transit system, followed by appropriate action based on the results. Furthermore, such transportation systems will need to reach out to the suburbs. Carpooling and vanpooling are also good alternatives for those who live too far to walk or bike. Involving employers with the planning and promotion of carpools and vanpools for employees might further increase utilization of transportation alternatives.

Community planners and government officials could provide incentives, including tax breaks for employers who increase carpool and public transit usage among employees by a predetermined percent. In Georgia, a state program known as "Partnership for a Smog-Free Georgia" successfully instituted such a program. This program involved subsidies for usage of commuting alternatives for employees. The Georgia Department of Transportation introduced this program to its employees and reduced the percentage of employees commuting in single-occupancy vehicles from 91.4% to 73.6% between May and August of 1999. The Georgia Board of Workers' Compensation decreased single-occupancy commutes by 28% using this same program between March and April of 1999 (Partnership for a Smog-Free Georgia, 2000).

Results of this study also indicate that exercise is an incentive for walking and bicycling for younger individuals. Therefore, programs aimed at providing incentives and encouraging fitness through walking and bicycling might be attractive to younger commuters. Such programs might include employer support such that employers provide clean, comfortable, modern facilities in which employees who have biked or walked to work can change clothes, clean up, and possibly even shower before beginning their workday. This might be especially important for females, who report the exercise/fitness benefits of bicycling as an incentive, but perceive looking messy as a result of bicycling as a barrier. On the other hand, employers could encourage employees to bike or walk to work by allowing employees to dress more casually on days they walk or bike.

Accompanying the efforts to involve local government, community planners, and employers, educational programs aimed at consciousness raising are needed to assist in moving target populations into more advanced stages of change for alternative transportation usage. Such programs might include education regarding the role of the automobile in the development of O_3 air pollution, and the current and future health effects of living in a city with unhealthful levels of O_3.

Health educators can play a significant role in bringing about social and political changes that will reduce O_3 air pollution and increase the implementation and usage of more sustainable transportation practices. They can participate in bringing about political change by increasing involvement in political advocacy. Areas in which health educators could play a vital role might be advocacy work aimed at tightening air quality standards, political action aimed at increasing incentives for government and businesses who develop programs that increase utilization of alternative transportation, and advocating for research and development of transportation sources that do not require fossil fuel consumption.

Health educators can also play a vital role in reducing air pollution by developing and implementing programs that will provide education and will work to increase alternative transportation usage. Such programs may address a wide variety of issues pertaining to single occupancy vehicle usage and the importance of O_3 air pollution reduction. Examples of programs might include educational programs in which government officials, community leaders, and the public become aware of the sources and the health effects of O_3 air pollution, social and community programs to reduce barriers and increase incentives for using alternative transportation, and social marketing programs to educate and inform the public about transportation alternatives.

Recommendations for Further Study

Results of this study show that the majority of respondents experience similar barriers and benefits to the usage of alternative transportation. However, because this study utilized a relatively small convenience sample of college students, studies involving a larger and more representative sampling of community populations need to be performed. In particular, those future studies should include participants from a wide variety of professions in the communities being examined.

Qualitative studies are needed to determine other barriers and incentives for usage of alternative transportation that may not have been mentioned in this study. Such analysis might then be used to develop future instrumentation for assessment.

It is also recommended that future studies more closely assess specifics pertaining to various barriers and incentives. For example, living too far from work or school was a barrier for a large portion of respondents in this study. The study did not determine what distance is an acceptable distance to walk or bicycle to work.

Since the perception that alternative transportation takes too much additional time out of one's schedule was also a commonly identified barrier in this study, future studies might seek to determine the beliefs about the additional time involved, what would be an acceptable amount of time loss, and whether or not respondents have actually determined that they would lose time using alternative transportation.

Females, Whites, and Asians indicated that personal safety concerns acted as a barrier to public transit usage. Therefore, future studies might seek to determine if this is a barrier for the general population, what specific safety concerns exist, and what measures might reduce these personal safety concerns. In addition, studies about the safety of public transit need to be performed in order to determine whether or not public transit really is safe. Studies such as this will need to take place in local communities, since safety of public transit may vary from city to city.

Incentives to alternative transportation also need to be explored in greater depth. For example, since exercise was reported as a strong incentive for walking and bicycling, a more detailed analysis might reveal how program planning might build upon this incentive in a way that will increase usage of walking and bicycling. It is also important to note that incentives and barriers may differ based on the nature of the community and geographical location. Factors such a weather, safety, and proximity to work and school destinations often vary widely in different geographical locations. Therefore, it is recommended that communities assess the barriers and incentives for their particular community.

In addition, studies need to be performed to assess the readiness, attitudes, barriers, and incentives regarding the development and implementation of alternative transportation programs among community planners, local governments, and employers. Such studies could examine what barriers and incentives might influence government, community, and employer participation in programs aimed at increasing usage of alternative transportation.

Finally, studies of communities that have experienced success in increasing use of alternative transportation could be particularly useful in designing programs for other communities. A wide variety of such studies might be performed in this area, including a look at the logistics of the systems in place, the planning procedures involved in the implementation of the system, and the publicity campaigns involved in marketing the program. Furthermore, studies could also be performed which will analyze the public's perception of the alternative transportation sources being utilized, in order to determine the benefits and barriers to use of alternative transportation.

In essence, studies far broader in scope need to be performed in order to make definitive decisions regarding program development aimed at increasing alternative transportation usage. Barriers and incentives need to be examined in greater depth, utilizing a population that is representative of the community's population as a whole. Furthermore, there is a need for studies that will examine barriers and benefits to community planners and employers for developing programs to increase use of alternative transportation, and studies that will examine the strategies used by organizations and communities that have successfully increased utilization of alternative transportation.

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APPENDIX A

SUSTAINABLE TRANSPORTATION SURVEY

Sustainable Transportation Survey

Directions: Please complete all sections of this questionnaire and return it to the researcher. In order to maintain your anonymity, do not put your name on the questionnaire. *The return of your completed questionnaire constitutes your informed consent to act as a participant in this research.*

1. Age: _____.

2. Gender: ☐ Male ☐ Female

3. What best describes your current living situation:
   ☐ Living with parents ☐ Living alone ☐ Living with roommates
   ☐ Single parent living with children ☐ Living with spouse or partner

4. Do you have children? ☐ Yes (If so how many?): _____ ☐ No

5. Ethnicity:
   ☐ African American ☐ American Indian ☐ Asian
   ☐ Hispanic ☐ Pacific Is/Filipino ☐ White
   ☐ Other (please specify): ____________________

6. What is your annual income? (If married or living with parents please indicate household income)
   ☐ $0-10,000 per year ☐ $10,001-20,000 per year ☐ $20,001-30,000 per year
   ☐ $30,001-50,000 per year ☐ $50,001-100,000 per year ☐ More than $100,000 per year

7. Highest level of education:
   ☐ High school diploma/GED ☐ Master's degree
   ☐ Associate degree ☐ Doctorate
   ☐ Bachelor's degree ☐ Other (Please specify): ____________________

8. Please indicate the total number of high school courses taken which covered environmental issues as part of the course. Examples of such courses may include environmental science, environmental biology, general biology, ecology etc.:

   Total number of high school courses taken which covered environmental issues: ______

9. Please indicate which of the following courses you have taken in college which have included a discussion of environmental issues as part of the course. Also indicate the total number of coursework units/credit hours for the course. For example, if you have taken 2 environmental science courses in college and each course was 3 credit hours, you would enter 6 credit hours. (Please check all that apply).

   ☐ Environmental Science Credit hours: ____ ☐ Field biology Credit hours ____

   ☐ Environmental Biology Credit hours: ____ ☐ Botany Credit hours ____

   ☐ Conservation Biology Credit hours: ____ ☐ General biology Credit hours: ____

   ☐ Environmental Health Credit hours: ____ ☐ Forestry Credit hours ____

   ☐ Ecology Credit hours: ____ ☐ Health courses Credit hours ____

   ☐ Other courses in which environmental issues were discussed: (Please indicate the title and number of credit hours for each course.) ____________________

10. What is your current major in college? (Please list your major or enter "undecided," whichever is applicable)______________________________

11. Which of the following do you believe is the primary source of ozone air pollution (that which occurs on hot summer days "Spare the Air Days")? (Please check only one item)

☐ Industrial emissions
☐ Motor vehicles
☐ Agricultural practices (for example, field burning, farm vehicles, etc.)

12. Do you currently have access to a motor vehicle that you can drive? ☐ yes ☐ no

13. Do you drive a motor vehicle on a regular basis? ☐ yes ☐ no

If you answered "No" to questions 12 or 13, please skip to number 17

14. On average, how many hours do you spend driving a motor vehicle each day during the week, Mondays through Fridays?

☐ Less than 1 hour per day
☐ 1-2 hours per day
☐ 3-4 hours per day
☐ Over 4 hours per day

15. On average, how many hours do you spend driving a motor vehicle each day on weekends, Saturdays and Sundays?

☐ Less than 1 hour per day
☐ 1-2 hours per day
☐ 3-4 hours per day
☐ Over 4 hours per day

16. How do you spend most of your driving time? (Please check only one)

☐ Commuting to and from school and/or work
☐ Social activities
☐ Visiting family and/or friends
☐ Running errands
☐ Sports activities
☐ Transporting children
☐ Other (Please specify): ______________________________

17. Do you use methods of transportation other than a motorized vehicle? ☐ yes ☐ no

If "yes," what type(s) alternative transportation do you use? (Please check all that apply).

☐ Walking
☐ Bicycle
☐ Public transportation (such as bus or light rail)
☐ Carpooling/vanpooling (sharing a ride in a car, truck or van with at least one other person)
☐ Other (Please specify): ______________________________

18. Which of the following alternative transportation methods you would consider using? (Please check all that apply).

- ☐ Public transportation (such as the bus or light rail)
- ☐ Walking
- ☐ Telecommuting – working at home and communicating with employer via phone and computer
- ☐ Bicycling
- ☐ Other (Please specify): ______________________________
- ☐ I would not consider using an alternative method of transportation for commuting purposes.

19. Please indicate which of the following statements best describes your current status regarding using public transit (such as the bus or light rail) as a method of alternative transportation for getting to and from school or work. (Please check only one)

- ☐ I have not been using public transit regularly, and I do not intend to begin using it regularly any time in the future.
- ☐ I have not been using public transit regularly, but I am thinking about using it regularly within the next six months.
- ☐ I have not been using public transit regularly, but I am planning to start using it regularly within the next month.
- ☐ I have been using public transit regularly for less than six months.
- ☐ I have been using public transit regularly for six months or longer.

20. Please indicate which of the following statements best describes your current status regarding the use of carpooling or vanpooling as a method of alternative transportation to get to and from school or work. (Carpooling or vanpooling is sharing a ride in a car, truck or van with at least one other person.) (Please check only one).

- ☐ I have not been carpooling/vanpooling regularly and I do not intend to begin to carpool/vanpool regularly anytime in the future.
- ☐ I have not been carpooling/vanpooling regularly but am thinking about doing it regularly within the next six months.
- ☐ I have not been carpooling/vanpooling regularly, but am planning to start doing so regularly with in the next month.
- ☐ I have been carpooling/vanpooling regularly for less than six months.
- ☐ I have been carpooling/vanpooling regularly for six months or longer.

21. Please indicate which of the following statements best describes your current status regarding bicycling as a method of commuting to and from school or work. (Please check only one).

- ☐ I have not been bicycling for commuting purposes on a regular basis and I do not intend to begin to bicycle regularly for commuting purposes, anytime in the future.
- ☐ I have not been bicycling regularly as a means of commuting, but am thinking about doing so regularly within the next six months.
- ☐ I have not been bicycling regularly as a means of commuting, but am planning to start doing so regularly with in the next month.
- ☐ I have been bicycling regularly, as a means of commuting, for less than six months.
- ☐ I have been bicycling regularly, as a means of commuting, for six months or longer.

22. Please indicate which of the following statements best describes your current status in regards to walking as a method of commuting to and from school or work. (Please check only one).

- ☐ I have not been walking, as a means of commuting, on a regular basis and I do not intend to begin to walk regularly for commuting purposes, anytime in the future.
- ☐ I have not been walking regularly as a means of commuting, but I am thinking about doing so regularly within the next six months.
- ☐ I have not been walking regularly as a means of commuting, but am planning to start doing so regularly with in the next month.
- ☐ I have been walking regularly, as a means of commuting, for less than six months.
- ☐ I have been walking regularly, as a means of commuting, for six months or longer.

23. Which of the following would **discourage** your use of public transit? (Please check all that apply).

- ☐ Using public transit takes too much additional time out of my schedule
- ☐ I have concerns about my personal safety
- ☐ Public transit lines are not easily accessible for me
- ☐ I can't come and go exactly when I please
- ☐ It seems that public transit is for lower class individuals
- ☐ Other (Please specify): ________________________________

24. Which of the following would **encourage** your use of public transit? (Please check all that apply).

- ☐ I would save money on transportation costs
- ☐ I would be doing my part in helping to reduce air pollution
- ☐ Financial incentives (receiving money, tax breaks or perks)
- ☐ Other (Please Specify): ________________________________
- ☐ Nothing could encourage me to use public transit

25. Which of the following would **discourage** you from walking as a means of commuting? (Please check all that apply).

- ☐ Walking takes too much additional time out of my schedule
- ☐ I have concerns about my personal safety
- ☐ I have concerns about looking like I have been exercising (messy hair and clothes) when I get to work or school and I have no place to "freshen up"
- ☐ Bad weather
- ☐ It seems that walking is for lower class individuals
- ☐ I live too far from work and/or school to walk
- ☐ Other (Please specify): ________________________________

26. Which of the following would **encourage** you to walk as a means of commuting? (Please check all that apply).

- ☐ I would save money on transportation costs
- ☐ I would be doing my part in helping to reduce air pollution
- ☐ Financial incentives (receiving money, tax breaks or perks)
- ☐ Walking would be good exercise and I would be more physically fit
- ☐ Other (Please Specify): ________________________________
- ☐ Nothing could encourage me to walk as a means of commuting

27. Which of the following would **discourage** you from bicycling as a means of commuting? (Please check all that apply)

☐ Bicycling takes too much additional time out of my schedule
☐ I have concerns about my personal safety
☐ I have concerns about looking like I have been exercising (messy hair and clothes) when I get to work or school and I have no place to "freshen up" or change clothes.
☐ Bad weather
☐ It seems that bicycling is for lower class individuals
☐ I live too far from work and/or school to bicycle
☐ Other (Please specify): ______________________

28. Which of the following would **encourage** you to bicycle as a means of commuting? (Please check all that apply).

☐ I would save money on transportation costs
☐ I would be doing my part in helping to reduce air pollution
☐. Financial incentives (receiving money, tax breaks or perks)
☐ Bicycling would be good exercise and I would be more physically fit
☐ I would bicycle if there were more bike trails (trails for bicycles and walkers only, no cars)
☐ Other (Please Specify): ______________________
☐ Nothing could encourage me to bicycle as a means of commuting

29. Do you believe that air pollution is currently affecting your health?
☐ Yes
☐ No
☐ I don't know

30. Do you believe that air pollution will affect your health in the future?
☐ Yes
☐ No
☐ I don't know

31. Do you believe that air pollution currently affects the health of your family or friends?
☐ Yes
☐ No
☐ I don't know

32. Do you believe that air pollution will affect the health of family or friends in the future?
☐ Yes
☐ No
☐ I don't know

33. Do you believe that the air pollution problem can be improved by citizens increasing usage of alternative transportation such as bicycling, public transit, telecommuting and walking?
☐ Yes
☐ No
☐ I don't know