

Survey of the Use of Ozone-generating Air Cleaners by the California Public

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California Air Resources Board
Research Division
1001 I Street
Sacramento, CA 95814

Prepared by:

Thomas Piazza, Principal Investigator
Robert H. Lee and Jacqueline Hayes, Primary Authors

Survey Research Center
2538 Channing Way #5100
University of California
Berkeley, California 94720-5100

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The statements and conclusions in this report are those of the contractor and not necessarily those of the California Air Resources Board. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

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TABLE OF CONTENTS

DISCLAIMER	ii
ACKNOWLEDGEMENTS	iii
TABLE OF CONTENTS	v
LIST OF TABLES	vii
ABSTRACT	viii
EXECUTIVE SUMMARY	ix
1. INTRODUCTION	1
1.1. Summary of Literature	2
1.2. Project Objectives	4
1.2.1. Determine the Prevalence of Ownership of Ozone-Generating Air Cleaners in California Homes	4
1.2.2. Determine the Reasons for Ownership of Ozone-Generating Air Cleaners.	5
1.2.3. Determine the Frequency and Duration of Their Use.	6
1.2.4. Obtain Other Information Needed to Assess the Potential Impact of These Appliances on Public Health.....	6
1.3. Report Organization	6
2. MATERIALS AND METHODS	7
2.1. Target Population and Eligibility	7
2.3. Constructing the Sampling Frames	7
2.4. Questionnaire Design and the Project Objectives	9
2.5. Outcome of the Sample of Telephone Numbers	9
2.6. Quality Assurance & Quality Control Procedures.....	11
2.6.1. Testing the Questionnaire	11
2.6.2. Data Management & Cleaning	11
2.6.3. Training of Interviewers	12
2.6.4. Monitoring of Telephone Interviewers	13
3. RESULTS	14
3.1. Determine the Prevalence of Ownership of Ozone-Generating Air Cleaners in California Homes	14
3.2. Determine Reasons for Ownership of Ozone-Generating Air Cleaners	22
3.3. Determine the Frequency and Duration of Their Use.....	25
3.4. Obtain Other Information Needed to Assess the Potential Impact of These Appliances on Public Health.....	30
4. DISCUSSION	39
5. SUMMARY AND CONCLUSIONS.....	41
6. RECOMMENDATIONS	43

REFERENCES	44
GLOSSARY OF TERMS, ABBREVIATIONS, AND SYMBOLS	46
APPENDIX A – Survey Questionnaire	47
APPENDIX B – List of Brands	80

LIST OF TABLES

Table 1: Outcome of the Sample of Telephone Numbers	10
Table 2: Prevalence of Portable Air Cleaner Ownership	14
Table 3: Type of Air Cleaners Owned (Percent of All California Households)	16
Table 4: Number of Air Cleaners Owned by California Households, by Type.....	17
Table 5: Special Features of Purposeful and By-Product Ozone-Generating Air Cleaners.....	18
Table 6: Room Where Air Cleaner Is Used Most Often: by Air Cleaner Type.....	19
Table 7: Year of Purchase of Air Cleaners, by Type	20
Table 8: Cost of Air Cleaners, by Type	21
Table 9: Where Air Cleaners are Purchased, by Type	22
Table 10: Reasons Air Cleaners are Purchased, by Air Cleaner Type	23
Table 11: Reasons Specific Models are Selected, by Air Cleaner Type	25
Table 12: Year-Round or Seasonal Use, by Air Cleaner Type	26
Table 13: Number of Days per Week for Usage of Air Cleaners, by Type	26
Table 14: Proportion of Households that Use Air Cleaners Every Day & Continuously	27
Table 15: Air Cleaner Has Plates for Particle Collection, by Type.....	28
Table 16: How Often Particle Collection Plates are Cleaned, by Type	28
Table 17: Present Use of Air Cleaners, by Type	29
Table 18: Reasons for Little or No Use of Air Cleaners.....	29
Table 19: Annual Income, by Air Cleaner Type	31
Table 20: Ethnicity, by Air Cleaner Type.....	32
Table 21: Effect of Race and Income on Air Cleaner Ownership.....	33
Table 22: Number of Adults Living in Households, by Air Cleaner Type.....	34
Table 23: Number of Children in Household, by Air Cleaner Type	34
Table 24: Knowledge that Ozone-Generating Air Cleaners Emit Ozone	35
Table 25: Perception of Indoor Air Quality, by Air Cleaner Type.....	36
Table 26: Warnings in Manual, by Ozone-generating Cleaner Type.....	37
Table 27: Types of Warnings Recalled from the Owner's Manual.....	37
Table 28: Knowledge that Ozone is a Pollutant	38

ABSTRACT

A representative telephone survey of 2,019 California adults was conducted to determine the extent to which Californians purchased and used indoor air cleaners, specifically models that produce ozone either intentionally or as a by-product, as well as the reasons for their purchase, the frequency and duration of their use, and to determine other factors that may impact public health. Fourteen percent of California households own an air cleaner. Ten percent of California households own an air cleaner that produces ozone intentionally or as a by-product: two percent (2%) of California households own an air cleaner that intentionally emits ozone, while eight percent (8%) own one that may emit ozone as a by-product. Although these are small percentages of the total California households, this equates to about 282,000 households and 828,000 Californians who are exposed to ozone emitted intentionally from air cleaners, and many more who may be exposed to lower levels from by-product devices. Californians purchase air cleaners primarily for health reasons, and most use their air cleaners continuously every day.

EXECUTIVE SUMMARY

Background

Electronic air cleaners that emit ozone either purposely (ozone generators) or as a by-product of their particle removal process (ionizers and electrostatic precipitators [ESP's]) have been marketed aggressively, with manufacturers claiming that the devices can remove many types of indoor air pollutants. Concerns have been raised that some of these devices (purposeful ozone generators) can emit enough ozone to exceed the 1-hour California ambient air quality standard of 90 parts per billion (ppb). Ozone can cause chest pain, coughing, shortness of breath, throat irritation, and compromise the ability of the body to fight respiratory infections. Vulnerable populations, such as the elderly and those with asthma or other respiratory diseases, are especially at risk for health complications.

At the time this project was initiated, there were no reliable data on the actual purchase and use of ozone-generating air cleaners in California. The purpose of this study was to: 1) determine the extent of ownership (prevalence) of these ozone generators by Californians; 2) determine the reasons for their purchase; 3) determine the frequency and duration of their use; and 4) to obtain other information needed to assess the potential impact of these appliances on public health. The information obtained is of immediate use for addressing the impact of air cleaners on Californians' health and to guide future exposure and risk reduction approaches by the California Air Resources Board.

Methods

A telephone survey was conducted with 2,019 households throughout California using a list-assisted random digit dialing sample of 12,008 telephone numbers, of which 9,383 were households. Once a telephone number was confirmed to be a household, any adult resident, 18 years of age or older was eligible to act as the survey respondent. Questions were asked about whether or not the household owned an indoor air cleaner, and if so, what brand and model of air cleaner it was, and a series of questions designed to elicit information relating to the objectives of the study. All interviews were conducted in English.

Results

Approximately 14% of California households report that they own or used a portable air cleaner during the past five years. Ten percent of California households own an air cleaner that produces ozone, either by design or as a by-

product. About two percent of all California households report owning an air cleaner that purposefully emits ozone, and approximately eight percent report owning an air cleaner that may emit ozone as a by-product.

Based on recent population and household data showing that California has over 12 million households (CDOF, 2006), an estimated 282,000 California households own an air cleaner that purposely emits ozone, and an estimated 828,000 Californians are potentially at risk of substantially elevated exposure to ozone indoors from their ozone generator. About 45% of households with purposeful ozone-generating air cleaners have children.

About half (50%) of all air cleaner owners (including purposeful ozone-generating air cleaners and those that may emit ozone as a by-product) purchased their air cleaner because of allergies or asthma in the home.

Households with all types of air cleaners use them extensively. Seventy-seven percent of all air cleaner owners (and 80% of owners of purposeful ozone generators and by-product devices) use their primary air cleaner year-round. A majority (57%) of all air cleaner owners, and an even larger percentage of purposeful ozone generator (72%) and by-product (64%) device owners, use their air cleaners continuously every day.

The survey found that almost 29% of households that own any air cleaner and 22% of owners of air cleaners that emit ozone by design or may emit ozone as a by-product, no longer use their air cleaner. A majority (about 58%) of owners of any air cleaner no longer use their device because they felt they no longer needed it. A little less than half (45%) of owners of purposeful ozone-generating air cleaners, and a little more than half (51%) of owners of air cleaners that may emit ozone as a by-product, felt they no longer needed their device(s).

Both ethnicity and income were found to be related to air cleaner ownership. While 59% of all respondents who completed the interview considered themselves to be white or Caucasian, 74% of all air cleaner owners, regardless of type, consider themselves to be white or Caucasian. The reverse trend was seen for Latinos and for African Americans; whereas those two groups comprise 28% of respondents, they only comprise 10% of air cleaner owners of any type of device. Higher income households in all ethnic groups are more likely to own air cleaners than lower income households, but ethnic differences persist within each income level. Income and ethnicity overlap somewhat in their effect on air cleaner ownership, but most of the effect of ethnicity is independent of the effect of income.

Most air cleaners, 65% for all primary air cleaners and somewhat more of purposeful (67%) or by-product (71%) ozone-generating devices were purchased from 2003 to the present. About 53% of all air cleaner owners spent \$200 or less for their primary air cleaner, but 73% of purposeful ozone generator owners

spent more than \$200 for their primary air cleaner. In fact, fully 35% of purposeful ozone-generating air cleaner owners, spent more than \$600 for their air cleaner, compared to just 4% of owners of by-product machines and 10% of owners of all types of air cleaners.

Most air cleaner owners report a perception of improved indoor air quality (IAQ) as a result of their air cleaner, 71% for all air cleaner owners, 81% for owners of purposeful ozone generating devices, and 71% of owners of by-product devices. About 29% of all air cleaner owners, 19% of purposeful ozone-generating air cleaners, and 29% of owners of by-product devices say their air quality stayed the same. There were no reports that indoor air quality was worse for either group.

Conclusions

About one in seven (14%) households in California owns an indoor air cleaner or has previously owned one during the past five years. The prevalence of purposeful ozone-generating air cleaners in California households is approximately 2%, and the prevalence is 8% for ionizers and electrostatic precipitators, which may emit ozone as a by-product. Although the proportion of California households that owns these devices is relatively low, the potential impact may be great because about 828,000 Californians live in households that use purposeful ozone generators, and the air cleaners are very heavily used by their owners. A sizeable majority of households (57% for all air cleaner owners, 72% for owners of purposeful ozone-generating air cleaners, and 64% of owners of by-product devices) never turn off their primary air cleaner. Indoor air cleaners are purchased for a variety of reasons, but the most commonly stated reason for purchase is a concern about asthma or allergies.

SURVEY OF THE USE OF OZONE-GENERATING AIR CLEANERS BY THE CALIFORNIA PUBLIC

1. INTRODUCTION

Portable electronic air cleaners that emit ozone either purposely (ozone generators) or as a by-product of their particle removal process (ionizers and electrostatic precipitators [ESP's]) have been marketed aggressively for years, with manufacturers claiming that the devices can remove many types of indoor air pollutants. Concerns have been raised because research in chamber and test home studies have shown that both ozone generators and some ionizers can emit ozone at rates that result in unhealthy indoor concentrations (Chen and Zhang, 2004; Mason *et al.*, 2000, and Britigan *et al.*, 2006), sometimes several times greater than the 1-hour California ambient air quality standard of 90 parts per billion (ppb; Phillips and Jakober, 2006). The California Air Resources Board (ARB), the California Department of Health Services, and other government agencies advise the public not to use any device that emits ozone by design (ARB, 2006).

Breathing ozone can be harmful, especially for children, the elderly, and for people with asthma, bronchitis or other respiratory problems (ARB, 2005). Ozone irritates the eyes, nose, and throat; can cause chest pain, coughing, shortness of breath, and throat irritation; and may trigger asthma attacks in those with asthma. Long-term exposure to ozone may permanently reduce a person's breathing ability. Ozone can also compromise the ability of the body to fight respiratory infections.

Reliable data were not available on the actual purchase and use of portable ozone-generating air cleaners in California, nor was it known whether most purchasers were aware of the potential harm to health the ozone emissions may cause. Without reliable data on the extent of use of these ozone generators by Californians, it was difficult to estimate the extent of their potential impact on public health. This was an important data gap in accurately quantifying the scope of the problem.

Despite the claims of manufacturers and distributors, ozone generators are ineffective at cleaning indoor air. Independent studies have shown that they do not remove indoor pollutants, nor do they eliminate airborne microbes when operated at safe levels. Rather, they can lead to a significant increase in indoor levels of formaldehyde and other aldehydes, as well as other pollutants, through reaction with other chemicals present indoors (Boeniger 1995; Foarde *et al.*, 1997; Chen and Zhang, 2004). Some of these reaction products are listed as California Toxic Air Contaminants, and can irritate the mucous membranes and respiratory tract or cause other health problems.

In addition, ozone deadens the sense of smell, giving the occupants a false sense of security because they cannot detect any indoor odors, including elevated ozone levels. Ozone cannot eliminate airborne bacteria, mold, or viruses in occupied spaces because very high levels of ozone – 5,000 ppb or more are needed to kill them. Even when used in unoccupied places to generate high levels of ozone, the deadened cell parts remain and can trigger asthma and allergy symptoms in sensitive individuals.

1.1. Summary of Literature

A brief review of research studies showing ozone emissions and the ineffectiveness of ozone in cleaning indoor environments is summarized as follows:

▪ ***Ozone Emissions***

Phillips and Jakober (2006) tested ozone emissions from four models of ozone generators that are widely marketed in California. The devices were operated according to manufacturers' instructions in a small test room furnished with a desk and chair, under environmental conditions common in homes. The test results showed that all of the models produce room ozone concentrations that exceed health-based standards (often several times higher) and can pose a serious health risk.

Mason *et al.* (2000) measured ozone emissions from ozone generators in a test chamber and in a home. They measured ozone levels well above health-based standard levels, even in the home under different central fan conditions.

Researchers at UC Irvine (Britigan, *et al.*, 2006) tested several types of air purifiers and the amount of ozone produced in various indoor air environments. In many cases, ozone concentrations were well in excess of public and/or industrial safety levels set by the federal U.S. Environmental Protection Agency, California ARB, and the federal Occupational Safety and Health Administration. In some cases, measured ozone concentrations exceeded 350 ppb.

▪ ***Ineffective in Controlling Microbial Growth on Indoor Surfaces***

Foarde *et al.* (1997) tested the effect of ozone in a stainless steel chamber on both vegetative and spore-forming fungi as well as spore-forming bacteria that are commonly found indoors. For the test organisms on glass slides, ozone concentrations of 6 ppm or greater were required for significant kill. [California health-based outdoor air standards are 0.09 ppm for a 1-hour exposure, and 0.07 ppm for an 8-hour exposure.] For

test organisms on surfaces of actual building materials (3 types of heating duct materials, 2 types of ceiling tiles), no microbial kill was demonstrated even at concentrations as high as 9 ppm ozone. [Building surfaces, especially those with porous surfaces rather than hard surfaces, do not allow ozone to reach the microbes as effectively.]

Dyas *et al.* (1983) tested the growth of bacteria and fungi commonly found in hospitals by placing agar plates in a cupboard with ozone concentrations of 0.3-0.9 ppm, and in a hospital room with ozone concentrations less than 0.001 ppm. Ozone concentrations of 0.9 ppm [10 times the California outdoor air quality standard] reduced the number of most species tested by 95%, but the *Candida albicans* fungus was relatively resistant. No bactericidal effects were seen in the hospital room test. The authors noted concern that one study has reported that ozone caused mutations in *E. coli* bacteria.

▪ ***Ineffective in Removing Gaseous Pollutants and Particles from Indoor Air***

Chen and Zhang (2004) tested the initial removal of 16 volatile organic chemicals (VOCs) by commercially available air cleaners in a full-scale stainless steel chamber. The air cleaners using ozone oxidation, ionization, or plasma decomposition showed insignificant removal of the VOCs. The exception was d-limonene, which reacts with ozone to produce formaldehyde, a known human carcinogen and common indoor air pollutant.

Boeniger (1995) reviewed several studies of the effectiveness of ozone generators in removing indoor air pollutants. Ozone reduced alkene concentrations (such as benzene, xylene) produced by a carpet sample, but converted those compounds into other compounds of concern, including aldehydes (such as formaldehyde), organic acids, and ketones, and increased the level of total VOCs. Ozone did not effectively remove formaldehyde, body odor, tobacco smoke odor, or several other odorous compounds (ozone has been shown to reduce one's sense of smell.)

In 1992, Consumers Union scientists tested a variety of air cleaners on the market, and found that the two brands of ozone generators tested (Alpine Air and Quantum) performed poorly in removing smoke and dust. Because of their ineffectiveness and their excess ozone emissions, they were rated as "not acceptable" (Consumers Union, 1992). In two 2005 articles of Consumer Reports Magazine, concerns about ozone emissions from some ionizing air cleaners (electrostatic precipitators and ionizers) are highlighted (Consumers Union, 2005a,b).

Shaughnessy *et al.* (1994) tested the effectiveness of commercially available portable air cleaning devices in a test chamber. An ozone generator model without a glass media particle filter was not effective in removing common indoor pollutants: dust, pollen, spores, tobacco smoke particles, formaldehyde, carbon monoxide, and nitrogen dioxide. The ozone generators and ionizers were the least effective among all the air cleaner types in removing particles.

1.2. Project Objectives

In order for the ARB to determine how much of an impact ozone-generating air cleaners have on public health, reliable data were needed on prevalence of ownership and usage patterns of California residents. This project was intended to gain an understanding of the extent to which Californians purchase and use air cleaners, particularly purposeful ozone generator models, in their homes.

This report summarizes data from telephone interviews with 2,019 adults throughout California. The survey questions are provided in Appendix A. The survey questions were designed to meet the following specific project objectives, to:

- Determine the prevalence of ownership of portable ozone-generating air cleaners in California homes.
- Determine the reasons for ownership of portable ozone-generating air cleaners.
- Determine the frequency and duration of their use.
- Obtain other information needed to assess the potential impact of these appliances on public health.

This report examines the use of portable indoor air cleaners only. It does not examine whole house air cleaners or in-duct systems. The information obtained is of immediate use for addressing the impact of portable air cleaners on Californians' health and to guide future exposure and risk reduction approaches by the ARB.

1.2.1. Determine the Prevalence of Ownership of Ozone-Generating Air Cleaners in California Homes.

Questions were asked to determine the prevalence of ownership in California households of ozone-generating devices, as well as the prevalence of ownership of air cleaners that do not emit ozone, and finally what proportion of California households do not own any air cleaner at all. Once a household reported owning or using an electronic air cleaner, additional questions were asked about:

- The brand and model that was used;
- The year the device(s) was/were purchased;
- The cost of the device(s);
- Where the air cleaners were purchased;
- The number of air cleaners owned by the household;
- In which room(s) the device(s) is/are used
- Whether or not the device had any special features;
- What types of filters the device had, if any, and how often the filters were changed;
- The function of the device – was the device meant to clean:
 - An entire house;
 - A small room or bathroom;
 - A single car or a handheld personal device?

Those that report owning only a car or personal air cleaner were not administered the full interview.

Respondents who answered affirmatively to owning an air cleaning device were asked additional questions to determine whether the air cleaner:

- Emits ozone by design,
- May emit ozone as a by-product of the particle removal process,
- Has a filter and the cleaner does not emit ozone
- Has a filter, but the cleaner may also emit ozone as a by-product

1.2.2. Determine the Reasons for Ownership of Ozone-Generating Air Cleaners.

Questions were asked about the various reasons for purchasing an air cleaning device and the reasons they selected a particular model. Respondents were asked if they purchased and or selected an air-cleaning device because:

- Someone in the household had allergies, asthma, or some other health condition.
- There was a desire to remove substances such as mold, bacteria, dust, airborne particles, chemical contaminants, tobacco, smoke, or pet dander.
- There was a recommendation from a doctor or dentist.
- An advertisement in a newspaper, magazine, radio, TV, Internet, or an actual demonstration of an air-cleaning device was seen or heard.

1.2.3. Determine the Frequency and Duration of Their Use.

Questions were asked about how often and how long the device was used, whether or not the device was used year-round, or only during certain seasons, whether or not the device was used daily, weekly, etc. and how long the device was used, hourly or less than hourly.

1.2.4. Obtain Other Information Needed to Assess the Potential Impact of These Appliances on Public Health.

Questions were asked about key demographics such as age, income, ethnicity, home ownership, and location of the household. Information was available regarding whether or not the household is in an urban or rural area, as this information was included in the original sample frame. The answers to these questions as well as geographic information regarding the residential dwelling, helped to determine if one or more of these demographic characteristics might correlate with ownership of an ozone-generating air cleaner.

In addition, questions were asked about the household's knowledge of how the device functions, knowledge of the manufacturer's instructions and cautions, knowledge that ozone is a pollutant and other relevant information that might help assess the impact of these appliances on public health.

1.3. Report Organization

Section 2, labeled "Materials and Methods" outlines the overall design of the study, which includes a discussion of the target population, the sample frame, the questionnaire design in relation to the project objectives, the outcome of the sample, as well as the quality assurances and quality control procedures. Section 3 of the report is devoted to the analysis of the interview data and the results for each of the study objectives. Section 4 labeled "Discussion", discusses the implications of the findings with respect to each project objective. The summary and conclusions of the project are found in Section 5, followed by future recommendations found in Section 6.

2. MATERIALS AND METHODS

Data for this project were obtained through a telephone survey, as this was the most efficient means to locate households that own air cleaners. A sample of 12,008 telephone numbers was used to obtain interviews from 2,019 households throughout the state of California. The sample was generated using a procedure called list-assisted random-digit sampling. This method preserves the characteristics of a simple random sample, but takes advantage of the availability of large computer databases of telephone directory information to make the sample more efficient. It allows us to reduce the number of unproductive calls to non-working telephone numbers and to obtain a higher proportion of households in our sample than would be achieved by simple random-digit dialing.

2.1. Target Population and Eligibility

Adult residents, 18 years of age or older, who speak English and lived in a household served by a fixed-line telephone, were eligible for inclusion in the study. Only those respondents who reported their household owned a portable air cleaner answered the complete survey. Those who reported that they did not own an electronic air cleaner as well as those that reported the household owned only a car air cleaner or a personal air cleaner were excluded from the full battery of questions.

2.2. General Design of the Sample

The sample for this research study was a cross-sectional, list-assisted Random Digit Dialing (RDD) sample covering residential telephone exchanges in the state of California. In each selected household, one adult, aged 18 or older, was asked to answer the survey questions for the entire household.

2.3. Constructing the Sampling Frames

All possible telephone numbers in the state of California were divided into two strata: 1) telephone numbers from series of 100 numbers with zero or one residential listing in the telephone directories, and 2) telephone numbers from series with at least two such listings. These series of 100 numbers are referred to as banks of numbers. The banks come from telephone exchanges where it has been verified that there are at least two residential numbers listed within the batch. The sample of telephone numbers used for this project was randomly selected from the stratum containing the series of telephone numbers with at least two residential listings. This method of random generation allowed us to select unlisted telephone numbers into the sample. The stratum containing series of

telephone numbers with zero or one residential listing is unlikely to contain many residential numbers, and therefore is excluded from the final sampling frame (Casady, and Lepkowski, 1993).

After the initial sample of telephone numbers is generated by Marketing Systems Group (MSG), the sample vendor from whom the sample was purchased, three further steps (the MSG GENESYS Idplus process) are applied, in order to eliminate some of the non-residential numbers.

- **The Pre-Dialer Phase:** the file of generated numbers is matched against a database comprised of the GENESYS-Plus business database and the listed household database. Business numbers are eliminated, and listed household numbers are set aside, to be recombined after the Dialer Phase.
- **The Dialer Phase:** the remaining telephone numbers are then processed using automated dialing equipment. In this phase, the dialing, during the restricted hours of 9 a.m. - 5 p.m. local time, is 100% performed by staff members rather than by an automated process and the telephone is allowed to ring up to two times. Specially trained agents are available to speak to anyone who might answer the telephone and the disposition call result outcome of each number called is identified and recorded. Given this human intervention in evaluating all call results, virtually all remaining business and non-working intercepts can be identified. This provides the opportunity to identify many more business connects, fax and modem connections, and it compensates for differences in non-working intercept behavior.
- **The Post Dialer Phase:** the sample is then reconstructed, excluding the nonproductive numbers identified in the previous two phases. The sample is also divided at random into replicates. Replicates are small random samples within the larger randomly selected sample. Replicates are useful in efficiently managing the survey sample once production interviewing begins.

The results of this process of random telephone numbers selection is a sample of telephone numbers for the interviewing staff to call that contains far fewer telephone numbers that are not going to produce an interview (non-working numbers, businesses and other non-residential numbers). This method is efficient in reducing both interviewer and telephone calling costs.

2.4. Questionnaire Design and the Project Objectives

Survey questions were chosen to address the project objectives: 1) to determine the prevalence of ownership of ozone-generating air cleaners in California homes; 2) to determine the reasons for ownership of ozone-generating air cleaners; 3) to determine the frequency and duration of their use; and 4) to obtain other information needed to assess the potential impact of these appliances on public health.

The primary set of questions asked whether or not each household owns an indoor air cleaner, and if so the brand and model of air cleaner. The primary set of questions served to classify each interviewed household into one of three possible categories: 1) households that own ozone-generating air cleaners; 2) households that own air cleaners that are not ozone-generating; and 3) households that do not own an air cleaner of any type. Additional questions were asked to determine the year they were purchased, the reasons for their purchase and use, the frequency of their use, as well as other questions about the owner's knowledge of the function, cautions, and other factors related to the use of the machine.

2.5. Outcome of the Sample of Telephone Numbers

Table 1 shows the various outcomes for the total telephone numbers in the sample. Of the 12,008 telephone numbers called, 2,625 were verified as non-residential telephone numbers. Of the remaining 9,383 telephone numbers, 2,019 were confirmed to be households and completed the interview. From these confirmed households that granted an interview, 290 respondents (14.4%) reported ownership of any type of air cleaner.

The final response rate of 21.5% is lower than desired. However, telephone survey response rates in general have been dropping to such levels in recent years. Furthermore, the reduced budget for this survey called for a maximum of six calls to be made to a single telephone number. Had more calls been made, more numbers would have been identified as non-eligibles, thus increasing the response rate calculation.

Some characteristics of the households in this survey are somewhat different from the California population. For example, the percentage of respondents identifying themselves as black or Hispanic/Latino was 28.0%, compared to the corresponding figure of 41.9% for Californians in 2005 (US Census Bureau, American Community Survey, 2005). Additionally, the income distribution was slightly higher for respondents to the survey than in the general population. About 37.5% of households in this survey have annual family incomes greater than \$75,000 (see Table

19 on page 31), whereas the corresponding percentage in the 2005 California population was 30.5%.

Table 1: Outcome of the Sample of Telephone Numbers	Number	Percent of Total	Percent of Eligibles	Percent of Completes
Total telephone numbers	12,008	100.0		
Ineligible				
Computer/FAX	1,087	9.1		
Business	628	5.2		
Not in service, non-working	604	5.0		
Not English speaking	267	2.2		
Group quarter, institution, vacation home, cell phone etc.	39	0.3		
Total Ineligible	2,625	21.9		
Eligible Households	9,383	78.1	100.0	
Non-response				
Unresolved (reached call limit, end of study) *	4,284	35.7	45.7	
Refusals	3,008	25.0	32.0	
Unable to participate due to illness/disability	39	0.3	0.4	
Respondent never available	33	0.3	0.4	
Total Non-Response	7,364	61.3	78.5	
Completed Telephone Interview				
With electronic air cleaner (excluding those with personal or car cleaners only)	284	2.4	3.0	14.1
Without electronic air cleaner	1,735	14.4	18.5	85.9
Total Completes	2,019	16.8	21.5	100.0

* Some of the unresolved cases would have been classified as ineligible, if there had been sufficient resources to keep calling. The true response rate, consequently, is higher than reported here.

2.6. Quality Assurance & Quality Control Procedures

2.6.1. Testing the Questionnaire

The questionnaire content and the concepts that underlie that content were tested with a small convenience sample of six telephone interviews of California households that were known to own an air cleaner. The Survey Research Center (SRC) provided five of the six households to be interviewed for the pre-test, and the California Air Resources Board provided the sixth. The questionnaire data were helpful in evaluating the effectiveness, clarity, and salience of the survey questions as well as obtaining insights into the knowledge and perceptions that these respondents had about air cleaners and their knowledge of ozone. Modifications to the data collection questionnaire were made based on this effort. These procedures allowed us to conduct a miniature version of the proposed data collection process in a significantly shortened period of time.

2.6.2. Data Management & Cleaning

All data were collected via Computer Assisted Telephone Interviewing (CATI). This technology, in which the interviewer sits at a computer workstation with a telephone and headset, allows the interviewers to ask questions that are stored in the computer memory and recalled in programmed sequences, and displayed for each interviewer on a computer terminal.

The Computer Assisted Survey Execution Systems (CASES) package is a CATI software program that allows interviewers to enter directly the responses to the survey questions into computer files. Since the responses entered are almost all pre-coded responses with numerical values that represent each answer (for example, 1 represents Yes and 5 indicates No), the “data entry” of such closed-ended variables is automatic. In addition, all open-ended question responses are entered verbatim by the interviewer and stored automatically in electronic files.

All data that were entered and coded were carefully checked to ensure that only valid codes were included in the data set and that all logical checks were enforced.

Additionally, supervisory staff at the Survey Research Center (SRC) reviewed all “other specify” response categories as well as any questions that were not pre-coded. When responses to these questions yielded multiple answers that were similar, additional numeric codes were built to correspond appropriately to those responses. When a respondent gave an answer as an “other” response, which clearly corresponded to a pre-

existing code category for a question, the response was “up-coded” to the appropriate pre-existing code. All coded responses, original verbatim, and “other specify” responses, were provided to the client in an electronic file.

Some of the advantages of the CATI system compared to ordinary telephone interviewing allow for quality assurance and quality control automatically, such as:

- Skipping to certain questions based on the answers to previous questions. This is handled by the computer, thus eliminating a major source of interviewer error in complex paper and pencil questionnaires.
- Interview questions can be modified automatically to insert information already obtained such as names, or to phrase questions appropriate to personal characteristics such as sex or marital status, or, in the case of this study, air cleaner ownership.
- Programming the questionnaire in such a way that only valid response codes are accepted. Discrepancies between the responses of more than one question can be identified, so that clarifications can be obtained while the respondent is still on the telephone.

Additionally, CASES software was programmed to ensure that all sample points were called uniformly and appropriately to ensure that appointments were kept and that unresolved cases received calls during a weekday evening, weekend, and weekday times.

2.6.3. Training of Interviewers

All interviewers received training prior to the start of this project on both general and neutral interviewing techniques, as well as the intent of specific study questions. With this training, interviewers would immediately recognize whether or not a valid response was given and be able to probe appropriately and neutrally for a response.

In an effort to obtain as high a response rate as possible, all interviewers received substantial training to help avoid initial refusals as well as to convert previous refusals. Once a case was coded as a refusal, it was returned to the field approximately one week later, for another attempt at completing the survey. Refusal conversion specialists were assigned the cases for these additional attempts.

2.6.4. Monitoring of Telephone Interviewers

Supervisory staff carefully monitored the performance of all interviewers every week. Immediate feedback was given to each interviewer regarding appropriate reading of the questions and answer choices, and for correct and neutral probing of ambiguous responses. Approximately 10% of experienced interviewers' telephone surveys were monitored each week, and the less experienced interviewers had approximately 15-20% of their surveys monitored.

When an interviewer's work is "monitored" a supervisor remotely observes the interviewer's computer screen and listens, in real time, to both sides of the interview conversation (interviewer and respondent) without either party being aware of the third party. For all surveys conducted by CATI at SRC, as a measure of full disclosure, the interviewer reads a statement to the respondent that "the interview may be monitored for quality control purposes".

3. RESULTS

3.1. Determine the Prevalence of Ownership of Ozone-Generating Air Cleaners in California Homes

- **Ownership of Air Cleaners**

About one in seven households, or 14% (N=284), reported ownership of a portable indoor air cleaner, as shown in **Table 2**. Of the original 290 respondents who answered affirmatively to the air cleaner ownership question, six (6) respondents reported their household owned **only** a car or personal air cleaner. Since one of the goals of this study was to determine the prevalence of larger portable air cleaners, those six cases were neither administered the full battery of questions in the telephone interview, nor were they included in the analysis of households with air cleaners.

Table 2: Prevalence of Portable Air Cleaner Ownership				
(Among All California Households)				
	Estimated Percentage	Standard Error*	95% Confidence Interval**	
			Lower	Upper
Total with Air Cleaner	14.07	0.77	12.55	15.58
No Air Cleaner	85.93	0.77	84.42	87.45
Total %	100.00			
Total N in Sample	2,019			

Standard error of a binomial for a simple random sample = square root((Percent)(100-Percent) / (n-1))

**Confidence interval = Percent +/- 1.96 * (Standard Error)

As seen in **Table 2**, 14.07 percent of the households where a telephone interview was conducted owned a portable room air cleaner (284 out of the 2,019 households). In order to extrapolate this result to the State as a whole, note the estimated standard error and 95% confidence interval for that figure. Taking into account that there was a sample of only 2,019 households, there is 95% confidence that the true proportion in the State

is between 12.55% and 15.58%. This confidence interval only takes into account sampling error. It is possible that other errors and biases, due for example to non-response, also affected our estimates, but there is no way of measuring those possible errors directly.

- ***Type of Air Cleaners Owned***

Table 3 provides basic information about patterns of air cleaner ownership in California households. Note in this table that if a household owns more than one type of air cleaner, it is categorized by the air cleaner that is higher on this list. For example, if one air cleaner in the household generates ozone by design, and the other air cleaner is a non-ozone-generating filter, the household is coded as having an air cleaner that generates ozone by design. Air cleaners that produce ozone as a by-product include those machines that are electrostatic precipitators (ESPs) and ionizers.

As seen in the previous table that 14.07% of households had a portable room air cleaner. **Table 3** breaks that figure into four categories. There were 2.28% of households own an air cleaner that could be classified as emitting ozone by design. Another 7.83% of households own an air cleaner that generates ozone as a by-product. Another 2.53% of households own only a non-ozone-generating filter device such as a pleated filter, a HEPA filter, and/or an activated carbon filter. (Those air cleaners that have a filter but also produce ozone as a by-product are included in the “Ozone by-product” category.) Finally 1.44% of the households owned a portable air cleaner but were unable to provide sufficient information for us to classify their devices into one of the categories indicated below. As in the previous table, the standard error and 95% confidence interval for each estimate is provided.

Table 3: Type of Air Cleaners Owned (Percent of All California Households)				
	Estimated Percentage	Standard Error*	95% Confidence Interval**	
Type of Air Cleaner			Lower	Upper
Emits Ozone by Design	2.28	0.33	1.63	2.93
By-Product	7.83	0.60	6.65	9.00
Non-ozone Filter	2.53	0.35	1.84	3.21
Unclassifiable Air Cleaner	1.44	0.26	0.92	1.96
Total with Air Cleaner	14.07	0.77	12.55	15.58
No Air Cleaner	85.93	0.77	84.42	87.45
Total %	100.00			
Total N in Sample	2,019			

Standard error of a binomial for a simple random sample = square root ((Percent)(100-Percent) / (n-1))

**Confidence interval = Percent +/- 1.96 * (Standard Error)

The results indicate that 2.28% of California households own an air cleaner that intentionally produces ozone. While this initially appears to be a small percentage, in reality it equates to a substantial number of households and people affected. Using California Department of Finance (2006) updated estimates of 36,307,217 persons residing in 12,367,468 households (2.936 persons per household) in the State as of January 1, 2006, it is estimated that at least 282,000 California households own an ozone generator. This means that at least 828,000 Californians are potentially exposed to substantially elevated—and harmful—levels of ozone in their home. This is an underestimate of those affected by air cleaners, for a couple of reasons. First, some of the by-product devices can produce unhealthy levels as well. Second, households with higher family incomes are more likely to own ozone-generating air cleaners (whether by design or as a by-product), but households with the highest family incomes were slightly under-represented in this survey sample.

- **Number of Air Cleaners Owned**

As shown in **Table 4**, about 31% of households with air cleaners own more than one device. Although 68% own only one air cleaner, 19% own two, and the other 12% own three or more. For households that have an air cleaner that generates ozone by design, 28% have more than one. About 60% of households that own an air cleaner that may emit ozone as a by-product own one such air cleaning device, and 40% own more than one. Although there may be some apparent differences between owners of air cleaners that emit ozone by design and those that own ones that may emit ozone as a by-product, caution should be used in comparing these results due to the small number of owners of purposeful ozone generators interviewed.

Number of Air Cleaners Owned	Any Air Cleaners	Air Cleaners that Emit Ozone by Design	Air Cleaners that May Emit Ozone as a By-Product
One	68%	72%	60%
Two	19%	17%	22%
Three	8%	7%	13%
More than three	4%	4%	5%
<i>(Owns Two or More)</i>	<i>(31%)</i>	<i>(28%)</i>	<i>(40%)</i>
Total %	100%	100%	100%
Total N in group	284	46	158

*Percentages may not add to 100% due to rounding

** NOTE: Tables 4 through 27 contain percentages rounded to the nearest whole percentage for ease of reading.

- **Air Cleaners with Special Features**

Because added features on a given air cleaner may increase the production of ozone emissions, several questions were asked about the special features that reported air cleaners may or may not have. Respondents were asked what special features, if any, their first, and if applicable, their second air cleaner might or might not have. About one in three households reported that their air cleaner had at least one special feature (36% of respondents with one air cleaner and 30% of respondents who own two air cleaners).

Examining the data for both the first and second ozone-generating air cleaners shows that the special feature of an “ozone boost” is the most common special feature reported (58% and 56% respectively for air cleaner owners). Because air cleaners can have more than one special feature, multiple responses can be made for a single air cleaner. The table below, **Table 5**, summarizes the proportion of households who answered affirmatively to each unique feature for either their first or second air cleaner that emits ozone. This table is for purposeful ozone-generating air cleaners and by-product air cleaners only.

	Air Cleaner 1	Air Cleaner 2
Ozone Boost	58%	56%
Ozone filter	38%	36%
UV Light	35%	35%
Power or Fan Boost	29%	32%
Germicidal Button	23%	16%
Other Feature	18%	12%
Total N in Group	80	25

* Due to multiple mentions, percentages add to more than 100%.

▪ **Rooms Where Air Cleaners Are Used**

Several questions were asked to determine in which rooms an air cleaner was most often used for both the first and second air cleaners. As shown in **Table 6**, the master bedroom is the room where the air cleaner is most often used (40% for air cleaner 1, and 36% for air cleaner 2). These figures are for any type of air cleaner. Because the data for air cleaners is very similar for air cleaner 1 and air cleaner 2, when air cleaners that emit ozone are discussed, either by design or may emit ozone as a by-product, this analysis will examine only air cleaner 1; however, the columns are divided to show the distribution of the different types of (possible) ozone-generating air cleaners.

Almost three in ten (28%) of households that own an air cleaner that emits ozone by design, use it most often in the living room, and about 20% use it most often in the master bedroom. For air cleaners that may emit ozone as a by-product, 43% of households use it most often in the bedroom and 28% use it most often in the living room. Although there may be some apparent differences between owners of air cleaners that emit ozone by design and those that own ones that may emit ozone as a by-product, caution should be used in comparing these results due to the small number of ozone by design owners interviewed.

	Air Cleaner 1 Any Type	Air Cleaner 2 Any Type	Air Cleaner 1 Emits Ozone By Design	Air Cleaner 1 May Emit Ozone as By- Product
Master Bedroom	40%	36%	20%	43%
Living Room	27%	11%	28%	28%
Someplace Else	11%	12%	20%	10%
Children's Room	9%	14%	4%	8%
Family Room	6%	10%	11%	6%
Office	4%	4%	7%	3%
Kitchen	2%	7%	11%	1%
Bathroom	1%	6%	0%	2%
Total %	100%	100%	100%	100%
Total N in Group	284	90	46	158

**Percentages do not add to 100% due to rounding*

Those who stated that their secondary air cleaner was used most often in the master bedroom generally said (56%) that the primary air cleaner was used most often in the living room. However, 12% also said that the primary air cleaner was (also) used primarily in the master bedroom. No not attempt was made to clarify the reported usage, but it appears that more than one air cleaner is sometimes used in a room.

- ***Year Purchased Air Cleaner***

A majority of air cleaners, 65%, for the first air cleaner (any type) and 70% for the second air cleaner (any type), were purchased from 2003 to the present, as shown in **Table 7**. The proportion of ozone-generating air cleaners purchased from 2003 to the present is a little higher, 67% for the air cleaners that emit ozone by design and 71% for the air cleaners that may emit ozone as a by-product. Although there may be some apparent differences between owners of air cleaners that emit ozone by design and those that own ones that may emit ozone as a by-product, caution should be used in comparing these results due to the small number of ozone by design owners interviewed.

Note: For the following tables (Tables 7 et seq.) the N may change slightly because not everyone answered every question.

	Air Cleaner 1 (Any Type)	Air Cleaner 2 (Any Type)	Air Cleaner 1 Emits Ozone by Design	Air Cleaner 2 May Emit Ozone as a By-Product
1990 or earlier	3%	1%	0%	1%
1991 - 1995	3%	3%	0%	1%
1996 - 2000	12%	11%	11%	11%
2001 or 2002	17%	14%	22%	16%
2003 or 2004	39%	39%	51%	39%
2005 – June 2006	26%	31%	16%	32%
Total %	100%	100%	100%	100%
Total N in group	279	90	45	154

* Percentages do not add to 100% due to rounding

▪ **Cost of Air Cleaner**

Most owners of air cleaners spent \$200 or less for their machine (53% for air cleaner 1 [any type], and 63% for air cleaner 2 [any type]), as shown in **Table 8**. However, the majority of owners of ozone-generating devices paid more than \$200 for their machine. Most importantly, owners of purposeful ozone generators paid more by far for their machines than did owners of other types of air cleaners. About 73% of households that own air cleaners that emit ozone by design paid more than \$200 for their device; in fact, 51% of owners of purposeful ozone generators spent more than \$400 for their air cleaner, compared to just 19% for owners of all types of air cleaners. Additionally, 35% of households that own ozone-generating air cleaners by design, but only 4% of households that own air cleaners that may emit ozone as a by-product and 10% of households overall, spent more than \$600 for their units. Although there appear to be significant differences between the costs paid by owners of ozone generators and owners of by-product devices, caution should be used in comparing these results due to the small number of ozone generators interviewed.

Table 8: Cost of Air Cleaners, by Type				
	Air Cleaner 1 (Any Type)	Air Cleaner 2 (Any Type)	Air Cleaner 1 Emits Ozone by Design	Air Cleaner 1 May Emit Ozone as a By-Product
Less than \$100	26%	28%	14%	23%
\$100-\$200	27%	35%	14%	23%
\$201-\$400	28%	25%	22%	38%
\$401-\$600	9%	8%	16%	11%
Or over \$600	10%	5%	35%	4%
Total %	100%	100%	100%	100%
Total N in group	246	80	37	138

* Does not add to 100% due to rounding

▪ **Where Air Cleaners are Purchased**

Table 9 shows the distribution of where air cleaner owners purchased their device(s). The majority of air cleaners (any type) are purchased at a retail store, 59% and 64% for the primary and secondary air cleaners respectively. The distribution for air cleaners that generate ozone by design is much more wide spread with regard to place of purchase: 24% report purchasing their unit at a retail store, 26% from an independent distributor, 19% from the Internet, and 29% from “somewhere else”. This 29% represents 12 cases (households). The most common response for these 12 cases is “over the phone”. The majority of owners of air cleaners that may emit ozone as a by-product purchase their units at a retail store (63%). Although there may be some apparent differences between owners of air cleaners that emit ozone by design and those that own devices that may emit ozone as a by-product, caution should be used in comparing these results due to the small number of ozone by design owners interviewed.

Table 9: Where Air Cleaners are Purchased, by Type				
	Air Cleaner 1 (Any Type)	Air Cleaner 2 (Any Type)	Air Cleaner 1 Emits Ozone by Design	Air Cleaner 1 May Emit Ozone as a By-Product
Retail store	59%	64%	24%	63%
From a catalog	7%	8%	2%	10%
Independent distributor	9%	5%	26%	6%
Internet	14%	18%	19%	15%
Somewhere else	11%	6%	29%	6%
Total %	100%	100%	100%	100%
Total N in group	259	85	42	145

* Percentages do not add to 100% due to rounding

3.2. Determine Reasons for Ownership of Ozone-Generating Air Cleaners

- **Reasons Air Cleaners are Purchased**

Several questions were asked to ascertain the reasons an air cleaner was purchased. When the reasons for purchase of any air cleaner are examined, whether or not it emits ozone, the three most mentioned reasons were as follows: 1) someone in the home had allergies or asthma, 2) they wanted to remove dust; and 3) there was a concern over indoor air quality (IAQ). About half of the households indicated that the presence of someone in the household with allergies or asthma was a reason for purchase (50% of those answering about the first air cleaner and 47% of those answering about the second one. Around one in three indicated that a reason for purchase was to remove dust (36% for cleaner one and 32% for cleaner two. Nearly identical proportions indicated they made the purchase to improve indoor air quality (36% and 33% respectively).

The distribution is similar regarding the reasons respondents purchased an air cleaner that emits ozone, either intentionally or as a by-product. Among households that own ozone-generating air cleaners, the three leading reasons for purchase are the same as found among all owners,

namely, a concern about allergies and asthma, the removal of dust, and concern about indoor air quality. Respondents purchased an air cleaner that produces ozone because: 1) someone in the home had allergies or asthma (50%) for air cleaners one and two); 2) they wanted to remove dust (41% and 34% for air cleaners one and two); and 3) there was a concern over indoor air quality (37% and 32% for each air cleaner one and two). See **Table 10** for the distribution of all reasons queried. The most common “other reason” was to remove odor.

Because respondents often had more than one reason for their choice of a particular air cleaner, multiple responses were allowed within the questionnaire. **Table 10** summarizes the proportion of respondents who answered affirmatively to each unique reason for purchasing an air cleaner either one that produces ozone or one that does not.

	Air Cleaner 1 Any Type	Air Cleaner 2 Any Type	Air Cleaner 1 Emits Ozone	Air Cleaner 2 Emits Ozone
Allergies/ Asthma	50%	47%	50%	50%
Remove Dust	36%	32%	41%	34%
Concern Over Indoor Air Quality (IAQ)	36%	33%	37%	32%
Remove Pet Dander	17%	21%	19%	24%
Remove Mold/Bacteria	13%	17%	15%	17%
Control Tobacco Smoke	10%	7%	8%	4%
Chemical Contaminants	10%	13%	11%	14%
Protect Infants/Children	7%	5%	7%	5%
Received as a Gift	6%	4%	6%	4%
Other Health Condition	6%	4%	5%	5%
Other Reason	6%	8%	6%	12%
Total N in Group	283	91	203	76

* Due to multiple mentions, percentages add to more than 100%.

▪ **Reasons for Model Selection**

After respondents were queried on the reasons for their decision to purchase an air cleaner, several questions were asked to ascertain the reasons they chose to select a specific model. Data for model selection for any air cleaner, whether or not it emits ozone, show that the most reported reasons were: 1) respondents saw the model in a store (30% for air cleaner one, and 23% for air cleaner two); 2) they were referred by a friend or relative (17% and 21% for air cleaners one and two respectively);

3) they saw or heard an advertisement on TV or the radio (16% and 15% for each air cleaner one and two); and 4) cost (16% and 15% for air cleaners one and two). Many respondents indicated that they made their model choice for some “other” reason than those asked in the interview (21% for air cleaner 1 and 24% for air cleaner 2).

The distribution is similar regarding the reasons respondents selected a specific model of air cleaner that emits ozone, either intentionally or as a by-product. Data for model selection of an air cleaner that emits ozone show that the most reported reasons were: 1) respondents saw the model in a store (28% for air cleaner one, and 19% for air cleaner two); 2) they were referred by a friend or relative (19% for both air cleaner one and two); 3) they saw or heard an advertisement on TV or the radio (20% and 16% for air cleaners one and two respectively); and cost (16% and 18% for air cleaners one and two). A large proportion of these owners also indicated that they made their model choice for some “other” reason than those asked in the interview (19% for air cleaner one, and 23% for air cleaner two). The three most common “other reasons” regardless of type of air cleaner, were: 1) the household did not select the model as it was a gift; 2) the household did a lot of personal research on the internet; and 3) the household liked the specific features that a particular unit came with. For a summary list of air cleaner brands that survey households own, see Appendix B.

For a distribution of all reasons that an air cleaner model, whether ozone-generating or not, was selected, see **Table 11**. Once again, because multiple responses are allowed, the total proportion of all unique reasons for model selection is more than 100%.

	Air Cleaner 1 Any Type	Air Cleaner 2 Any Type	Air Cleaner 1 Emits Ozone	Air Cleaner 2 Emits Ozone
Saw a Model in the Store	30%	23%	28%	19%
Other Reason	21%	24%	19%	23%
Recommendation from Friend/Relative	17%	21%	19%	19%
Advertisement on TV/Radio	16%	15%	20%	16%
Cost	16%	15%	16%	18%
Advertisement in Newspaper or Magazine	11%	10%	13%	12%
Low Noise	9%	3%	9%	4%
Advertisement on the Internet	7%	6%	7%	7%
Saw a Demonstration	6%	3%	7%	4%
Article in Consumer Reports	5%	1%	5%	1%
Recommendation by Doctor or Dentist	4%	2%	2%	1%
Door to Door Flyers	1%	0%	0%	0%
Government Web Site	1%	1%	1%	1%
Total N in Group	266	87	192	73

* Due to multiple mentions, percentages add to more than 100%.

3.3. Determine the Frequency and Duration of Their Use.

Since the length of exposure to ozone emissions can have an impact on the health of those who own and use these air cleaners, several questions were asked about how often and how long the device was used, whether or not the device was used year-round or only during certain seasons, and whether or not the device was used every day, or less often. Additional questions were asked regarding the length of time of each use, whether it was used part of each day when used or used continuously.

- ***Seasonal Versus Year-round Use***

As shown in **Table 12**, most air cleaner owners use their devices year-round (77% for air cleaner 1 and 82% for air cleaner 2). The proportion of air cleaners that are used during certain seasons is 23% for air cleaner one and 18% for air cleaner two. The distribution for air cleaners that emit ozone is similar; 80% of both purposeful and by-product devices are used year-round.

Table 12: Year-Round or Seasonal Use, by Air Cleaner Type				
	Air Cleaner 1 Any Type	Air Cleaner 2 Any Type	Air Cleaner 1 Emits Ozone By Design	Air Cleaner 1 May Emit Ozone as By- Product
Use Year Round	77%	82%	80%	80%
Use in Certain Seasons	23%	18%	20%	20%
Total %	100%	100%	100%	100%
Total N in Group	282	91	46	158

- **Days Per Week Usage of All Air Cleaners**

Not only do owners of air cleaners typically use these devices year-round, but they also tend to use them every day. As shown in **Table 13**, about eight out of ten (78% for air cleaner 1 and 82% for air cleaner 2) are used every day. Considering only the ozone-generating air cleaners, 76% of air cleaners that emit ozone by design and 82% of air cleaners that may emit ozone as a by-product are used every day. Due to the small number of ozone by design owners interviewed, these differences may not be significant.

Table 13: Number of Days per Week for Usage of Air Cleaners, by Type				
	Air Cleaner 1 Any Type	Air Cleaner 2 Any Type	Air Cleaner 1 Emits Ozone By Design	Air Cleaner 1 May Emit Ozone as a By-Product
Less Than 1 Day per Week	4%	2%	4%	3%
1 to 2 Days per Week	6%	6%	9%	4%
3-4 Days per Week	8%	6%	7%	7%
5-6 Days per Week	4%	4%	4%	5%
Every Day	78%	82%	76%	82%
Total %	100%	100%	100%	100%
Total N in Group	278	89	46	155

- **Prevalence of Every Day and Continuous Use of Air Cleaners**

Furthermore, 57% of all primary air cleaners are used every day and continuously, and 61% of second air cleaners are used every day and continuously (see **Table 14**). Ozone-generating air cleaners are used even more, 72% of air cleaners that emit ozone by design, and 64% of air cleaners that may emit ozone as a by-product are used continuously every day. However, due to the small number of ozone by design owners interviewed, these differences must be interpreted with caution.

Table 14: Proportion of Households that Use Air Cleaners Every Day & Continuously				
	Air Cleaner 1 Any Type	Air Cleaner 2 Any Type	Air Cleaner 1 Emits Ozone By Design	Air Cleaner 1 Emits Ozone as a By-Product
Used Every Day and Continuously	57%	61%	72%	64%
Total N in Group	277	89	46	154

- **Maintenance of Air Cleaners: Cleaning of Plates**

Because there is evidence that ozone emissions may increase from electrostatic precipitators that are poorly maintained (Dorsey and Davidson, 1994), this research examined whether or not the household has an air cleaner that contains metal plates for particle collection that are supposed to be cleaned periodically, and, if so, how often these households clean these plates.

Table 15 shows that 60% of owners of any primary air cleaner have a unit that contains these metal plates. About 64% of second air cleaners contain these metal plates. The proportion of households that have air cleaners that contain these metal plates is highest among households that own air cleaners that emit ozone as a by-product (79%), although purposeful ozone generators tended to have these plates as well (73%)

Table 16 shows the distribution of how often the metal plates that collect particles are cleaned, by air cleaner type. The distribution is similar regardless of the type of air cleaner owned. Nearly one-half (46%)

indicate that they clean their plates quarterly or more often, but at least 12%, and possibly up to 54%, clean their plates less often than quarterly.

Table 15: Air Cleaner Has Plates for Particle Collection, by Type

Does Air Cleaner Have Plates for Particle Collection, that Need Cleaning?	Air Cleaner 1 Any Cleaner	Air Cleaner 2 Any Cleaner	Air Cleaner 1 Emits Ozone By Design	Air Cleaner 1 Emits Ozone as By-Product
Yes	60%	64%	73%	79%
No	40%	36%	27%	21%
Total %	100%	100%	100%	100%
Total N in Group	270	89	45	151

**Due to multiple mentions, percentages add to more than 100%*

Table 16: How Often Particle Collection Plates are Cleaned, by Type

	Air Cleaner 1 Any Cleaner	Air Cleaner 2 Any Cleaner	Air Cleaner 1 Emits Ozone By Design	Air Cleaner 1 Emits Ozone as By-Product
Monthly	34%	32%	34%	34%
Quarterly	12%	7%	12%	13%
Twice a Year	6%	7%	12%	5%
Once a Year	4%	4%	9%	3%
As Needed	21%	14%	19%	19%
Never	2%	2%	0%	2%
Other	21%	35%	12%	25%
	100%	100%	100%	100%
Total N in Group	161	57	32	119

**Due to multiple mentions, percentages add to more than 100%*

▪ **Present Use of Air Cleaners**

The purpose of the study was to examine the prevalence of households who currently own or have owned an air cleaner. **Table 17** shows that about 70% of air cleaner owners presently use their primary air cleaner, and 78% of owners of air cleaners that emit ozone by design or that may emit ozone as a by-product currently use their air cleaner. Thus, about one-quarter of air cleaner owners do not use their air cleaner, or use them infrequently.

Does Household presently use the air cleaner?	Air Cleaner 1 Any Cleaner	Air Cleaner 2 Any Cleaner	Air Cleaner 1 Emits Ozone By Design	Air Cleaner 1 Emits Ozone as By-Product
Yes	70%	78%	78%	78%
No	29%	21%	22%	22%
Total %	100%	100%	100%	100%
Total N in Group	284	91	46	158

**Due to multiple mentions, percentages add to more than 100%*

▪ **Reasons for Little or No Use**

Among households that own air cleaners, but no longer use them, or use them infrequently, the main reason for this non-use or limited use is that households no longer have need for it. About 58% for all primary air cleaners and 45% for second air cleaners report non-use or limited use. The distribution is similar for ozone-generating air cleaners. About 45% of owners of air cleaners that emit ozone by design and 51% of owners of air cleaners that may emit ozone as a by-product, report they no longer use the device because they no longer have need for the unit. Other major reasons for non-use are that they don't seem to work, or are too noisy.

Because respondents can report more than one reason they no longer and/or infrequently use their air cleaner, ozone-generating or not, multiple responses were allowed; therefore, more than 100% for each air cleaner is possible. See **Table 18**.

	Air Cleaner 1 Any Cleaner	Air Cleaner 2 Any Cleaner	Air Cleaner 1 Emits Ozone By Design	Air Cleaner 1 Emits Ozone as By-Product
No Longer Need It	58%	45%	45%	51%
Doesn't Seem to Work	20%	14%	18%	19%
Too Noisy	12%	23%	18%	11%
Expensive	6%	9%	18%	5%
Emits Odor	5%	18%	9%	5%
Made Household Members Not Feel Well	3%	0%	9%	3%
Total N in Group	88	22	11	37

**Due to multiple mentions, percentages add to more than 100%*

3.4. Obtain Other Information Needed to Assess the Potential Impact of These Appliances on Public Health

To assess the potential impact of these appliances on public health, several demographic factors were considered, such as the:

- Income of households that own an air cleaner either ozone-generating or not,
- Race and ethnicity of the person in the household who completed the telephone interview.
- Number of adults (18 and over) living in the household,
- Number of children (17 or younger) living in the household, and the

The following parameters were also examined:

- The belief by air cleaner owners of whether or not their device improved their indoor air quality
- Whether or not air cleaner owners recall seeing any warnings about ozone, and/or any usage limitations that may have been stated in the owner's manual that came with their air cleaning device
- Whether or not air cleaner owners are aware that their air cleaning device emits ozone, and whether or not
- Owners of ozone-generating air cleaners are aware that ozone is a pollutant

▪ ***Annual Income Distribution***

Table 19 shows the distribution of the owners of any type of air cleaner, including air cleaners that emit ozone, into each income group. Compared to all households interviewed for this study, fewer households with air cleaners are in the lowest annual income category with annual family incomes under \$35,000 annually (13%, compared to 29% overall). On the other hand, more households with air cleaners are in the upper three categories, with family incomes of \$75,000 or more (53%, compared to 37%).

Ownership of ozone-generating air cleaners was more prevalent in households with higher income. Among owners of air cleaners that generate ozone by design, 64% of households earn \$75,000 or more and 22% earn \$150,000 or more. The corresponding figures for owners of air cleaners that may generate ozone as a by-product are 51% and 18%.

Notice from the last column of the table that the income distribution of English-speaking households with telephones in the 2005 American Community Survey for California is very close to the income distribution for all households interviewed in our study. This gives us some additional

confidence that the income effects found in our data are genuine. Indeed, the correlation of higher income with air cleaner ownership is one of the strongest findings in our data.

	All Respondent Households	Households With Any Air Cleaner	With Air Cleaner that Emits Ozone by Design	With Air Cleaner that May Emit Ozone as a By-Product	California Population of English Speakers that own Telephones
Under \$35,000	29%	13%	8%	12%	30%
\$35,000-\$50,000	16%	16%	17%	17%	14%
\$50,000-\$75,000	18%	18%	11%	19%	19%
\$75,000-\$100,000	15%	18%	25%	14%	13%
\$100,000-\$150,000	12%	18%	17%	19%	13%
\$150,000 or more	10%	17%	22%	18%	11%
Total %	100%	100%	100%	100%	100%
Total N in group	1,534	223	36	126	10,484,933

▪ **Ethnicity / Race**

Although this survey represents the behavior of households, the question on the survey that asked about ethnicity was asked of the person who completed the telephone survey. **Table 20** shows the ethnicity of all respondents who completed the interview, the ethnicity of respondents who own any type of air cleaner, and the ethnicity of respondents who live in households with air cleaners that emit ozone, either by design, or those that may emit ozone as a by-product. While 59% of all respondents who completed the interview consider themselves to be white or Caucasian and 52% of Californians who speak English and own a telephone identify as white or Caucasian, 74% of all air cleaner owners consider themselves to be white or Caucasian. The reverse is true for Latinos and for African Americans. Whereas those two groups comprise 28% of the survey respondents and 35% of Californians that speak English and own a telephone, they comprise only 10% of air cleaner owners. See **Table 20**.

Table 20: Ethnicity, by Air Cleaner Type					
Ethnicity of Respondent	All Respondent Households	Households with Any Air Cleaner	With Air Cleaner that Emits Ozone by Design	With Air Cleaner that May Emit Ozone as a By-Product	California Population of English Speakers that own Telephones *
White	59%	74%	74%	74%	52%
Black	6%	2%	0%	2%	8%
Latino	22%	8%	9%	8%	27%
Asian/Filipino/ Pacific Islander	6%	7%	7%	8%	11%
Other, Mixed	7%	9%	9%	8%	2%
Total %	100%	100%	100%	100%	100%
Total N in Group	1870	266	43	152	28,763,669

*Data comes from the 2000 Census

- **Joint Effect of Race and Income on Air Cleaner Ownership**

In trying to understand the factors that contribute to ownership of portable air cleaners, the full range of variables available from the survey were examined. The effect of income – higher income households are more likely to own air cleaners than lower income households – was discussed above, but there is also an interesting effect of the ethnicity of the household members (or, more accurately, the ethnicity of the person responding to the survey).

There were too few members of the various ethnic groups to analyze air cleaner ownership for each group separately. However, it is clear that air cleaner ownership is substantially lower for blacks and Latinos than for whites and others. Compared to the overall ownership rate of 14%, the ownership rate for blacks and Latinos is only 5%, whereas the rate is 18% for the combination of whites, Asians, mixed, and all other ethnic groups.

Since household income for blacks and Latinos is lower than for the average California household, further analysis was conducted to see if the income difference could account for the observed ethnic difference. A summary of that analysis is shown in **Table 21**. What was found was that both household income and ethnicity are significant predictors of air cleaner ownership. Within each (combined) ethnic group, higher income households are more likely to own air cleaners than lower income households, but the difference between blacks and Latinos versus all others persists within each level of household income. Income and ethnicity overlap somewhat in their effect on air cleaner ownership, but most of the effect of ethnicity is independent of the effect of income.

In trying to explain further the effects of ethnicity, family size (number of adults and children in the households) was also examined. As shown in Tables 22 and 23, these variables do not seem to be related to air cleaner ownership.

Table 21: Effect of Race and Income on Air Cleaner Ownership						
<i>Income Group</i>	Black or Latino Respondents N	% of These Households with an Air Cleaner	White and Other Respondents N	% of These Households with an Air Cleaner	Total for Both Groups N	% of These Households with an Air Cleaner
<i>Under \$35,000</i>	212	1%	218	11%	430	7%
<i>\$35,000 - \$50,000</i>	89	4%	147	20%	236	14%
<i>\$50,000 - \$75,000</i>	57	11%	207	16%	264	15%
<i>\$75,000-\$100,000</i>	47	6%	179	21%	226	18%
<i>\$100,000-\$150,000</i>	27	19%	160	21%	187	21%
<i>\$150,000 or more</i>	7	14%	138	24%	145	23%
Total	439	5%	1,049	18%	1,488	14%

- **Number of Adults in Household**

Most households (58%) that own an indoor air cleaner, either ozone-generating or not, are composed of two adults. **Table 22** shows the distribution of adults living in households that have an air cleaner (any type or ozone-generating).

- **Number of Children in Household**

Table 23 shows that about one-third of households (37%) with any type of air cleaner have children. About 45% of households with air cleaners that emit ozone by design have children, and 30% of households with air cleaners that may emit ozone as a by-product have children. This is

similar to both the proportion of all households interviewed who have children (41%) as well as the population of Californians who speak English and own a telephone (38%). Caution should be used in comparing these results due to the small number of ozone by design owners interviewed.

Number of Adults Living in Household	All Households	With Any Air Cleaner	With Air Cleaner that Emits Ozone
1 Adult	24%	20%	23%
2 Adults	53%	58%	58%
3 Adults	13%	14%	13%
4 Adults	6%	6%	5%
5 Adults	2%	1%	1%
6+ Adults	1%	0%	0%
Total %	100%	100%	100%
Total N in Group	2019	284	204

* Percentages do not add to 100% due to rounding

Number of Children in Household	All Households	With Any Air Cleaner	With Air Cleaner that Emits Ozone by Design	With Air Cleaner that May Emit Ozone as a By-Product	California Population of English Speakers that own Telephones*
0 Children	59%	62%	54%	70%	62%
1 Child	18%	18%	24%	12%	15%
2 Children	14%	14%	15%	14%	14%
3 Children	6%	5%	4%	4%	6%
4 Children	2%	0%	0%	0%	2%
5+ Children	1%	0%	2%	0%	1%
Total %	100%	100%	100%	100%	100%
Total N in group	2,019	284	46	161	10,259,256

* Note: Data comes from the 2000 Census

- **Knowledge that Household Ozone-Generating Air Cleaners Emit Ozone**

Most owners of air cleaners that emit ozone by design know that their cleaner emits ozone (73%), whereas only 21% of owners of air cleaners that may emit ozone as a by-product have such knowledge. Although there may be some apparent differences between owners of air cleaners that emit ozone by design and those that own ones that may emit ozone as a by-product, caution should be used in comparing these results due to the small number of ozone by design owners interviewed. See **Table 24**.

Table 24: Knowledge that Ozone-Generating Air Cleaners Emit Ozone		
Know that Air Cleaner Emits Ozone?	Air Cleaner Emits Ozone by Design	Air Cleaner May Emit Ozone as a By-Product
Yes	73%	21%
No	27%	79%
Total %	100%	100%
Total in Group	33	107

- **Perception of Indoor Air Quality with Use of Air Cleaner**

Households were asked if they believed their indoor air quality improved, worsened, or stayed about the same since they began using their air cleaner. For the primary air cleaner, regardless of type, most households report their perception of improved indoor air quality since they began using their air cleaner. 71% and 83% of owners of primary and secondary air cleaners of any type, report that their indoor air quality (IAQ) had improved. These percentages include all owners who reported that they own or have owned an air cleaner regardless of whether or not they were currently using their device. For those owners of ozone-generating air cleaners, 81% of owners of air cleaners that emit ozone by design and 71% of owners of air cleaners that may emit ozone as a by-product report improved indoor air quality. There were no reports that the air quality had worsened. Although there may be some apparent differences between owners of air cleaners that emit ozone by design and those that own ones that may emit ozone as a by-product, caution should be used in comparing these results due to the small number of ozone by design owners interviewed. See **Table 25**.

Table 25: Perception of Indoor Air Quality, by Air Cleaner Type				
	Air Cleaner 1 (Any Type)	Air Cleaner 2 (Any Type)	Air Cleaner 1 Emits Ozone by Design	Air Cleaner 1 May Emit Ozone as a By-Product
Improved Indoor Air Quality (IAQ)	71%	83%	81%	71%
IAQ stayed about the same	29%	17%	19%	29%
Total %	100%	100%	100%	100%
Total N in group	269	87	43	149

▪ ***Warnings in Manual Regarding Ozone***

Households were asked if the owner’s manual that came with their air cleaner stated any limitations about the use of the air cleaner, such as, not to run the air cleaner more than a specified time, not to run the air cleaner with children in the room, or any caution about ozone. About 46% of the owners with air cleaners that emit ozone by design recall no warnings or limitations in their owner’s manual, and 49% of owners of air cleaners that may emit ozone as a by-product recall no such warnings. These percentages may be even higher as there were an additional 10 owners of air cleaners that generate ozone by design, and an additional 51 owners of air cleaning devices that may emit ozone as a by-product, that were not asked if they recalled any warnings in their owner’s manual. They were not asked this question because they had previously reported that they had not received an owner’s manual, they had not read the owner’s manual, or that they had not recalled receiving an owner’s manual. Although there may be some apparent differences between owners of air cleaners that emit ozone by design and those that own ones that may emit ozone as a by-product, caution should be used in comparing these results due to the small number of ozone by design owners interviewed. See **Table 26**.

	Air Cleaner 1 Emits Ozone by Design	Air Cleaner 1 May Emit Ozone as a By-Product
Yes	40%	19%
No	46%	49%
Do Not Recall	14%	32%
Total %	100%	100%
Total N in group	35	98

Given that there were very few warnings and/or limitations recalled from the owner's manual, there are also very few responses to each of the possible warnings queried. The distribution of possible reasons recalled is outlined in **Table 27**. The most common "other warnings" recalled by households were instructions to wash the filters, but to be careful with the device around water. For example, some households reported a warning about not putting wet filters in the device, not having the power cord near water, and not to leave water in the machine. Although there may be some apparent differences between owners of air cleaners that emit ozone by design and those that own ones that may emit ozone as a by-product, caution should be used in comparing these results due to the small number of ozone by design owners interviewed.

Table 27: Types of Warnings Recalled from the Owner's Manual

Warnings Recalled from the Owner's Manual	Air Cleaner 1 Emits Ozone by Design	Air Cleaner 1 May Emit Ozone as a By-Product
Do Not Exceed Time Limit	21%	17%
Do Not Use in Bedroom or Near the Sedentary	33%	0%
Do Not Use When Children are Present	15%	11%
Do Not Use High Setting When People are in Room	42%	5%
Do Not Use Near Where People are Sitting	9%	16%
Caution about Ozone	31%	26%
Other	38%	53%
Total N in Group	13	19

* Due to multiple mentions, percentages add to more than 100%

- **Knowledge that Ozone is a Pollutant**

All respondents to the survey, whether they owned an air cleaner or not, were asked if they were aware that ozone is an air pollutant. Seven out of ten (70%) indicated they were aware that ozone is a pollutant to the air. A somewhat smaller proportion of air cleaner owners (61% for all air cleaners, and 59% for intentional ozone generators, and 63% of ozone by-product devices that may generate ozone as a by-product) said that ozone is a pollutant. Although there may be some apparent differences between owners of air cleaners that emit ozone by design and those that own ones that may emit ozone as a by-product, caution should be used in comparing these results due to the small number of ozone by design owners interviewed. See **Table 28**.

Table 28: Knowledge That Ozone is a Pollutant				
<i>Knowledge that Ozone is a Pollutant</i>	All Households	Any Air Cleaner	By Design	By-Product
Yes	70%	61%	59%	63%
No	30%	39%	41%	37%
Total %	100%	100%	100%	100%
Total N in Group	2,006	281	46	156

4. DISCUSSION

This research was conducted, in part, because there was very little information available about how many California households own and use indoor air cleaners that generate ozone. Although a solid body of research has established that ozone introduced into the indoor air of homes is potentially harmful to the health of its occupants, no research has been done to establish how common these products are among the population of this country, and, in particular among the California population.

To bridge this gap in information, a randomly selected, representative sample of California households was interviewed by telephone to determine the proportion of households that own these devices. Telephone surveys are a quick and relatively inexpensive means for the measurement of behaviors and attitudes.

About one in every seven California households, or about 14%, owns a portable indoor air cleaner. The prevalence of ownership of an air cleaner that either intentionally generates ozone or may generate ozone as a by-product is approximately 10%. Thus, the majority of the air cleaners found in California homes may generate some ozone, mostly as a by-product of the air cleaning process. About 2% of California households own an air cleaner that intentionally generates ozone by design, and about 8% of households own one that may emit ozone as a by-product.

Based on these results, it is estimated that about 282,000 households in California own an air cleaner that intentionally generates ozone and 828,000 individuals live in those households and thus may be exposed to unusually high ozone levels.

Owners of air cleaners tend to use these devices a great deal, and owners of ozone-generating air cleaners use them even more frequently than owners of other types. Most owners run them throughout the year, regardless of season, and run them on a more or less continuous basis.

So, while the overall statewide ownership prevalence is fairly low, the potential health impact may be significant for the residents who live in the homes where these devices are used. This is particularly true when you consider that the most commonly mentioned reason for the purchase of an air cleaner is the presence of someone in the household who has asthma or allergies. In addition, less than half of the owners of air cleaners that may generate ozone (either intentionally or as a by-product) are aware of any warnings about the use of their air cleaner. These percentages may be even higher as there were an additional 61 owners of ozone generating air cleaners either by design or possibly as a by-product that were not asked if they recalled any warnings in their owner's manual because of

a previous response that they had not received an owner's manual, they had not read the owners manual, or that they had not recalled receiving a manual.

There appears to be a correlation between higher household income levels and ownership of an air cleaner. This is particularly true among the Caucasian population of California. As their income increases, Caucasians are much more likely than African American and Hispanic households to own an air cleaner. In addition, it was found that both household income and ethnicity are significant predictors of air cleaner ownership. Higher income households are more likely to own air cleaners than lower income households, but the difference between blacks and Latinos versus all other ethnic groups persists within each level of household income.

A significant minority (37%) of households that own air cleaners have children present in the home. However, almost half (45%) of the households that own air cleaners that generate ozone intentionally have children present. Thus, the potential negative effects of the use of an ozone generator will impact many children.

There is a high level of awareness among Californians that ozone is an air pollutant. Those who own air cleaners that generate ozone intentionally or as a by-product also tend to be aware that ozone is a pollutant, yet, despite this awareness, these owners are heavy users of their air cleaners. This discrepancy may be due to the fact that many owners of by-product ozone-generating air cleaners (e.g. ionizers and electrostatic precipitators) are not aware that their own air cleaner may emit ozone, and they tend to believe that the air cleaner has improved the quality of the air inside the home.

More than 70% of households that own air cleaners believe that the quality of their indoor air has improved since the purchase and operation of the air cleaner, including 81% of owners of intentional ozone generators and 71% of owners of air cleaners that may generate ozone as a by-product. These percentages include all owners who reported that they own or have owned an air cleaner, regardless of whether or not they were currently using their device. This belief, coupled with the knowledge that ozone is a pollutant, combine to make for a difficult challenge, namely, how to inform owners (or potential owners) about the health risks of ozone-generating devices when they tend to believe the indoor air quality is improved with one of these devices? Many ozone generators often incorporate more than one air cleaning technology in the device and may have a particle filter, ionizer or electrostatic precipitator that reduces particle levels. Owners need to be informed that it is these technologies, not the ozone, which is cleaning their air.

5. SUMMARY AND CONCLUSIONS

This research project was designed to assess the prevalence and the scope of the impacts of air cleaners on the health of the California population. Of particular interest was the prevalence of air cleaners that purposely generate ozone. The project also was designed to measure the reasons for purchase of air cleaners, to determine the frequency and typical duration of usage, and to obtain other information that would help to assess the potential impact air cleaners have on public health.

To meet these project needs, a representative, random statewide telephone survey of 2,019 California adults was conducted by the Survey Research Center of the University of California, Berkeley. Respondents to the survey were called on a fixed-line telephone using a list-assisted random digit dialing sample of telephone numbers throughout California.

This study provides the California Air Resources Board much of the information it needs to assess the scope of the impacts of air cleaners on Californians' health and to guide future exposure and risk reduction approaches.

While ownership of indoor air cleaners is found in only one out of every seven (14%) California households, the vast majority who own these devices have one that may generate ozone intentionally or as a by-product. The total prevalence of such air cleaners in California homes is approximately 10%. Among households in California with an ozone-generating air cleaner, the majority own one that may emit ozone as a by-product of the particle removal process; air cleaners that may emit ozone as a by-product, such as ionizers or electrostatic precipitators, are much more prevalent than air cleaners that are specifically designed to generate ozone. About 2% of California households own an air cleaner that generates ozone by design, while the prevalence of by-product devices is approximately 8% among California households.

This study indicates that approximately 2% of all California households own an air cleaner that can produce harmful levels of ozone, which equates to about 282,000 households and 828,000 individuals potentially exposed to very high levels of ozone from their air cleaners. The potential health risks may be particularly high, since most owners, especially those with intentional ozone generators, run their equipment continuously throughout the day and throughout the year. This intensive usage pattern poses a serious potential health risk for such households.

Owners of air cleaners in California purchase these devices for many different reasons, but many do so out of a concern over health issues and the pollutants that might be in the air in their homes. The survey found that (50%) purchased their primary air cleaner because of a concern about allergies or asthma.

Related concerns with the presence of dust or airborne particles (36% for the primary air cleaner [any type], and 41% for the primary air cleaner that emits ozone either by design, or may emit ozone as a by product) and the quality of the air inside the home (36% for the primary air cleaner any type, and 37% for the primary ozone-generating air cleaner either by design or as a by-product) were mentioned somewhat less often.

Although the prevalence of indoor air cleaners is relatively low, in households that own them, usage of these devices is very high, particularly among those who own ozone-generating (intentional or by-product) devices. Owners of intentional ozone-generating air cleaners or air cleaners that may emit ozone as a by-product, run them most of the time, regardless of season or time of day. In fact, significant majorities of these air cleaner owners not only use them year-round, they also tend to use them every day and on a continuous basis throughout the day.

Only a small proportion of owners of air cleaners, about 40% for the primary air cleaner that emits ozone by design, and an even smaller proportion (19%) for the primary air cleaner that may emit ozone as a by-product, indicate that the owner's manual for their machine identified any warnings or limitations in the use of the device. These proportions may be even smaller as there were an additional 61 owners of ozone generating air cleaners either by design or possibly as a by-product that were not asked if they recalled any warnings in their owner's manual because of their previous response that they had not received an owner's manual, they had not read the owners manual, or that they had not recalled receiving a manual. Very few were aware of any time limits on the use of the machine, limits on the rooms where the device might be used, or restrictions on the use of the device around children or those who are ill.

6. RECOMMENDATIONS

This project was conducted, in part, because of a lack of publicly available data on the prevalence of ownership of air cleaners among California households. In survey research, this is referred to as a “baseline” study. It would be of significant value to conduct a similar study again in the future to measure the change in ownership patterns, particularly to assess the change in prevalence of ozone generators, after ARB adopts its future regulation for ozone emissions as directed by AB 2276 (Pavley, Statutes of 2006)

Question “ozone1”, asked, “Have you heard that ozone is an air pollutant?” The question was designed to assess awareness of the problem ozone presents to those who are exposed to it. Were this survey to be conducted again, the authors recommend that this question be re-phrased to more objectively assess awareness. As currently worded it is somewhat leading in that it states as fact the very thing that the question is supposed to measure. There are a number of standardized ways to ascertain awareness that might be more effective.

The survey results highlight a serious concern about usage patterns. Most owners of air cleaners that generate ozone run them nearly all the time. These owners are probably at a higher health risk than normal because of this pattern of use. This should be kept in mind as ARB develops their new regulation to limit ozone emissions from air cleaners.

REFERENCES

- Air Resources Board (ARB), 2006. Beware of Ozone-generating Indoor “Air Purifiers”, Fact Sheet, Sacramento, CA, March 2006.
- Air Resources Board (ARB), 2005. Review of the California Ambient Air Quality Standard for Ozone. Volumes I - IV. March 2005.
- Boeniger MF, 1995. Use of ozone-generating devices to improve indoor air quality. *J Am Ind Hyg Assoc.* 56(6):590-8.
- Britigan, N., Alshawa, A., and Nizkorodov, S.A., 2006. Quantification of Ozone Levels in Indoor Environments Generated by Ionization and Ozonolysis Air Purifiers. *J Air & Waste Management Assoc.* 56:601-610.
- California Department of Finance, 2006. *E-5 Population and Housing Estimate for Cities, Counties and the State, 2001-2006, with 2000 Benchmark.* Sacramento, California, May.
- Casady, Robert J. and Lepkowski, James, M., “Stratified Telephone Survey Designs,” *Survey Methodology*, Vol. 19 (June, 1993), pp. 103-113.
- Chen W, and Zhang JS, 2004. Effectiveness of Portable Air Cleaners for Control of Volatile Organic Compounds in Air. Presented at CIB World building Congress 2004, Toronto, Canada, May 2-7, 2004.
- Consumers Union, 1992. Household Air Cleaners, *Consumer Reports*, October, 1992, p. 657-662.
- Consumers Union, 2005a. “New Concerns about Ionizing Air Cleaners”, *Consumer Reports*, May, pages 22-25.
- Consumers Union 2005b. “Air Cleaners – Some Do Little Cleaning”, *Consumer Reports*, October, pages 39-41.
- Dyas A, Boughton BJ, Das BC, 1983. Ozone Killing Action Against Bacterial and Fungal Species; Microbiological Testing of a Domestic Ozone Generator. *J Clinical Pathology* 36:1102-1104.
- Foarde K, van Osdell D, Steiber R, 1997. Investigation of Gas-Phase Ozone as a Potential Biocide. *Applied Occupational Environmental Hygiene* 12(8):535-542.
- Mason MA, Sparks LE, Moore SA, Dolgov I, Perry RB, 2000, Characterization of ozone emissions from air cleaners equipped with ozone generators and

- sensor and feedback control circuitry. In: *Engineering Solutions to Indoor Air Quality Programs Symposium*, Research Triangle Park, NC. VIP-98, A&WMA, July, 2000, pp. 254-269.
- Phillips, T, and Jakober, C, 2006. Evaluation of Ozone Emissions from Portable Indoor “Air Cleaners” That Intentionally Generate Ozone. Staff Technical Report to the California Air Resources Board. May 5, 2006. 32 pages.
- Piazza, Thomas L., and Cheng, Y, Sampling Methods and Field Results for the 1989-90 Activity Pattern Survey of California Children, SRC Technical Report, 1991.
- Piazza, Thomas L., and Cheng, Y, Sampling Methods for the 1987-88 California Activity Pattern Survey, SRC Technical Report, 1989.
- Shaughnessy RJ, Levetin E, Blocker J, Sublette KL, 1994. Effectiveness of Portable Indoor Air Cleaners: Sensory Testing Results. *Indoor Air* 4:179-188.
- United States Census Bureau, 2005 American Community Survey, *B03002 Hispanic or Latino Origin by Race – Universe: Total Population*.

GLOSSARY OF TERMS, ABBREVIATIONS, AND SYMBOLS

ARB	California Air Resources Board
CATI	Computer Assisted Telephone Interviewing
CASES	Computer Assisted Survey Execution System
ESPs	electrostatic precipitators
IAQ	indoor air quality
MSG	Marketing Systems Group
ppb	parts per billion
ppm	parts per million
RDD	Random Digit Dialing
SRC	Survey Research Center
VOCs	volatile organic chemicals

APPENDIX A

This Appendix contains a copy of the telephone questionnaire for the study entitled "Survey of the Use of Ozone-Generating Air Cleaners by the California Public", Study Questionnaire 05-301.

**SURVEY OF THE USE OF OZONE-GENERATING
AIR CLEANERS BY THE CALIFORNIA PUBLIC**

STUDY QUESTIONNAIRE

>btsA< (INSTRUMENT TIMER STARTS HERE)

NOTE: DON'T KNOW/REFUSED <d,r> ARE OPTIONS FOR ALL QUESTIONS.

>ac1<

During the past five years, have you owned or used a portable air cleaner, either electric or battery-powered?

READ ALL:

By "air cleaner" we mean any device that can be moved from room to room. This would include room air cleaners designed for small spaces such as a bathroom, up to a large air cleaner designed to clean the whole house, and would include car air cleaners or personal air purifiers as well. We are not interested in air cleaners that are part of central heating and air conditioning systems, or plug-in type fragrance air fresheners such as Glade plug-ins.

<1> Yes

<5> No (SKIP TO 'ozone1')

<d,r> Don't Know/Refused (SKIP TO 'ozone1')

@

>acintr<

Since you do own a portable air cleaner we would like to ask you some more questions about this product.

Type ENTER to proceed @

>ac2<

Most air cleaners are made for use in any part of the home. However, there are some made specifically for use in the car or as personal devices. Please tell me what types of air-cleaners you now own or have owned? How about...

(READ EACH) (1) Yes (5) No

~~~~~  
A room air cleaner? @a  
An air cleaner for the entire house? @b  
A small air cleaner such as one  
designed for a bathroom? @c  
A car air cleaner? @d  
A Personal device? @e

(IF 'YES' TO 'ac2@a' OR 'ac2@b' OR 'ac2@c' SKIP TO 'ac3')

>ac2a<

THIS IS ASKED IF 'ac2@a', 'ac2@b', AND 'ac2@c' ARE ALL 'NO'  
AND EITHER 'ac2@d' OR 'ac2@e' IS 'YES'.

You said you own a (car air cleaner/personal device).

What brand or model is that?

<1> EcoQuest <2> Bionaire  
<3> Sharper Image <4> Honeywell  
<5> Oreck <6> Alpine Air  
<7> Prozone <8> Kenmore

<11> Other brand (SPECIFY)

@1

IF 'ac2@1' IS <11> THE INTERVIEWER WILL ASK:

ENTER BRAND NAME: @2

IF RESPONDENT ONLY OWN A CAR AND/OR PERSONAL AIR CLEANER,  
THE  
INSTRUMENT PATH SKIPS TO 'ozone1' AFTER ANSWERING.

-----  
>ac3<

How many portable air cleaners for use in the home have you  
used or do you now use (for the whole house, in a specific  
room, or a bathroom type air cleaner)? Would you say...

<1> One,

<2> Two,  
<3> Three,  
<4> or more? (SPECIFY)

@

WORDING FOR 'ac4' - 'ac31a' WILL VARY DEPENDING ON HOW MANY AIR CLEANERS RESPONDENTS REPORTS OWNING.

>ac4<

(IF ONE AIR CLEANER)

What is the BRAND of the air cleaner you use or used?

(IF MORE THAN ONE AIR CLEANER)

Now we'd like to ask you some questions about the air cleaner that you use most often.

What is the BRAND of the air cleaner you use or used most often?

<1> EcoQuest      <2> Bionaire  
<3> Sharper Image   <4> Honeywell  
<5> Oreck          <6> Alpine Air  
<7> Prozone        <8> Kenmore

<11> Other brand (SPECIFY)

@1

IF 'ac4@1' IS <11> THE INTERVIEWER WILL ASK:

ENTER BRAND NAME: @2

>ac5<

What is the MODEL name or MODEL number of the air cleaner (you use most often)?

MODEL NAME/NUMBER: @

>ac6<

Does (your air cleaner/the air cleaner you use most often) have any special features, such as a germicidal button, ozone boost, general power boost, ozone filter, or UV light?

<1> Yes  
<5> No (SKIP TO 'ac7')

<d,r> Don't Know/Refused (SKIP TO 'ac7')

@

>ac6a<

What special features does it have? Does it have...

(READ EACH) (1) Yes (5) No

~~~~~  
Germicidal button? @1
Ozone boost? @2
General power or fan boost? @3
Ozone filter? @4
UV light? @5
Some other feature? (SPECIFY) @6

>ac7<

Does this air cleaner (that you use most often) have a filter
or filters that are supposed to be replaced?

<1> Yes
<5> No (SKIP TO 'ac8')

<d,r> Don't Know/Refused (SKIP TO 'ac8')

@

>ac7a<

What type of filter does this air cleaner have?

CODE '1' TO ALL THAT APPLY, OTHERWISE CODE '5' OR PRESS
ENTER

~~~~~

Would you say a...

- @1 Pleated fiber filter (includes HEPA),
- @2 a carbon filter,
- @3 or other filter? (SPECIFY)

>ac7b<

What is the approximate cost of each filter?

- <1> \$50 or less,
- <2> between \$51 - \$100,
- <3> between \$101 and \$150,
- <4> between \$151 and \$200,
- <5> between \$201 and \$250,
- <6> between \$251 and \$300,
- <7> or more than \$300?

@

>ac7c<

How often, if ever, do you replace the filter or filters?

Would you say...

- <1> monthly,
- <2> quarterly,
- <3> twice a year,
- <4> once a year,
- <5> as needed,
- <6> never,
- <7> or what? (SPECIFY)
  
- <8> VOLUNTEERED: Hasn't had to change it yet.

>ac8<

WORDING IS VARIED IF RESPONDENT ANSWERS 'YES' TO 'ac7'.

(Not counting the filter we just talked about,) does the air cleaner (that you use most often) contain metal plates for particle collection that are supposed to be cleaned periodically?

<1> Yes

<5> No (SKIP TO 'ac9')

<d,r> Don't Know/Refused (SKIP TO 'ac9')

>ac8a<

How often do you clean them? Would you say...

<1> monthly,

<2> quarterly,

<3> twice a year,

<4> once a year,

<5> as needed,

<6> never,

<7> or what? (SPECIFY)

>ac9<

Is this air cleaner [that you use most often] an ionizer, that is, one that release ions?

<1> Yes

<5> No

<7> VOLUNTEERED: Releases negative ions

>ac10<

Does the air cleaner (that you use most often) intentionally emit ozone, or does the box or owner's manual mention that the air cleaner releases ozone, "activated oxygen", "super oxygen", or another similar term?

<1> Yes

<5> No

>ac11<

Does the air cleaner (you use most often) give off any odors?

<1> Yes

<5> No (SKIP TO 'ac12')

<d,r> Don't Know/Refused (SKIP TO 'ac12')

@a

(IF 'YES')

Please describe the odor, is it like...(READ CHOICES)

<1> "Clean air" (like after a thunderstorm),

<2> pungent, sharp, or irritating,

<3> bleach-like or chemical,

<4> burning or electrical,

<5> musty or mildewy,

<6> dusty?

<7> Other (SPECIFY)

>ac12<

What were your reasons for purchasing or using the air cleaner (that you use most often)?

CODE '1' TO ALL THAT APPLY, OTHERWISE CODE '5' OR PRESS ENTER

~~~~~

@a Concern over indoor air quality

@b Allergies or asthma in the home

@c Other health conditions in the household (SPECIFY)

@d Protect infants and young children

@e Remove mold and/or bacteria

@f Remove dust and airborne particles

@g Remove chemical contaminants from air

@h Control tobacco smoke (or smoke odor)

@i Remove pet dander

@j Other reasons (SPECIFY)

@k VOLUNTEER: Did not purchase, received as gift

IF RESPONDENT DID NOT PURCHASE AIR CLEANER ('ac12@k' IS 'YES') SKIP TO 'ac15'.

>ac13<

How did you select the PARTICULAR MODEL you purchased?

CODE '1' TO ALL THAT APPLY, OTHERWISE CODE '5' OR PRESS
ENTER

- @a Referral or recommendation from friend or relative
- @b Recommendation from doctor, dentist, etc
- @c Advertisement in newspaper OR magazine
- @d Advertisement on radio or television
- @e Advertisement on Internet
- @f Saw demonstration
- @g Door to door, or flyers
- @h Saw model in store
- @i Low noise level
- @j Cost
- @k Article in Consumer Reports or other magazine
- @l Air Resources Board/USEPA/other government website
- @m Other (SPECIFY)

>ac15<

What year did you purchase or acquire the air cleaner (that
you use most often)?

Was it...

- <1> 1990 or earlier,
- <2> between 1991 and 1995,
- <3> between 1996 and 2000,
- <4> between 2001 and 2002,
- <5> between 2003 and 2004,
- <6> between 2005 and the present?

@

IF RESPONDENT DID NOT PURCHASE AIR CLEANER ('ac12@k' IS 'YES')
SKIP TO 'ac18'.

>ac16<

What was the purchase cost of the air cleaner (used most often)?

Was it...

<1> Less than \$100?

<2> \$100 - \$200?

<3> \$201 - \$400?

<4> \$401 - \$600?

<5> or over \$600?

>ac17<

Where was it purchased? Was it...

<1> at a retail store,

<2> from a catalog,

<3> from an independent distributor

<4> online from the Internet

<5> or somewhere else? (SPECIFY)

@

>ac18<

Do you presently use the air cleaner?

<1> Yes

<5> No

<7> VOLUNTEER: don't currently have or own

@

WORDING FOR 'ac19' - 'ac26' VARIED BY PRESENT/PAST
USE/OWNERSHIP.

>ac19<

Do/Did you use the air cleaner (you use/d most often) year-round
just during certain seasons?

<1> Year-round (SKIP TO 'ac20')

<5> just certain seasons

<d,r> Don't Know/Refused (SKIP TO 'ac20')

>ac19a<

During what seasons do/did you use the air cleaner?

CODE '1' TO ALL THAT APPLY, OTHERWISE CODE '5' OR PRESS
ENTER

~~~~~

- @a Spring
- @b Summer
- @c Winter
- @d Fall

>ac20<

When using it, how many days a week do/did you use the  
air cleaner (the one used most often)?

- <1> less than one day a week,
- <2> 1 to 2 days per week,
- <3> 3 to 4 days per week,
- <4> 5 to 6 days per week,
- <5> or every day?

@

IF RESPONDENT CURRENTLY OWNS AN AIR CLEANER AND USES IT AT  
LEAST  
1-2 DAY/WEEK, ('ac18' IS 'YES' AND 'ac20' IS GREATER THAN <1>  
SKIP TO 'ac22')

>ac21<

THIS QUESTION WILL BE ASKED IF RESPONDENT NO LONGER USES OR NO LONGER OWNS AND AIR CLEANER ('ac18' IS <5> OR <7>), OR IF THEY USE THIER CURRENT AIR CLEANER LESS THAN ONE DAY PER WEEK ('ac20' IS <1>).

Why do you no longer use the air cleaner, or use it less than one day a week? Because...

CODE '1' TO ALL THAT APPLY, OTHERWISE CODE '5' OR PRESS ENTER

~~~~~

- @a It is too noisy
- @b It has an odor
- @c It doesn't seem to work
- @d It is expensive (cost of energy, filter, etc.)
- @e It made me or others not feel well?
- @f No longer need it

>ac22<

When use/d each time, how long do/did) you generally let the air cleaner run? (The one used most often.)

Would you say...

- <1> less than 1 hour
- <2> 1-4 hours,
- <3> 5-12 hours,
- <4> just at night,
- <5> all day during the day,
- <6> continuously (24/7)?

@

>ac23<

What operating setting do/did you typically use (on the air cleaner used most often)?

Would you say...

<1> Low,

<2> Medium,

<3> High,

<4> Mixed (DESCRIBE SETTINGS)

(e.g. fan speed and room size, or fan speed and ozone production)

<5> or something else? (SPECIFY)

<6> VOLUNTEER: Has on/off only

>ac24<

Do/Did you find the air cleaner (used most often) to be noisy?

<1> Yes

<5> No

<7> Sometimes

@

>ac25<

When you use the air cleaner (the one used most often), in what room is it most often located?

Is it in the...

<1> living room,

<2> master bedroom,

<3> children's bedroom,

<4> family room,

<5> bathroom,

<6> office,

<7> kitchen,

<8> or some place else? (SPECIFY)

@

>ac26<

Do/Did you ALSO use it in another room?

<1> Yes

<5> No @a

(IF 'YES')

What room is that? Is it the...

<1> living room,

<2> master bedroom,

<3> children's bedroom,

<4> family room,

<5> bathroom,

<6> office,

<7> kitchen,

<8> or some place else? (SPECIFY)

@b

>ac27<

When you run the air cleaner (that you use most often) in the (room from 'ac25'), is the door to the room usually open or closed?

<1> Open

<5> Closed

<7> VOLUNTEER: room has no doors

>ac28<

How satisfied are you with the air cleaner we've been talking about?

Would you say...

<1> very satisfied, [SKIP TO 'ac29']

<2> somewhat satisfied, [SKIP TO 'ac29']

<3> neither satisfied nor dissatisfied, [SKIP TO 'ac29']

<4> somewhat dissatisfied,

<5> very dissatisfied?

<d,r> Don't know/Refused (SKIP TO 'ac29')

>ac28a<

Why are you dissatisfied with this air cleaner?

Because...

- <1> It is/was too noisy
- <2> It has/had an odor
- <3> It didn't seem to work
- <4> It was expensive (cost of energy, filter, etc.)
- <5> It made me or others not feel well
- <6> Some other reason (SPECIFY)

@

>ac28b<

THIS IS ASKED IF 'ac28a' is <5>, OTHERS SKIP TO 'ac29'.

What symptoms did you or others have?

CODE '1' TO ALL THAT APPLY, OTHERWISE CODE '5' OR PRESS
ENTER

~~~~~

- @a Irritated eyes or throat;
- @b Affected lungs (difficulty breathing or chest tightness)
- @c Headache
- @d Aggravated asthma condition
- @e Other (DESCRIBE)

>ac29<

Since you began using this air cleaner, have you experienced improved indoor air, worsened indoor air or has the indoor air stayed about the same?

- <1> Improved indoor air
- <2> Worsened indoor air
- <3> Stayed about the same

@

>ac30<

Is the owner's manual easy to read and understand?

<1> Yes

<5> No

<6> VOLUNTEER: Did not receive one (SKIP TO '2ac4')

<7> VOLUNTEER: Did not read it (SKIP TO '2ac4')

<d,r> Don't Know/Refused (SKIP TO '2ac4')

>ac31<

Do you recall if the manual states any warning or limitations about the use of the air cleaner?

For example, does it mention things like not to run the air cleaner more than a specified time, or not to run the air cleaner with children in the room, or any caution about ozone?

<1> Yes

<5> No (SKIP TO '2ac4')

<7> VOLUNTEER: Do not recall (SKIP TO '2ac4')

<d,r> Don't Know/Refused (SKIP TO '2ac4')

@

>ac31a<

What warnings are mentioned? How about...

(1) Yes (5) No

~~~~~

Do not exceed run time limit? @1

(IF 'YES')

What is the run time limit? Hours: @1a Minutes: @1b

Do not use in bedroom or room with sedentary or sick person? @2

Do not use in rooms with children present? @3

Do not use high settings when people are in the room? @4

Do not place air cleaner near where people are sitting? @5

Any caution about ozone? @6
Were there any other warnings? (SPECIFY) @7

QUESTIONS '2ac4' - '2ac31a' ARE ASKED IF RESPONDENT OWNS MORE THAN ONE AIR CLEANER 'ac3' IS <2-4>. ALL OTHERS SKIP TO 'ozone1'.

>2ac4<

Now we'd like to ask you some questions about the second most often used air cleaner in your home.

What is the brand of this air cleaner?

<1> EcoQuest <2> Bionaire
<3> Sharper Image <4> Honeywell
<5> Oreck <6> Alpine Air
<7> Prozone <8> Kenmore

<11> Other brand (SPECIFY)

@1

IF '2ac4@1' is <1-10> THIS WILL BE AUTOMATICALLY FILLED FROM THE ABOVE LIST. IF '2ac4@1' IS <11> THE INTERVIEWER WILL ASK:

ENTER BRAND NAME: @2

>2ac5<

What is the MODEL name or MODEL number of this air cleaner?

ENTER NAME/NUMBER: @

>2ac6<

Does your air cleaner have any special features, such as a germicidal button, ozone boost, general power boost, ozone filter, or UV light?

<1> Yes
<5> No (SKIP TO '2ac7')

<d,r> Don't Know/Refused (SKIP TO '2ac7')

>2ac6a<

What special features does it have? Does it have...

(READ EACH)	(1) Yes	(5) No
Germicidal button?	@1	
Ozone boost?	@2	
General power or fan boost?		@3
Ozone filter?	@4	
UV light?	@5	
Some other feature? (SPECIFY)		@6

>2ac7<

Does this air cleaner have a filter or filters that are supposed to be replaced?

<1> Yes

<5> No (SKIP TO '2ac8')

<d,r> Don't Know/Refused (SKIP TO '2ac8')

@

>2ac7a<

What type of filter does this air cleaner have?

CODE '1' TO ALL THAT APPLY, OTHERWISE CODE '5' OR PRESS ENTER

~~~~~

Would you say a...

@1 Pleated fiber filter (includes HEPA),

@2 a carbon filter,

@3 or other filter? (SPECIFY)

>2ac7b<

What is the approximate cost of each filter?

- <1> \$50 or less,
- <2> between \$51 - \$100,
- <3> between \$101 and \$150,
- <4> between \$151 and \$200,
- <5> between \$201 and \$250,
- <6> between \$251 and \$300,
- <7> or more than \$300?

@

>2ac7c<

How often, if ever, do you replace the filter or filters?

Would you say...

- <1> monthly,
- <2> quarterly,
- <3> twice a year,
- <4> once a year,
- <5> as needed,
- <6> never,
- <7> or what? (SPECIFY)
  
- <8> VOLUNTEERED: Hasn't had to change it yet.

@

>2ac8<

WORDING IS VARIED IF RESPONDENT ANSWERS 'YES' TO '2ac7'.

(Not counting the filter we just talked about,) does this air cleaner contain metal plates for particle collection that are supposed to be cleaned periodically?

- <1> Yes
- <5> No (SKIP TO '2ac9')
- <d,r> Don't Know/Refused (SKIP TO '2ac9')

@

>2ac8a<

How often do you clean them? Would you say...

- <1> monthly,
- <2> quarterly,
- <3> twice a year,
- <4> once a year,
- <5> as needed,
- <6> never,
- <7> or what? (SPECIFY)

@

>2ac9<

Is this air cleaner an ionizer (i.e. does it release ions)?

- <1> Yes
- <5> No
- <7> VOLUNTEERED: Releases negative ions

@

>2ac10<

Does this air cleaner intentionally emit ozone, or does the box or owner's manual mention that the air cleaner releases ozone, "activated oxygen", "super oxygen", or another similar term?

- <1> Yes
- <5> No

@

>2ac11<

Does your air cleaner give off any odors?

- <1> Yes
- <5> No (SKIP TO '2ac12')

<d,r> Don't Know/Refused (SKIP TO '2ac12')

@a

(IF 'YES')

Please describe the odor, is it like...(READ CHOICES)

- <1> "Clean air" (like after a thunderstorm),
- <2> pungent, sharp, or irritating,
- <3> bleach-like or chemical,
- <4> burning or electrical,
- <5> musty or mildewy,
- <6> dusty?
- <7> Other (SPECIFY)

@b

>2ac12<

What were your reasons for purchasing or using this air cleaner?

CODE '1' TO ALL THAT APPLY, OTHERWISE CODE '5' OR PRESS  
ENTER

~~~~~

- @a Concern over indoor air quality
- @b Allergies or asthma in the home
- @c Other health conditions in the household (SPECIFY)
- @d Protect infants and young children
- @e Remove mold and/or bacteria
- @f Remove dust and airborne particles
- @g Remove chemical contaminants from air
- @h Control tobacco smoke (or smoke odor)
- @i Remove pet dander
- @j Other reasons (SPECIFY)
- @k VOLUNTEER: Did not purchase, received as gift

IF RESPONDENT DID NOT PURCHASE AIR CLEANER ('2ac12@k' IS 'YES')
SKIP TO '2ac15'.

>2ac13<

How did you select the PARTICULAR MODEL you purchased?

CODE '1' TO ALL THAT APPLY, OTHERWISE CODE '5' OR PRESS
ENTER

- ~~~~~
- @a Referral or recommendation from friend or relative
 - @b Recommendation from doctor, dentist, etc
 - @c Advertisement in newspaper OR magazine
 - @d Advertisement on radio or television
 - @e Advertisement on Internet
 - @f Saw demonstration
 - @g Door to door, or flyers
 - @h Saw model in store
 - @i Low noise level
 - @j Cost
 - @k Article in Consumer Reports or other magazine
 - @l Air Resources Board/USEPA/other government website
 - @m Other (SPECIFY)

>2ac15<

What year did you purchase or acquire the air cleaner? Was it...

- <1> 1990 or earlier,
- <2> between 1991 and 1995,
- <3> between 1996 and 2000,
- <4> between 2001 and 2002,
- <5> between 2003 and 2004,
- <6> between 2005 and the present?

IF RESPONDENT DID NOT PURCHASE AIR CLEANER ('ac12@k' IS 'YES')
SKIP TO 'ac18'.

>2ac16<

What was the purchase cost of the air cleaner? Was it...

- <1> Less than \$100?
- <2> \$100 - \$200?
- <3> \$201 - \$400?
- <4> \$401 - \$600?
- <5> or over \$600?

>2ac17<

Where was it purchased? Was it...

- <1> at a retail store,
- <2> from a catalog,
- <3> from an independent distributor
- <4> online from the Internet
- <5> or somewhere else? (SPECIFY)

>2ac18<

Do you presently use the air cleaner?

- <1> Yes
- <5> No

<7> VOLUNTEER: don't currently have or own

WORDING FOR '2ac19' - '2ac26' VARIED BY PRESENT/PAST USE/OWNERSHIP.

>2ac19<

Do/Did you use the air cleaner year-round or just during certain seasons?

- <1> Year-round (SKIP TO '2ac20')
- <5> just certain seasons

<d,r> Don't Know/Refused (SKIP TO '2ac20')

>2ac19a<

During what seasons do/did you use the air cleaner?

CODE '1' TO ALL THAT APPLY, OTHERWISE CODE '5' OR PRESS ENTER

- @a Spring
- @b Summer
- @c Winter
- @d Fall

>2ac20<

When using it, how many days a week do/did you use the air cleaner...

- <1> less than one day a week,
- <2> 1 to 2 days per week,
- <3> 3 to 4 days per week,
- <4> 5 to 6 days per week,
- <5> or every day?

@

IF RESPONDENT CURRENTLY OWNS AN AIR CLEANER AND USES IT AT LEAST

1-2 DAY/WEEK, ('2ac18' IS 'YES' AND '2ac20' IS GREATER THAN <1> SKIP TO '2ac22')

>2ac21<

THIS QUESTION WILL BE ASKED IF RESPONDENT NO LONGER USES OR NO LONGER OWNS AND AIR CLEANER ('2ac18' IS <5> OR <7>), OR IF THEY USE THIER CURRENT AIR CLEANER LESS THAN ONE DAY PER WEEK ('2ac20' IS <1>).

Why do you no longer use the air cleaner, or use it less than one day a week? Because...

CODE '1' TO ALL THAT APPLY, OTHERWISE CODE '5' OR PRESS ENTER

~~~~~

- @a It is too noisy
- @b It has an odor
- @c It doesn't seem to work
- @d It is expensive (cost of energy, filter, etc.)
- @e It made me or others not feel well?
- @f No longer need it

>2ac22<

When used each time, how long do/did you generally let the air cleaner run?

Would you say...

- <1> less than 1 hour
- <2> 1-4 hours,
- <3> 5-12 hours,
- <4> just at night,
- <5> all day during the day,
- <6> continuously (24/7)?

@

>2ac23<

What operating setting do/did you typically use?

Would you say...

- <1> Low,
- <2> Medium,
- <3> High,
- <4> Mixed (DESCRIBE SETTINGS)  
(e.g. fan speed and room size, or fan speed and ozone production)
- <5> or something else? (SPECIFY)
- <6> VOLUNTEER: Has on/off only

@

>2ac24<

Do/Did you find the air cleaner to be noisy?

- <1> Yes
- <5> No
- <7> Sometimes

@

>2ac25<

When you use the air cleaner, in what room is it most often located?

Is it in the...

- <1> living room,
- <2> master bedroom,
- <3> children's bedroom,
- <4> family room,
- <5> bathroom,
- <6> office,
- <7> kitchen,
- <8> or some place else? (SPECIFY)

@

>2ac26<

Do/Did you ALSO use it in another room?

- <1> Yes
- <5> No @a

(IF 'YES')

What room is that? Is it the...

- <1> living room,
- <2> master bedroom,
- <3> children's bedroom,
- <4> family room,
- <5> bathroom,
- <6> office,
- <7> kitchen,
- <8> or some place else? (SPECIFY)

@b

>2ac27<

When you run the air cleaner in the (room from '2ac25'), is the door to the room usually open or closed?

- <1> Open

<5> Closed

<7> VOLUNTEER: room has no doors

@

>2ac28<

How satisfied are you with the air cleaner we've been talking about?

Would you say...

- <1> very satisfied, [SKIP TO 'ac29']
- <2> somewhat satisfied, [SKIP TO 'ac29']
- <3> neither satisfied nor dissatisfied, [SKIP TO 'ac29']
- <4> somewhat dissatisfied,
- <5> very dissatisfied?

<d,r> Don't Know/Refused (SKIP TO '2ac29')

@

>2ac28a<

Why are you dissatisfied with this air cleaner?

Because...

- <1> It is/was too noisy
- <2> It has/had an odor
- <3> It didn't seem to work
- <4> It was expensive, cost of energy, filter, etc.
- <5> It made me or others not feel well
- <6> Some other reason (SPECIFY)

@

>2ac28b<

THIS IS ASKED IF '2ac28a' is <5>, OTHERS SKIP TO '2ac29'.

What symptoms did you or others have?

CODE '1' TO ALL THAT APPLY, OTHERWISE CODE '5' OR PRESS  
ENTER

-----

- @a Irritated eyes or throat;
- @b Affected lungs (difficulty breathing or chest tightness)
- @c Headache
- @d Aggravated asthma condition
- @e Other (DESCRIBE)

>2ac29<

Since you began using this air cleaner, have you experienced improved indoor air, worsened indoor air or has the indoor air stayed about the same?

- <1> Improved indoor air
- <2> Worsened indoor air
- <3> Stayed about the same

@

>2ac30<

Is the owner's manual easy to read and understand?

- <1> Yes
- <5> No

- <6> VOLUNTEER: Did not receive one (SKIP TO 'ozone1')
- <7> VOLUNTEER: Did not read it (SKIP TO 'ozone1')

<d,r> Don't Know/Refused (SKIP TO 'ozone1')

@

(@)<d,r>

>2ac31<

Do you recall if the manual states any warning or limitations about the use of the air cleaner?

For example, does it mention things like not to run the air cleaner more than a specified time, or not to run the air cleaner with children in the room, or any caution about ozone?

<1> Yes

<5> No (SKIP TO 'ozone1')

<7> VOLUNTEER: Do not recall (SKIP TO 'ozone1')

<d,r> Don't Know/Refused (SKIP TO 'ozone1')

@

>2ac31a<

What warnings are mentioned? How about...

(1) Yes (5) No

~~~~~

Do not exceed run time limit? @1

(IF 'YES')

What is the run time limit? Hours: @1a Minutes: @1b

Do not use in bedroom or room with sedentary or sick person? @2

Do not use in rooms with children present? @3

Do not use high settings when people are in the room? @4

Do not place air cleaner near where people are sitting? @5

Any caution about ozone? @6

Were there any other warnings? (SPECIFY) @7

>ozone1<

Have you heard that ozone is an air pollutant?

<1> Yes

<5> No

@

>ozone2<

THIS QUESTION IS ASKED ONLY IF RESPONDENT OWNS AN AIR CLEANER ('ac1' IS 'YES'). NON-OWNERS SKIP TO 'zipcode'.

As an air pollutant, ozone can cause coughing, difficulty breathing, and throat or airway irritation.

When operating your air cleaner, have you or anyone in your household noticed or experienced any of these symptoms?

<1> Yes

<5> No

@

(IF 'YES')

Which of these have you experienced? (1) Yes (5) No

Coughing?

@b

Difficulty breathing?

@c

Throat or airway irritation?

@d

Any other symptoms? (SPECIFY)

@e

(# Demographic questions:

>zipcode<

In order to compare responses from different people, we need to know the general area where they live. Could you please tell us your zip code?

<00001-99997> ENTER ZIP CODE

<99998> Don't know

<99999> Refused

>nadlt1<

Including yourself, how many adults - age 18 or older- live in your household?

<1-10> ENTER NUMBER OF ADULTS @

<d,r> Don't Know/Refused (SKIP TO nchld1)

>nadlt2<

(IF ONE ADULT IN HOUSEHOLD)

How old are you?

(IF MORE THAN ONE ADULT IN HOUSEHOLD)

Starting with the oldest, what are their ages?

Adult 1: @2a

Adult 2: @2b

Adult 3: @2c

Adult 4: @2d

Adult 5: @2e

Adult 6: @2f

Adult 7: @2g

Adult 8: @2h

Adult 9: @2i

Adult 10: @2j

>nchld1<

How many children, age 17 or younger, if any, live in your household?

<0> No Children (SKIP TO 'income')

<1-10> ENTER NUMBER

<11> More than 10 (INTERVIEWER: You will only enter ages
for 10 children.

<d,r> Don't Know/Refused (SKIP TO 'income')

@

>nchld2<

(IF ONE CHILD)

What is the age of this child?

(IF MORE THAN ONE CHILD)

Starting with the oldest, what are the ages of the children
living in your household?

(INTERVIEWER: If less than 1 year old, enter "0")

Child 1: @2a

Child 2: @2b

Child 3: @2c
Child 4: @2d
Child 5: @2e
Child 6: @2f
Child 7: @2g
Child 8: @2h
Child 9: @2i
Child 10: @2j

>income<

And now to finish up, we would like to know the general range of your family's total income for 2005 BEFORE TAXES. This figure should include salaries, wages, pensions, dividends, interest, and all other income for all members of your family that live in your household.

Was it...

<1> Under \$35,000,
<2> \$35,000-\$50,000,
<3> \$50,000-\$75,000,
<4> \$75,000-\$100,000,
<5> \$100,000-\$150,000,
<6> or \$150,000 or more?

@

>race<

What ethnic or racial group do you consider yourself?

<1> Black or African-American
<2> Native American
<3> Hispanic or Latino
<4> Filipino
<5> Asian
<6> Pacific Islander
<7> White or Caucasian, or
<8> Some other group? (SPECIFY)
<9> VOLUNTEERED: Mixed race (SPECIFY)

@

>info1<

Would you like to receive information in the mail from the State Air Resources Board on indoor air pollution, indoor air cleaners, or on the health effects of ozone? If so, I will need your mailing address.

<1> Respondent would like information and will provide mailing address.

<5> Respondent would like information but refuses to provide mailing address.

<7> Respondent doesn't want any further information.

@

>cntc<

QUESTION IS ASKED IF RESPONDENT WOULD LIKE MORE INFORMATION AND PROVIDES NAME/ADDRESS ('info1' is <1>):

To whom should we send the information?

NAME: @a

What address should we mail that to?

Street address @b

City, State @c ZIP: @d

>info2<

At the end of the study, you will receive the requested information in the mail from the State Air Resources Board. In the meantime, if you have questions or simply want additional information about the health effects of ozone, indoor air cleaners, or indoor air pollution, call the ARB at 916-322-8282, or please visit the ARB website at: <http://www.arb.ca.gov/research/indoor/indoor.htm>

>etsA< (INSTRUMENT TIMER ENDS HERE)

APPENDIX B

This Appendix contains a summary list of brands of air cleaners mentioned in the telephone questionnaire for the study entitled "Survey of the Use of Ozone-Generating Air Cleaners by the California Public".

Appendix B: SUMMARY OF BRANDS IDENTIFIED IN TELEPHONE SURVEY

<u>Percent</u>	<u>N</u>	<u>Brand Name</u>
34.1	128	Sharper Image
11.2	42	EcoQuest
9.3	35	Honeywell
4.8	18	Bionaire
4.3	16	Oreck
3.5	13	Holmes
2.4	9	Hunter
2.4	9	Kenmore
1.9	7	Alpine Air
1.9	7	Hamilton Beach
0.8	3	Bell and Howell
0.5	2	Bemis
0.5	2	Environizer
0.5	2	Family Care
0.5	2	GE
0.5	2	IQ Air
0.5	2	Panasonic
0.5	2	Rainbow
0.5	2	Target
0.5	2	Whirlpool
0.3	1	Amana
0.3	1	Amcor
0.3	1	Atmosphere
0.3	1	Austin
0.3	1	Biozone
0.3	1	Black and Decker
0.3	1	Blue Air
0.3	1	Brookstone
0.3	1	DeLonghi
0.3	1	Duracraft
0.3	1	Environmental Air System
0.3	1	Fredrickson
0.3	1	Greenway
0.3	1	Haier
0.3	1	Home HEPA
0.3	1	Homemedics
0.3	1	Ionizer
0.3	1	Kori
0.3	1	Lasko
0.3	1	Lennox

0.3	1	Lifewise
0.3	1	NSA
0.3	1	Orbit
0.3	1	Platinum Air
0.3	1	Pure Ion
0.3	1	Remington
0.3	1	Sears
0.3	1	Shaklee
0.3	1	Sonic Breeze
0.3	1	Spacegard
0.3	1	Sun Pure
0.3	1	Sunbeam
0.3	1	Venta
0.3	1	Vornado
0.3	1	Westinghouse
0.3	1	Whisper Cool
9.1	34	Don't know (31), refused (1), unclassified (2)
~100	375	