Noise Annoyance in Canada

D.S. Michaud[1], S.E. Keith[1] and D. McMurchy[2]

[1]Consumer and Clinical Radiation Protection Bureau, Health Canada, Ottawa, Ontario, Canada
[2]Dale McMurchy Consulting, Box 252, Norland, Ontario, Canada

The present paper provides the results from two nation-wide telephone surveys conducted in Canada on a representative sample of 5,232 individuals, 15 years of age and older. The goals of this study were to gauge Canadians' annoyance towards environmental noise, identify the source of noise that is viewed as most annoying and quantify annoyance toward this principal noise source according to internationally accepted specifications. The first survey revealed that nearly 8% of Canadians in this age group were either very or extremely bothered, disturbed or annoyed by noise in general and traffic noise was identified as being the most annoying source. A follow-up survey was conducted to further assess Canadians' annoyance towards traffic noise using both a five-item verbal scale and a ten-point numerical scale. It was shown that 6.7% of respondents indicated they were either very or extremely annoyed by traffic noise on the verbal scale. On the numerical scale, where 10 was equivalent to "extremely annoyed" and 0 was equivalent to "not at all annoyed", 5.0% and 9.1% of respondents rated traffic noise as 8 and above and 7 and above, respectively. The national margin of error for these findings is plus or minus 1.9 percentage points, 19 times out of 20. The results are consistent with an approximate value of 7% for the percentage of Canadians, in the age group studied, highly annoyed by road traffic noise (i.e. about 1.8 million people). We found that age, education level and community size had a statistically significant association with noise annoyance ratings in general and annoyance specifically attributed to traffic noise. The use of the International Organization for Standardization/Technical Specification (ISO/TS)-15666 questions for assessing noise annoyance makes it possible to compare our results to other national surveys that have used the same questions.

Keywords: telephone survey, annoyance, noise, traffic, Canada, ISO/TS-15666

Introduction

Noise can be defined as unwanted sound and is commonly associated with annoyance reactions. Environmental noise is ubiquitous and annoyance is one of the most widely studied adverse reactions to noise. According to the World Health Organization (WHO), health should be regarded as "a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity" (World Health Organization 2001). Under this broad definition, noise-induced annoyance is an adverse health effect. As with any psychological reaction, annoyance has a wide range of individual variability, which is influenced by multiple personal and situational factors (Fields 1993, Broadbent 1972). On a community scale, however, annoyance is more uniform so that estimating community annoyance is possible through the use of established dose-response curves. The relationship between day-night sound level (Ldn) and the percentage of an exposed population highly annoyed by any transportation noise source was first given by Schultz as a single curve (Schultz 1978)[1]. The term "highly annoyed" refers to a response to a social survey question on noise annoyance with a response in the top 27 to 29% on an anchored numerical scale or in the top two categories on an adjectival, five point verbal scale (Schultz 1978). The Schultz curve has been updated

[1] $\%Highly\ annoyed = 0.8553Ldn - 0.0401Ldn^2 + 0.00047Ldn^3$

(Finegold and Finegold 2002)[2] (Fidell et al. 1991)[3] and separate relationships are also available for aircraft, road traffic and electric rail (Miedema and Oudshoorn 2001)[4] (ISO 2003)[5]. In the ISO standard for assessment procedures for environmental noise the percent highly annoyed is obtained from the rating level (RL) using equation:

%highly annoyed = 100/[1+exp(10.4-0.132*RL)]

where, RL is typically an adjusted Ldn[6], with adjustments made depending on the type of noise source. In the ISO standard, the relationship for road traffic noise is obtained when RL equals Ldn. The resulting curve nearly coincides with Schultz's original curve.

International estimates of exposure to road traffic noise have been made for Europe, Australia and the U.S. In 1996, it was estimated that, in Europe, 40% of the population was exposed to traffic sound levels between 45-65dBA (Ldn) and 20% (nearly 80 million people) were exposed to levels over 65dBA (Commission of the European Communities 1996). In Australia, approximately 8% of the population was exposed to outdoor road traffic noise levels greater than 65dBA during daytime hours (OECD 1991). In 1986, the Organization for Economic Co-operation and Development (OECD) estimated that 30% of the U.S. population was exposed to a 24 hr time-averaged (Leq24) traffic noise level between 55-65dBA and 7% was exposed to traffic levels above 65 dBA (Leq24) (OECD 1986). Eldred (1990) estimated that 138 million Americans were exposed to outdoor day-night sound levels above 55dBA, with more than 25 million U.S. citizens exposed to levels above 65dBA (Eldred 1990).

International estimates of road traffic noise annoyance from social surveys have also been made for several European countries. Estimations of road traffic noise annoyance from Austria and France (annoyed), Germany (severely affected) and the Netherlands (highly annoyed) range from 20% to 25% of the respective populations (Commission of the European Communities 1996, INRETS 1994). A recent national survey in the United Kingdom (UK) found that between 7-9% of the population was either very or extremely bothered, annoyed or disturbed by traffic noise (Department for Environment, Food and Rural Affairs 2002).

There has been a gap in our knowledge as to how Canada compares to international estimates of annoyance and noise exposure. Only by comparison to Australian data (OECD 1991) has it recently been estimated that about 2 million Canadians live in areas where road traffic noise exceeds Leq24 outdoor levels of 65 dBA (Health Canada 2001).

Comparing results from different surveys on annoyance is difficult because of differences in methodology, which include variability in reporting high annoyance (Finegold and Finegold 2002). As an attempt to circumvent this problem, the ISO/TS-15666 proposed that socio-acoustic surveys incorporate two standardized questions aimed at assessing annoyance (ISO 2001). Our objectives for the present study were to use these standardized questions in order to assess noise annoyance in Canada and characterize the source that was most annoying.

Methods

Subject sampling

The two surveys each entailed a probability

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[2] *%Highly annoyed=100/[1+exp(11.13 - 0.141Ldn)]*

[3] *%Highly annoyed= 78.9181 - 3.2645Ldn + 0.0360Ldn^2*

[4] *%Highly annoyed (aircraft) = -1.395*10^{-4}(Ldn-42)^3 + 4.081*10^{-2}(Ldn-42) + 0.342(Ldn-42)*

[5] *%Highly annoyed (road traffic) = 9.994*10^{-4}(Ldn-42)^3 - 1.523*10^{-2}(Ldn-42)^2 + 0.538(Ldn-42)*
*%Highly annoyed (rail) = 7.158*10^{-4}(Ldn-42)^3 - 7.774*10^{-3}(Ldn-42)^2 + 0.163(Ldn-42)*
%Highly annoyed= 100/[1 + exp(10.4 - 0.132Ldn)]

[6] *The number of daylight hours is 15, defined as the hours from 07:00-22:00 (ISO 2003)*

sample of approximately 2,600 Canadians 15 years and older, using the Waksberg-Mitofsky technique for random digit phone number selection. Most provinces were allocated a sample size reflecting a 5% margin of error and a 95% confidence interval; the Atlantic Provinces had smaller sample sizes and were grouped together for the purposes of analysis. For each region, the sample was then distributed among community strata according to their relative contributions to the overall provincial population. The five community strata used were as follows: i) less than 5,000; ii) 5,000-9,999; iii) 10,000-29,999; iv) 30,000-99,999; and v) 100,000-999,999. A sixth stratum was added for cities with a population over 1 million residents (Montreal, Toronto and Vancouver). Each respondent indicated the population of their community. Random digit dialing was used to generate potential telephone numbers and one subject within each household was selected using the Troldahl-Carter technique. This technique ensures that the sample accurately represents the eligible population according to its age and sex structures (Troldahl and Carter 1964). Once a potential respondent was chosen using this technique, no other person in the household could be substituted as a respondent. Upon completion of the survey, data were also weighted within provinces by age, sex and community size. Additionally, they were weighted nationally to reflect each province's relative contribution to the overall Canadian population. The national margin of error for this study is plus or minus 1.9 percentage points in 19 samples out of 20.

Telephone Survey #1

In the spring of 2002, PricewaterhouseCoopers Consulting™ performed a telephone survey for Health Canada wherein a randomized sample of 2,565 Canadians, age 15 and older, responded to a questionnaire on health, their experience with the health care system and health policy. The response rate to this survey was 33%. The questionnaire, that required 20-25 minutes to complete, contained the two following noise-related questions: *Over the past 12 months or so, when you are at home, how much are you bothered, disturbed, or annoyed by noise from outside your home?* Subjects were given the following response options: *Extremely, Very, Moderately, Slightly or Not at all.* The following open-ended question was asked to identify which source Canadians were most annoyed with: *What type of noise from outside your home bothers disturbs or annoys you the most?*

Telephone Survey #2

A follow-up telephone survey was conducted for Health Canada in December of 2002 by IBM Business Consulting Services™. This survey employed the same methodology as the first survey and the questionnaire was similar in content and length as the first and the response rate was 32%. However, the noise questions in this case specifically probed attitudes towards traffic noise, since this was the source identified as most annoying in the first survey. In accordance with the recommendations provided by ISO/TS-15666 the following two questions were asked to the randomized sample of 2,667 Canadians 15 years of age and older: *Thinking about the last 12 months or so, when you are at home, how much does noise from road traffic bother, disturb, or annoy you?* Again, subjects were asked to respond with one of the following options: *Extremely, Very, Moderately, Slightly or Not at all*. An important methodological shortcoming to the verbal scale is that the response categories do not necessarily engender the same meaning between individuals. As a way of checking this possibility the ISO/TS-15666 suggests that a second question with a numerical scale be used to validate the response obtained to the first question. Thus, in this survey the verbal question was followed by the following question: *Thinking about the last 12 months or so, what number from zero to ten best shows how much you are bothered, disturbed or annoyed by road traffic noise?* Prior to asking this question, the interviewer indicated to the respondent that *zero* is equivalent to "not at all bothered" and *ten* is equivalent to "extremely bothered".

Statistics

Univariate and bi-variate (cross-tabulations and t-tests) analyses were employed using statistical data management software, SPSS® version 11.5.

Table 1. Demographic characteristics of responses to the following question: Over the past 12 months or so, when you are at home, how much are you bothered, disturbed, or annoyed by noise from outside your home?

		Extremely (n)	Very (n)	Moderately (n)	Slightly (n)	Not at all (n)
Number of respondents (percentage of total N=2573)		108 (4.2)[7]	95 (3.7)	407 (15.8)	700 (27.3)	1257 (49.0)
Sex	male	52	30	192	364	662
	female	55	65	215	336	595
Age (years)	15-24	38	35	120	280	404
	25-44	38	38	155	234	362
	45-64	20	17	98	127	292
	65+	12	5	33	59	199
Gross salary (x1000/yr)	<20	22	24	94	153	229
	20-50	36	32	150	201	378
	>50	33	20	119	230	407
Education Level	<secondary	8	3	21	9	92
	secondary	57	25	151	335	565
	>secondary	41	67	230	355	594
Employment Status	not working	48	37	131	300	517
	working	59	59	275	399	739
Community Size (estimated by respondent)	<5,000	10	3	35	55	241
	5,000-99,999	6	8	91	125	249
	100,000+	92	84	281	520	768
Self-reported health status	poor-fair	25	11	66	118	176
	excellent-good	82	85	341	573	1080

[7] *Cells for each variable may not always add to the corresponding sample size because respondents could choose to not answer questions.*

Results reported were statistically significant at the 0.05 level. Where multiple variables were significant and deemed relevant, logistic regression was employed to identify those factors most predictive of the various outcomes.

Results

Table 1 shows that about 8% of the sample indicated that they were either very or extremely bothered, disturbed or annoyed by noise outside their home, whereas nearly half of the respondents (49%) were not at all bothered. The major findings presented in Table 1 indicate that there was a statistically significant relationship between age, community size, education and sex with the level of annoyance. People 65 and over were the least likely to be annoyed by noise and the larger the respondent's community size, the more likely he or she was to be very or extremely disturbed by noise. Females were more likely to respond that they were slightly to extremely annoyed by noise compared to males. Finally, respondents with greater than secondary education were the least likely to respond that they were slightly or not at all annoyed by noise compared to those with a secondary or less then secondary education.

Table 2 shows the breakdown of the sources that respondents identified as being most annoying.

Table 2. The percentage of people annoyed the most by a particular type(s) of noise as a function of the extent to which they were bothered by noise in general.

Type of noise [8]	extremely (n=108)	very (n=95)	moderately (n=407)	slightly (n=700)	not at all (n=1257)
Road traffic	39.9	37.6	51.8	44.9	17.9
Animals outside	25.8	3.5	10.0	11.1	6.6
Other people outside	16.2	23.0	12.4	9.8	2.2
Off road traffic	7.0	13.2	4.2	7.6	2.5
Children outside	5.9	13.8	9.7	5.0	2.2
Trains	4.4	0.8	7.2	6.9	1.5
Neighbor's Music/TV (in/outside their home)	10.1	15.1	6.9	2.9	2.0
Construction work	7.3	11.0	3.5	4.1	2.6
Social events	6.6	9.3	5.0	5.3	0.7
People/animals from inside another dwelling	12.3	8.6	3.9	2.7	1.6
Aircraft	7.2	1.7	1.9	3.9	1.7
Snow removal	0.4	3.3	3.9	3.1	1.2
Alarms	1.9	3.9	2.3	0.6	2.7
Factories/machinery	5.6	0.2	2.5	3.4	0.8
Garden equipment	0.0	5.1	1.0	1.8	1.4
Farming machinery	8.9	0.1	0.3	0.0	0.3
Power tools	0.6	1.7	0.2	0.5	0.5
Subways	0.0	1.7	0.3	0.0	0.3
Other	7.7	17.1	5.9	5.8	12.0

[8] *Columns may not add to 100% because respondents were free to identify more than one source of noise.*

It is apparent that traffic noise is the most significant source of noise annoyance in Canada.

Results from the December survey were intended to further probe Canadians' annoyance towards traffic noise. The major findings were that, while nearly 7% of the respondents indicated that they were either very or extremely bothered by traffic noise, almost 63% were not at all bothered. Figure 1, panel A, shows the distribution of annoyance towards traffic noise. In this survey, respondents also had the opportunity to indicate how annoyed they were with traffic noise on a ten-point numerical scale, where zero represented "not at all annoyed" and ten represented "extremely annoyed". These results are presented in Figure 1, panel B. Panel C, in Figure 1 presents the results from the numerical scale collapsed according to the following breakpoints (0+1=not at all; 2+3=slightly; 4+5+6=moderately; 7+8=very and 9+10=extremely). Collapsing the numerical scale in this way yielded a correlation coefficient of 0.765 ($p<0.001$) between panel A and panel C.

Table 3 shows how annoyance ratings varied as a function of community size. Not surprisingly, annoyance towards traffic noise increased as function of community size so that almost 78% of the respondents from communities with less than 5,000 people were not at all annoyed by traffic noise, compared to only 58% of the respondents in communities with more than 100,000 residents. In communities with more

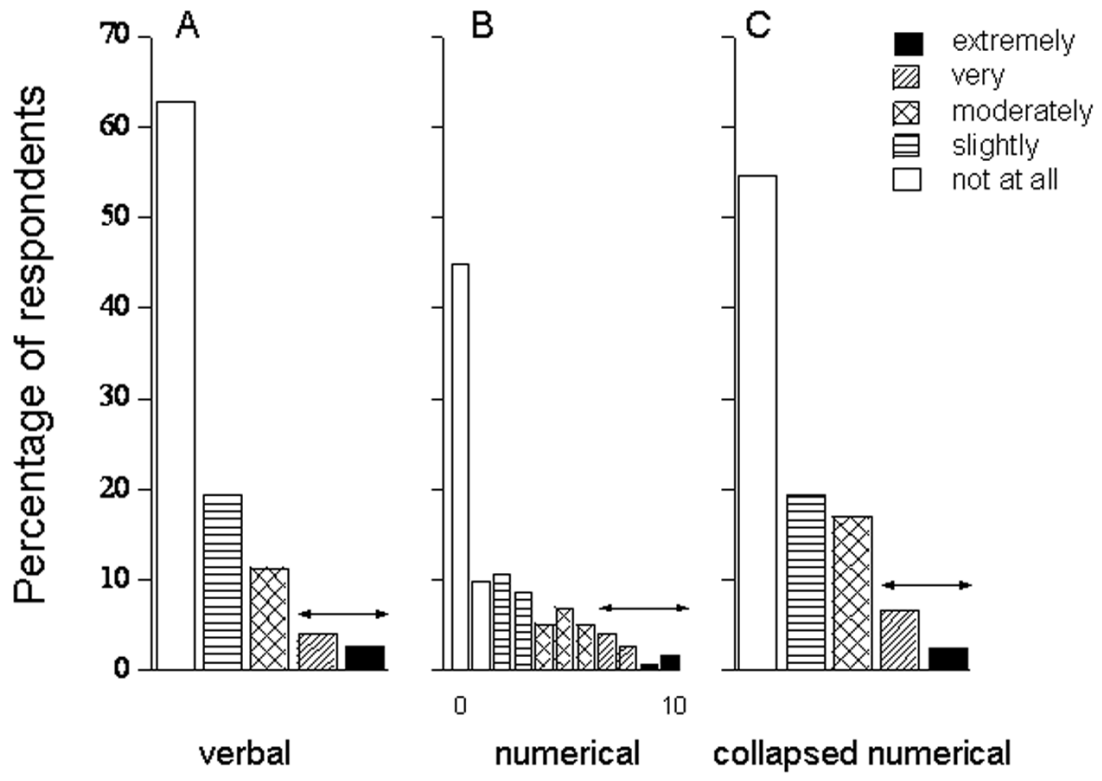

Figure 1. The distribution of self-reported annoyance towards traffic noise among respondents interviewed in the 2nd telephone survey using the ISO/TS 15666 recommended questions for assessing community annoyance. Panel A, shows the response on the verbal scale, Panel B shows the range of annoyance on the ten-point numerical scale and Panel C presents the results from the numerical scale collapsed according to the following breakpoints (0+1=not at all; 2+3=slightly; 4+5+6=moderately; 7+8=very and 9+10=extremely). Collapsing the numerical scale in this manner yielded a correlation coefficient of 0.765 ($p<0.001$) between panel A and panel C. Bars with arrowheads on each panel delineate the range of respondents considered "highly annoyed".

than 100,000 people, approximately 20% of respondents were moderately to extremely annoyed by traffic noise, compared to only 11% in communities with less than 5,000 residents.

Females were not only more annoyed by noise than males in general, but were 1.5 times more likely to be annoyed by traffic noise in particular. The average response from females on the numerical scale was 2.37 compared to 1.93 for males. Age and income had a statistically significant influence on respondent's annoyance ratings towards traffic noise. Individuals 65 and over were more likely to respond "not at all" annoyed and individuals between 25 and 44, were least likely to respond this way. Those in the middle-income bracket ($20,000-$49,999) were significantly more likely to be annoyed by traffic noise than respondents with incomes below and above this level. While almost three-quarters of those with less than a secondary education were not at all bothered by traffic

Table 3. The extent to which Canadians are bothered, annoyed or disturbed by road traffic noise as a function of community size.

		% Not at all	% Slightly	% Moderately	% Very	% Extremely
< 5,000	N=344	77.6	11.6	7.6	2.3	0.9
5,000-99,000	N=510	70.6	13.3	10.4	3.9	1.8
100,000+	N=1836	57.7	22.5	12.1	4.2	3.3

noise compared to 60% of those with a post-secondary education, no significant difference was found among education levels when those responding "slightly" and "not at all" were considered together. Another interesting observation was that individuals who rated their health as only fair or poor had a significantly higher mean rating on the numerical scale compared to those who said their health was good or excellent indicating that for traffic noise they had a greater level of annoyance (2.47 versus 2.09, respectively).

Discussion

There is no doubt that transportation noise can represent a significant source of annoyance. Efforts to reduce annoyance towards environmental noise should be greatly improved by an understanding of the pervasiveness of the annoyance. To our knowledge, the present study represents the first attempt to estimate noise annoyance in Canada using a national survey. Statistics Canada estimates that the Canadian population 15 years of age and over in 2003 was approximately 26 million (Statistics Canada 2004). Thus, our results suggest that nearly 2.1 million Canadians 15 years of age and over (+/- approximately 400,000) are either very or extremely annoyed by noise in general, and that 1.8 million Canadians 15 years of age and over (+/- 350,000) are similarly annoyed by traffic noise. It follows that the greatest reduction, nationally, in annoyance can be expected from efforts aimed towards reducing traffic noise in Canada. Our results are comparable to that obtained in the national survey conducted in the UK where it was found that 8% of the population was either very or extremely annoyed by traffic noise (BRE Environment 2002). This is an interesting comparison because the population of the UK in mid-2000 was about double that of Canada (Office for National Statistics 2003).

Our results indicate that traffic noise annoyance was greater among women and individuals with a higher income, and is lower among those 65 and over. In this study, education was no longer statistically associated with the level of traffic noise annoyance when the categories "slightly" and "not at all" were collapsed. However, these results were not entirely consistent with those of Fields (1993) in his review of the personal and situational factors contributing to noise annoyance. He found that education, income and age had no influence on annoyance ratings (Fields 1993). Our results are similar to a community study conducted in Canada 25 years ago that showed annoyance towards traffic noise was greater among residents classified as having a higher socioeconomic status (Bradley 1979). A higher socioeconomic status may be correlated with annoyance inasmuch as higher social status may be associated with a greater expectation of quiet, but this remains to be confirmed.

A recent study by (Ohrstrom 2004) showed the effectiveness of reducing annoyance by reducing traffic volume in a community in Sweden. In her longitudinal study, 58% of the exposed community was very annoyed by traffic noise caused by 25,000-30,000 vehicles per day (Leq-24hr = 67 dBA) and the average numerical rating on the 10-point annoyance scale was 8.9[9]. When traffic volume was reduced to 2,400 vehicles per day (Leq-24hr = 55dBA) the percentage highly annoyed dropped to 6.7% and the average numerical rating fell to 1.4. Not surprisingly, the reduction in traffic noise annoyance corresponded to an overall improvement in self-assessed general well-being. It is notable that it has been estimated that about 2 million Canadians are exposed to traffic noise levels in the range reported in Ohrstrom's study, before traffic volume was reduced (i.e. Leq24 > 65dBA). Based on the ISO curve (ISO 2003) though, it would not be expected that as many as 58% of these 2 million Canadians are very or extremely annoyed with traffic noise; non-acoustic variables likely contributed to annoyance in Ohrstrom's study sample (2001).

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9 *Using the dose-response curve recommended by ISO 1996-1: 2003, an Leq(24) of 67dBA would be associated with high annoyance in approximately 21% of the exposed community.*

Our findings provide a basis for establishing a full-scale national socio-acoustic survey similar to the UK study (BRE Environment 2002). This could further identify Canadian's concerns towards noise and, in turn, help devise strategies targeted at reducing annoyance. For instance, it was revealed in the UK survey that what specifically annoyed people the most about traffic was accelerating or speeding vehicles (BRE Environment 2002). In our initial survey we attempted to identify the sources which annoyed people the most, but among the 7.9% of respondents that were either very or extremely annoyed by noise in general, nearly 25% of them identified a type of source that was not one of the 18 sources listed in Table 2. More research could also help identify these unknown sources and target them to reduce annoyance among those highly annoyed.

Since acoustic variables may account for one third of the variance in annoyance, (Guski 1999) the present study would be improved if estimating respondent's noise exposure were possible. Future questions could specifically ask subjects how close they are to traffic and how often they are exposed. This would enable an estimate of the extent to which the noise levels correlate with annoyance scores.

The first survey was initiated as a pilot study to gauge Canadian's annoyance toward noise in general. It is of interest that among the 1257 respondents that indicated they were not at all annoyed by noise, 225 of them identified traffic as one of the sources that bothers, disturbs or annoys them the most. At first this finding seems paradoxical. It should be noted, however, that although everyone was asked both questions, most respondents that were not at all annoyed by noise in general did *not* provide a source that annoyed them the most. Thus, it is possible that one identifies traffic as the most annoying source of noise after indicating they are not at all annoyed by noise because 1) they have an expectation of the noise source that people would indicate as most annoying and they conform to this or 2) they find traffic so annoying that they effectively eliminate annoyance by avoiding the source that is most annoying.

Some caution should be made in comparing the results we obtained in the December survey to those conducted during warmer months since indoor noise exposure levels may be reduced in December with closed windows and people are more likely to be indoors during colder months. Although respondents are specifically instructed to respond based on their experience over the last 12 months or so, this may not fully account for seasonal effects. Seasonal effects on noise annoyance have been shown to account for as much as 10% of the variability in annoyance (Fields *et al.* 2000). Still, our results remain comparable to those obtained in the UK study since it was conducted in December/January.

For both surveys, the response rate was around 33%. Although this is common for public opinion research that utilizes random digit dialing (O'Rourke *et al.* 1998), we cannot rule out the possibility that selection bias may have had an impact on our results. It is important to note, though that a respondent's decision to participate or refuse to participate in the telephone survey was made without any knowledge that the survey would contain questions related to environmental noise. Furthermore, follow-up calls were made to individuals with soft refusals and numbers with no initial response.

The results of this study provide a basis for a more elaborate socio-acoustic survey that contains questions designed to estimate the respondent's level of noise exposure to transportation noise and to understand what non-auditory factors contribute to environmental noise annoyance. An ideal study would be supplemented with environmental noise mapping to better calculate how noise levels correlate with annoyance.

Correspondence address
David S. Michaud
Healthy Environments and Consumer Safety Branch, Product Safety Programme, Consumer and Clinical Radiation Protection Bureau, Acoustics Division, 775 Brookfield Road, Address Locator 6301B, Ottawa, Ontario, K1A 1C1, Canada
Tel: 1-613-954-6670 Fax: 1-613-941-1734
Email: dmichaud@hc-sc.gc.ca

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