



PERGAMON

Atmospheric Environment 35 (2001) 2417–2421

**ATMOSPHERIC
ENVIRONMENT**

www.elsevier.com/locate/atmosenv

Short communication

The impact of an air quality advisory program on voluntary mobile source air pollution reduction

Peter D. Blanken*, Jennifer Dillon, Genevieve Wismann

*Department of Geography and Program in Environmental Studies, University of Colorado at Boulder,
260 UCB Boulder, CO 80309-0260, USA*

Received 7 July 2000; received in revised form 12 October 2000; accepted 30 October 2000

Abstract

Air pollution from mobile source emissions is a major cause of air quality degradation in the Denver, Colorado, metropolitan area. The projected increase in both population and vehicle miles driven, coupled with the high altitude, predominantly clear skies, and prevalent wintertime temperature inversions aid in the formation and retention of pollutants. The Colorado Department of Public Health issues an air quality advisory daily during the high pollution season (November 1–March 31) with the objective of improving air quality through voluntary driving restrictions and a mandatory wood burning ban. We hypothesized that the advisory had no effect on commuter behavior due to lack of awareness and understanding, lack of alternative means of travel, or lack of concern. We mailed an anonymous, self-administered survey to 1000 commuters living in the cities of Boulder and Westminster, Colorado. Despite the fact that the vast majority of the respondents were aware of the daily advisory (94%), understood what it meant (93%), and heard the posting at least once a day (71%) in time to choose alternative forms of transportation, the advisory did not alter commuter travel. Commuters traveled mainly as the sole occupant of a car and most (76%) never changed the way they commuted based on the daily advisory. Many claimed schedules or work locations did not allow them to use alternative transportation methods. We suggested a practical way to improve the advisory would be to reduce or eliminate public transit fares on poor air quality days. © 2001 Elsevier Science Ltd. All rights reserved.

Keywords: Commuters; Emission control strategy; USA; Colorado; Denver; Vehicular emissions; Wood smoke

1. Introduction

Mobile-source emissions are a major cause of air quality degradation in major urban areas. In the Denver, Colorado, metropolitan area, air quality is especially susceptible to mobile-source pollutants as the predominately clear skies and the high altitude (ca. 1650 masl) provide ample ultra-violet radiation to drive the NO₂ photolytic cycle. In addition, the high altitude reduces the efficiency of combustion engines, and temperature inversions formed in part due to the adjacent Rocky

Mountains, are common in winter, hindering the dispersion of pollutants (Reddy et al., 1995). Moreover, the region is experiencing the fastest population and economic growth in the United States (US Census Bureau, 1999). The total distance Denver-area motorists traveled was approximately 77 million km d⁻¹ in 1996, increased to 89 million in 1999, and is expected to reach 113 million within the next 20 years.

As an effort to voluntarily reduce mobile-source pollutants, the Colorado Department of Public Health issues an air quality advisory daily during the high pollution season (November 1–March 31). A red (poor or worsening air quality; mandatory ban on wood burning and voluntary driving restrictions) or blue (good air quality; no restrictions on wood burning or driving) advisory is issued at 4 p.m., valid for the next 24 h, and broadcast using a variety of media. During the 1999–2000

* Corresponding author. Tel.: +1-303-492-5887; fax: +1-303-492-7501.

E-mail address: blanken@spot.colorado.edu (P.D. Blanken).

high pollution season, 48 red and 102 blue advisory days were issued compared to 52 red and 100 blue during 1989–1999.

The purpose of this study was to determine if commuter travel was affected by the air quality advisory. We hypothesized that the advisory had no effect on commuter behavior due to a lack of awareness and understanding, lack of alternative means of travel, or lack of concern. We mailed surveys to 1000 randomly selected vehicle owners and determined if they were aware of and understood the advisory, how and when they heard the advisory, and if they changed their method of commuting based on the advisory. We also obtained a general description of their commuting behavior.

2. Methods

A 12-question survey was tested on 150 people at five locations within the city of Boulder, Colorado. Their comments and suggestions were used to clarify ambiguous questions, and resulted in 14 revised questions (Table 1). The survey was mailed on November 5 1999, near the beginning of the advisory program, to 1000 randomly selected vehicle owners. Addresses were selected from a database consisting of confirmed homeowners, age 18–65, and registered owners of at least one motor vehicle (InfoUSA, Denver, CO). Five hundred addresses were selected at random each within the city of Westminster (zip code 80030) contained within metropolitan Denver, and the city of Boulder (zip codes 80301–80309). The anonymous, self-administered survey was distributed by post, and returned by post with pre-printed, self-addressed stamped envelopes.

3. Results

A total of 281 surveys were returned (28.1%), greater than 80% of those within the first 18 days after mailing. The number of surveys (n) required to achieve a sampling error of $\pm 5\%$ ($\alpha = 0.05_{2 \text{ tail}}$) of the true population was calculated as

$$n = \frac{N(1-p)p}{(N-1)(\alpha/z)^2 + (1-p)p}$$

(Dillman, 2000) where p is the probability that a response to a question is chosen, N is the population size, and z is the standard score with $\alpha = 0.05_{2 \text{ tail}}$ (1.96). The 14-question survey consisted of 66 responses, or a mean of 4.7 responses per question, hence $p = 1/4.7$. The population size was calculated as the total number of employees within each of the sampled zip code areas ($N_{80030} = 13,261$; $N_{80301-9} = 68,681$), as this would approximate

the total number of potential commuters. Using these parameters, $n = 256$, which we exceeded with our $n = 281$, indicating 19 out of 20 times, the sample population's responses were expected to be within five percentage points of the population's responses.

The majority was aware of the advisory's daily posting of red or blue conditions (94%) and had a general understanding of what these conditions meant (93%). Only 5% were not aware of the daily posting, and 4% did not understand what red or blue air quality advisories meant. Less than 1% and 3% were not sure if they were aware or understood the advisory, respectively.

The largest group was informed about the advisory over the television (45%) or the radio (35%). A newspaper informed 15%, while all other sources including the Internet, were not significant information outlets. Many heard the advisory once a day (51%), and 20% heard the advisory more than once a day. This is presumably directly linked to the frequency of television, radio, and newspaper announcements of the advisory, which may be several times a day in the case of radio. As awareness was a goal of the advisory, 71% were in fact aware of the advisory at least once a day. A total of 28% heard the advisory at frequencies of once a week or less, ineffective to alter their daily commuting behavior.

The random address selection process was effective in reaching the target population of commuters, as 79% did commute to work, 16% did not, and 5% sometimes commuted. The program would be most effective for reducing mobile-source air pollution if commuters heard about the air quality conditions sometime between the 4 p.m. daily posting and the time they began their commute the following day. The program was effective in this regard, as 25% and 36% most often heard the advisory before leaving for work or during the day, respectively. The times that people work was not known, but if it is assumed that most work during the day, then the 35% of the respondents that heard the advisory after returning from work would be aware of the air quality conditions expected for the following day based on the 4 p.m. posting.

The largest group (32%) reported a total daily commute distance of less than 8 km. An equal number commuted a total distance of between 8–16 km (22%) and 17–32 km (21%). Long distance commutes, greater than 32 km, were reported by 25% of the respondents. As the return-trip distance between the city centers of Westminster and Denver, and Boulder and Denver are 34 and 90 km, respectively, it appeared that only 25% were commuting between these locations. Most (75%) lived within 16 km of their work place. The majority (76%) made this daily commute alone in their car, and only 24% used alternate methods of transportation (e.g., 3% carpool, 9% public transit, 8% bike, 4% walk). Despite 32% living within 4 km of their workplace, only 11% walked or rode a bicycle.

Table 1

Final survey mailed to 1000 randomly selected Boulder and Westminster, Colorado, addresses

-
1. Are you aware of the Colorado Air Quality Advisory Program's daily posting of Red or Blue conditions?
 - Yes
 - No
 - Not Sure
 2. Do you have a general understanding of what Red or Blue air quality conditions entail?
 - Yes
 - No
 - Not Sure
 3. Where do you **most often** hear about the daily Air Quality Advisory?
 - Newspaper
 - Radio
 - Television
 - Internet
 - Friends
 - Other _____ (please specify)
 - I do not hear about the program
 4. About how often do you hear about the daily Air Quality Advisory?
 - More than once a day
 - Once a day
 - Once a week
 - Once a month
 - Never
 5. Do you commute to work?
 - Yes
 - No
 - Sometimes
 6. When do you **most often** hear about the daily Air Quality Advisory?
 - Before leaving for work
 - After returning from work
 - During the day
 - Sometime the following day
 - Never
 7. What is the average total distance that you commute or travel daily?
 - Less than 5 miles
 - Between 6 and 10 miles
 - Between 11 and 20 miles
 - Between 21 and 30 miles
 - Over 31 miles
 8. Do you commute or travel mainly by:
 - Car alone
 - Car with others (carpool)
 - Public Transit
 - Bike
 - Walk
 9. On days when there is a Red Air Pollution advisory, do you commute or travel mainly by:
 - Car alone
 - Car with others (carpool)
 - Public Transit
 - Bike
 - Walk
 10. On days when there is a Blue Air Pollution Advisory, do you commute or travel mainly by:
 - Car by myself
 - Car with others (carpool)
 - Public Transit
 - Bike
 - Walk
-

Table 1 (continued)

-
11. If you **do** change the way you commute or travel when there is a Red Air Pollution Advisory, how often do you choose alternate methods of transportation?
- Always
 - Seldom
 - Only when convenient
 - Never. I do not change the way I commute or travel based on the Air Quality Advisory
12. If you **do not** change the way you commute or travel when there is a Red Air Pollution Advisory, why not?
- I do not hear about the advisory at all
 - I do not hear about the advisory until the end of the day or after it's too late
 - I have no alternate methods of transportation
 - Other methods of transportation are too inconvenient
 - I already make efforts to use less polluting methods of transportation
 - I do not care about the program
13. Do you restrict your wood burning when there is a red air pollution advisory?
- Yes, always
 - Sometimes
 - No, never
 - I do not burn wood
14. Overall, how do you feel about the effectiveness of Colorado's Air Quality Advisory Program in reducing air pollution.
- Effective in its current form
 - Somewhat effective, but could be improved
 - Effective for wood burning, but not for cars
 - Effective for cars, but not for wood burning
 - Not effective because not enough people hear about the program
 - Effective in making people aware of the air quality, but not effective in decreasing air pollution
 - Not effective at all in reducing air pollution
- Additional Comments
-

The posting of a red or blue advisory had no significant effect on the method of transportation. Commuters traveled mainly as the sole occupant of a car and most (76%) never changed the way they commuted based on the daily advisory. Few (12%) said they changed the way they commuted under a red advisory only when it was convenient, but many reported that they had no alternative means of transportation (31%), or that the alternative methods were too inconvenient (38%).

Slightly over half (53%) of the respondents burned wood, and of those, 86% always restricted their wood burning when a red advisory was posted. Therefore, it appeared that the advisory was effective in restricting wood burning, probably because wood burning restrictions were mandatory and relatively easy to enforce.

Most of the respondents (36%) felt that the advisory was effective in reducing air pollution generated by wood burning, but less than 1% felt it was effective for reducing mobile-source air pollution. The advisory was perceived to be somewhat effective in making people aware of air quality, but not effective in decreasing air pollution (24%), and only somewhat effective but in need of improvement (14%). Approximately, an equal number of respondents (10%) felt that the advisory was effective in its current form, or not effective at all in reducing air

pollution. Only 6% felt the advisory was not effective because enough people were not informed.

4. Conclusions

The survey revealed that although the majority heard and understood the advisory, most neglected to alter their commuting behavior based on the advisory. Seventy-six percent used cars as their primary mode of transportation on a daily basis, traveled alone, and did not alter their means of transportation based on the advisory. The advisory was, however, effective in restricting wood burning under red advisory conditions.

Despite being aware of and understanding the advisory, many reported that the main reason they disregarded the daily posting was because there were no convenient alternate methods of transportation available. Comments often said that their schedules or work locations did not allow them to use alternative transportation methods other than their cars. We do not know if there was a significant difference in the measured air quality between red and blue advisory days, or if any difference if found could be explained by the issuance of the advisory. From this study, however, we conclude that

the advisory's inability to alter commuter behavior apparently lies not with awareness or understanding of the advisory, but rather commuters' unwillingness or inability to limit their driving. In its current form, the advisory can do no more in terms of air pollution abatement than it is already doing; effectively reaching and informing commuters of air quality. It is then up to the individual commuter to adjust their travel behavior accordingly.

We received several comments suggesting the program needed to be much more aggressive in order to be effective: "the program does not have any teeth", "it does not know how to pack a punch", etc. The Denver metropolitan area, in the view of many respondents, did not provide a sufficient system that might encourage one to travel by methods other than their car, despite the availability of multiple public transit routes throughout in much of the area. Further, the lack of consequences pertaining to vehicle usage (as opposed to those enforced for wood burning), discourage people from treating the advisory with enough seriousness.

Contrary to wood burning restrictions, car driving restrictions are neither conceivable nor practical to enforce. Indirect mobile-source pollution abatement methods, such as the use of oxygenated fuels, emission check programs, and the use of more fuel-efficient vehicles could lessen the impacts of an increase in air pollution based on the projected increase in population and vehicle use. A decline in sole-occupant personal vehicle use will only occur when it becomes less convenient than alternative transportation methods. Incentives such as subsidized public transit passes, improved public transit schedules and routes, improved bicycle and

walking paths, or tax rebates for fuel efficient vehicles could be implemented to reduce mobile-source air pollution. These incentives could be linked to the advisory, for example, by reducing or eliminating public transit fares on a red advisory day.

Acknowledgements

We would like to acknowledge the Undergraduate Research Opportunity Program at the University of Colorado (UROP) for providing financial support. Assistance from Larry Boehm (UROP) and Christopher Dann (Colorado Department of Public Health) was appreciated. We would also like to thank the people at each of our test sites for their willing cooperation and support in helping us finalize the survey. Finally, those who took the time to fill out the survey and contribute to our study deserve many thanks, because this would not have been possible without their participation. The thoughtful suggestions and comments from the reviewers and editorial staff were greatly appreciated.

References

- Dillman, D.A., 2000. *Mail and Internet Surveys*, 2nd Edition. Wiley, Inc., New York, 464 pp.
- Reddy, P.J., Barbarick, D.E., Osterburg, R.D., 1995. Development of a statistical model for forecasting episodes of visibility degradation in the Denver metropolitan area. *Journal of Applied Meteorology* 34, 616–625.
- US Census Bureau, 1999. *Population Projections by State*. Washington, DC.