Annoyance survey by means of social media

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Abstract

Social surveys have been the conventional means of evaluating the annoyance caused by transportation noise. Sampling and interviewing by telephone, mail, or in person are often costly and time consuming, however. Data collection by web-based survey methods are less costly and may be completed more quickly, and hence, could be conducted in countries with fewer resources. Such methods, however, raise issues about the generalizability and comparability of findings. These issues were investigated in a study of the annoyance of aircraft noise exposure around Brazil’s Guarulhos Airport. The findings of 547 interviews obtained with the aid of Facebook advertisements and web-based forms, were analysed with respect to estimated aircraft noise exposure levels at respondents’ residences. The results were analysed to assess whether and how web-based surveys might yield generalizable noise dose-response relationships.

1. INTRODUCTION

Hundreds of social surveys have been conducted to assess transportation noise-induced annoyance, primarily in economically-developed countires.1,2 Bassarab *et al.*5 have shown that most such surveys relied on telephone, mail, and face-to-face interviewing to contact respondents. Among 628 reported surveys reported by Bassarab *et al.*, only two used some kind of web-based interaction for interviewing respondents. Even in these cases, the initial approach to respondents was accomplished by traditional mail invitations and newspaper solicitations.5,10 More recently, transportation annoyance surveys have been undertaken in developing countries6,7,8,9, where data collection costs can be a hindrance to study design, and telephone subscription may not be universal.

Perhaps the most obvious difficulty with web-based interviewing is in generalizing findings inferred from samples of convenience (*i.e.*, self-selected respondents) to wider populations. Nonetheless, web-based surveys are becoming more common in several areas due to their considerably lower costs, shorter study durations, absence of interviewer-related biases, and respondents’ greater sense of privacy due to the absence of an interviewer11. Several studies attempting to better understand the advantages and disadvantages of web-based social surveying have recently been reported. Wang *et al.*12 cites several studies which compared web based and paper-based surveys. Some of them showed sizeable difference in findings, while others did not. Gosling and Vazire13 compared web-based and traditional surveys results to analyze six common beliefs about web-based questionnaires. They found little evidence to support the preconceptions that internet samples are not demographically diverse, and that web-based findings differ from those obtained with traditional methods. However, they also note that web-based surveys must be interpreted cautiously when representative population samples are required, as is the case with most uses of data collected in transportation annoyance surveys.

By definition, web-based surveys only reach respondents with internet access14. On the other hand, telephone-based interviewing only reaches those who subscriber to telephone service, which may not be as universal in the developing world as elsewhere. Even if internet service were available to all households in a community, demographic differences between internet users and non-users could restrict generalizability of findings to the general population. To address this problem, Best *et al.*15 list two general assumptions necessary for generalizing inferences to the general population from analyses of Internet samples: (1) that the decision-making processes of Internet users are similar to those used by the general population, and (2) that representative samples of Internet users can be drawn.

Vicente and Reis16 show that it is possible to reduce potential biases in Internet sampling by means of a simultaneous landline telephone survey that reaches people without internet access. However, even telephone-based interviewing is becoming more difficult to execute. The growth of commercial telemarketing and call-blocking technology has greatly reduced telephone interview completion rates; landline service is in decline in many areas; and wireless telephone subscribers do not always live at billing addresses.11

This paper presents the results of a social survey aircraft noise annoyance in which where both sampling (that is, solicitation for participation) and interviewing were accomplished by social media. The survey, which yielded 547 completed questionnaires, was advertised to Facebook users living in the city of Guarulhos-Brazil. The results were examined to investigate the plausibility of interpreting web-based surveys for constructing dosage-response relationships.

1. METHOD
2. **Target population**

The residents of the city of Guarulhos in Brazil were chosen as a target populaiton because Guarulhos Airport (IATA: GRU, ICAO: SBGR) is within city limits. GRU is the busiest airport in Brazil, with more than a doubling of aircraft movements over the last decade. (Fig. 1). Many residents of households near the airport experience considerable aircraft noise excposure.

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Fig. 1 Aircraft movements at GRU airport

Respondents were recruited by means of Facebook advertisements targeted exclusively at residents of Guarulhos city. According to Facebook, 740.000 residents of Guarulhos city, or 59% of the city residents according to the most recent census data available, from 2010, have Facebook accounts

Data from the year 2014 show that internet connection is available at 52.5% of the residences in Sao Paulo city metropolitan area (which encompasses Guarulhos city). However, this number falls to 25.7% when are only considered poorer residences with per capita income lower than half of the minimum monthly salary of Brazil (approximately $270 in 2016).

1. **Survey Description**

The annoyance questions generally followed the guidelines of ISO 15666:2003, which specifies questions and procedures for conducting socio-acoustic surveys.17 Since Portuguese is not among the nine languages with translated questions available at the standard, the noise-annoyance scale adverbs recommended by Gunther *et al.*18 were used.

The advertisement used to solicit respondents described a study of the quality of life in Guarulhos city. After clicking on the advertisement, potential respondents were redirected to an internet website that provided further information about the survey purposes and on the confidentiality of responses. E-mail and phone contacts were also offered further clarifications, but no questions were received. After the explanations, the respondent was invited to access the online form, which has hosted in a free Google Forms platform. No incentive was offered for participation in the survey.

The questionnaire was divided into 23 sequential Forms. Following the ISO standard recommendation, the verbal-scale annoyance question was placed early in the survey, in a matrix-question format. A concise overview of each form is given in Table I.

Table I - Description of the survey forms

|  |  |
| --- | --- |
| Form number | Description |
| 1 | General information about the time necessary to answer the survey, and on confidentiality of responses. |
| 2 | Address (street name and number) |
| 3 | Age |
| 4 | Verbal-scale matrix question about annoyance caused by 10 different local characteristics (traffic noise, traffic smoke and odors, trash and litter handling, aircraft noise, neighbor noise, industry noise, lack of parks and leisure places, lack of public transportation, lack of security, lack of public services). |
| 5 | General evaluation of the neighborhood in a 5-degree verbal scale. |
| 6 | General question on annoyance caused by noise (11-degree numerical scale) |
| 7 | Specific question on traffic noise annoyance (11-degree numerical scale) |
| 8 | Specific question on aircraft noise annoyance (11-degree numerical scale) |
| 9 | Verbal-scale matrix question about activity interference caused by aircraft noise (speech interference, phone calls, watch TV, sleep, reading) |
| 10 | Type of dwelling (building, detached or semi-detached house) |
| 11 | Floor number (in case of buildings) |
| 12 | Frequency of outdoor activities |
| 13 | Years of residence |
| 14 | Aircraft noise annoyance evolution during the period of residence |
| 15 | Fear of aircraft accidents |
| 16 | Number of trips using the local airport on the last year |
| 17 | Work relation with the local airport |
| 18 | Communication of the airport noise impacts by relevant entities (airport operator, media, neighbors, local government) |
| 19 | Perception on Aircraft noise mitigation measures |
| 20 | Perception of importance of the airport to the city |
| 21 | General sensitivity to noise |
| 22 | Specific question on aircraft noise annoyance (11-degree numerical scale) |
| 23 | Question on how the respondent reached the survey |

1. **Noise Modeling**

The noise levels observed at the respondents’ residences were estimated with INM (Integrated Noise Model) version 7.0d. The geographical location of each respondent was obtained from the address provided in Form 2 of the survey. Aircraft noise DNL values were calculated at each of the 547 respondents’ locations.

All the aircraft movements at SBGR airport in the year 2014 were included in the noise modeling. A database made available by ANAC (Brazilian Civil Aviation Authority) was used to obtain details on the aircraft movements (ICAO aircraft type, local time of movement and runway used). In total, 272 airplane movements were considered. Each movement was assigned to an INM aircraft model.

Ground track definition was done with respect to navigation charts for the airport, which were complemented with real aircraft trajectory data received from ADS-B (Automatic Dependent Surveillance-Broadcast) transponders installed on aircraft that operate at the airport. Each aircraft movement was assigned a specific ground track, given the runway used and flight origin or destination. Standard takeoff profiles were adopted for the lack of actual flight paths for all of the flights.

Terrain information was also included in the model to account for its effect in the sound propagation distance between the airplanes and the survey respondents. This information was obtained from SRTM database (Shuttle Radar Topography Mission), a world topography database developed by NASA.19

1. **Annoyance Evaluation**

Schultz1 defined as “Highly-annoyed” the responses that are on the upper 28% of an annoyance scale. For instance, on a 11-level numeric scale from 0 to 10, this would be equivalent to the top three annoyance levels (8, 9 and 10). Considering the verbal annoyance scale used by the work, if only the top annoyance category was considered as “highly-annoyed”, this would only include 20% of the total scale. To obtain results comparable to other recent dosage-response relationships, the number of highly-annoyed responses was calculated by counting the number of responses on the top annoyance category (extremely annoyed – Portuguese: “*extremamente incomodado”*), and adding 40% of the responses on the next annoyance category (very annoyed – Portuguese: “*muito incomodado*”). Together, these represents 28% of the total annoyance scale, as defined in other studies2,6

Annoyance prevalence rates were fit to a Community Tolerance Level (CTL) curve, as described by Fidell *et al*.24 CTL represents the DNL value at which 50% of the people in a community describe themselves as “highly annoyed” by aircraft noise. This is a decibel-denominated parameter that simplifies comparisons of surveys observed in different countries or cities. The annoyance prevalence rates function is defined in Equation (1).

(1)

The value of *m* is related to the DNL noise dose as defined in Equation (2):

(2)

The value of A was chosen to minimize the root-mean square error between the annoyance rates predicted by the CTL function and the empirically measured one.

1. RESULTS
2. **Survey response rate**

560 questionnaires were responded in full, for which 547 addresses could be validated. The advertisement was shown to 124,445 Facebook users between April and July of 2015, for awhich nominal a response rate of 0.23% relative to the total advertisement presentations. This calculation is somewhat misleading, however, since it is impossible to know how many users did not read or see the advertisement, or which users read the advertisement and then chose not to respond.

Another response rate can be calculated from the number of users who interacted with the advertisement in some way (clicked on it, liked it, or shared it). These are the potential respondents who acknowledged viewing the advertisement content, and then chose whether to respond. This response rate reaches 13.7% of 7,515 interactions.

1. **Noise contours and respondent locations**

Fig. 2 shows the location of the respondents with respect to DNL contours plotted at 2.5 dB intervals.

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Fig. 2 – DNL noise curves and respondents locations. Dark lines – noise contours (2.5 DNL resolution), White line – Guarulhos municipality limits. (color online)

The geographic dispersion of respondents seen in Fig. 2 clearly reflects the reach of the Facebook advertisement, presented only to residents within in the Guarulhos city limits. The correlation of these noise contours with Brazilian 2010 census data shows a total of 129,217 people subject to noise levels above 65 DNL, the current compatibility limit for residential use adopted by Brazilian regulations.20

1. **Dose-response curve**

The 547 questionnaires were binned into 2.5 dB intervals in DNL. The value of DNL associated with each bin was the average value of the DNLs at each respondent within the bin. Table II summarizes the survey results in terms of proportion of Highly-Annoyed people (%H.A.) at each noise exposure level:

Table II - % of people highly-annoyed by aircraft noise in Guarulhos city

|  |  |  |  |
| --- | --- | --- | --- |
| DNL range  (dB) | Number of responses | Average DNL | %H.A. (verbal scale) |
| 37.5-40 | 9 | 39.1 | 11.1 |
| 40-42.5 | 8 | 40.9 | 0.0 |
| 42.5-45 | 18 | 43.6 | 5.6 |
| 45-47.5 | 49 | 46.2 | 5.7 |
| 47.5-50 | 55 | 48.8 | 16.4 |
| 50-52.5 | 54 | 51.1 | 14.8 |
| 52.5-55 | 65 | 53.5 | 25.2 |
| 55-57.5 | 60 | 56.0 | 28.0 |
| 57.5-60 | 54 | 58.8 | 31.1 |
| 60-62.5 | 43 | 61.0 | 33.0 |
| 62.5-65 | 34 | 63.7 | 49.4 |
| 65-67.5 | 55 | 66.2 | 44.4 |
| 67.5-70 | 19 | 68.8 | 68.4 |
| 70-72.5 | 17 | 71.4 | 63.5 |
| 72.5-75 | 7 | 73.4 | 57.1 |

The 12 data points in the range between 42.5 to 72.5 dB were used to obtain a dose-response curve. The 37.5-42.5 and the 72.5-75 DNL ranges were not considered due to the small number of respondents at these noise levels. The results are shown in Fig. 3:

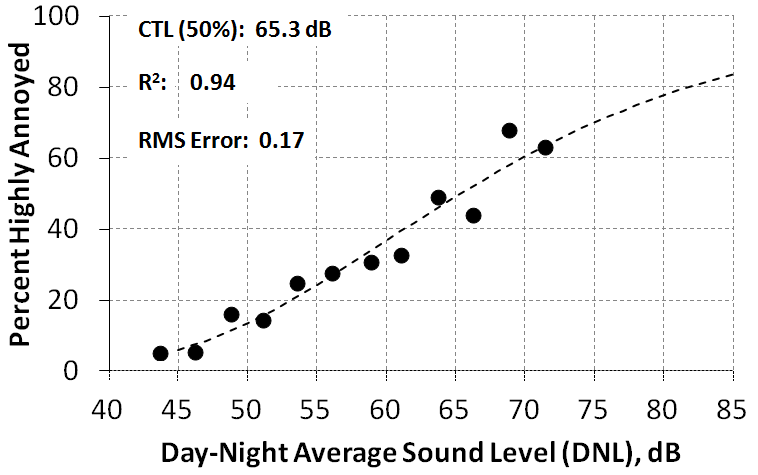


Fig. 3 – Dose-response curve obtained in CTL analysis (Guarulhos Airport)

1. **Distribution of responses per noise level**

Fig. 4. compares the distributions of aircraft noise levels of the survey respondents and of the general population of Guarulhos. The two distributions are generally similar, although respondents’ exposure is somewhat lower in the lower noise exposure ranges, and somewhat higher at higher noise levels.

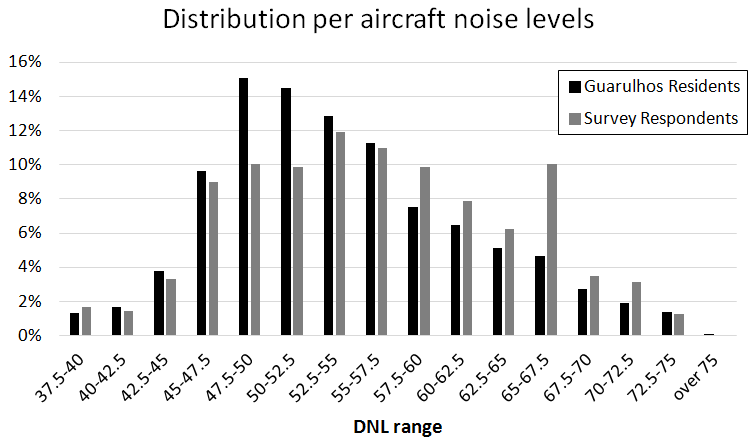


Fig. 4 – Noise levels distribution comparison

1. **Demographic analysis of sample**

Fig. 5 compares the age distribution of survey respondents with the overall age distribution of Guarulhos city citizens. Contrary to expectation, younger people are not greatly over-represented in the survey sample. The age distribution of the respondents is reasonably similar with the overall population of the city.



Fig. 5 – Age Distribution Comparison - Guarulhos City Citizens and Survey Sample

The survey form explained that the interview was intended to be answered by people over 18 years of age, however no special feature was used to enforce that. This was a design feature chosen in order to avoid the input of wrong age information just to allow access to the questionnaire. However, only 6 of the questionnaires (1%) were responded by respondents under 18; the youngest respondent was 14 years old.

An income question was not included in the survey because security concerns could lead to incorrect responses, or even to a failure to complete the rest of the questionnaire. Respondent income was therefore estimated on the basis of the average income of the respondent area, as registered by the 2010 Brazilian Census. Fig. 6 compares the average income of survey respondents with the overall income distribution of Guarulhos city citizens. Survey respondents are under-represented in the lower income categories, although they exhibit a wide range of estimated income levels.



Fig. 6 - Average income (in R$) comparison - Guarulhos city citizens and Survey respondents

The possibility of concentrated responses in areas with higher income or higher internet coverage was further evaluated with an analysis of the spatial distribution of the responses within the city. For that, all the city territory was divided into 1x1 km squares, and then the overall number of residents inside each square were counted, as well as the number of responses obtained in each of the squares. The results obtained are shown in Fig. 7.

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Fig. 7 - Number of respondents as a function of population density

The results show a good correlation between the number of respondents and the population density of the area. This suggests that the greater numbers of responses in some areas are simply a consequence of the greater numbers of people living in such areas, rather than a bias associated with other demographic variables.

The time of residence distribution of the sample is shown in Fig. 8. No comparison with the general population profile is possible due to the lack of information about the residence time of Guarulhos city residents in Census data. The distribution of residence durations nonetheless illustrates that the sample has a wide dispersion on this variable. Only two of the respondenents reported living in their current residence for less than one year.



Fig. 8 – Duration of residence (in years) of survey respondents

1. DISCUSSION

Web-based interviewing enjoys a great cost advantage over traditional interviewing methods, since the recruiting advertisements are relatively inexpensive, and results are quickly available, summarized in convenient form. Nonetheless, the results may not be freely generalized to a wider population for lack of proof that the sample is fully representative of a noise-exposed population. Web-based data collection may still be useful usefully interpreted for some purposes, however. For example, web-based interviewing could be conducted several times per year to track changes in noise exposure associated with operational growth. Any potential sampling biases would likely be consistent from one round of interviews to the next, so that *changes* in annoyance prevalence rates could be tracked without concern for sampling bias.

The CTL value of 65.3 DNL inferred from the current data suggests that Guarulhos respondents were about 8 dB less tolerant ( more sensitive) than the average community analyzed by Fidell *et al*.24 This could imply that the sample obtained with the web-based survey includes many respondents who are less tolerant than average of aircraft noise exposure.

However, the complete dataset presented by Fidell *et al*.24 shows variations of up to 30 dB in the CTL value (from 55 to 85 DNL), as shown in Fig. 9. This wide range precludes a simple conclusion that the present sample is necessarily a biased one.

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Fig. 9 - Comparison of CTL values on different surveys

Another obvious potential bias of survey respondents is toward digitally-literate people, who have active Facebook accounts and are probably younger than the average population. However, the socio-demographical analysis of the sample show good diversity of the sample in terms of age, income, and time of residence. It is also worth recalling that the influence of other demographical variables, extensively studied by Fields25 and by Miedema and Vos26, revealed no strong correlation between reported annoyance and demographic variables such as sex, age, income, or duration of residence.

Best *et al.*15 argues that representative samples of the internet population were not necessarily needed to extrapolate web-based surveys results to the general population, as long as the sample contains a dispersion of values for all the relevant variables, and that the decision-making processes of Internet users are similar to those of the general population on the question under analysis. On the first point, the socio-demographic analysis showed that the obtained sample presents a good dispersion of socio-demographical indicators. As for the second condition, it seems also reasonable to assume that access to the internet *per se* does not influence perception of aircraft noise.

If the results reflect a bias toward highly-annoyed people, it would be also be expected a high concentration of responses in higher noise levels, when compared with the overall city residents exposure to noise. However, the noise level distribution analysis in Fig. 4 showed only a slight trend for a concentration of responses at higher noise levels, between 57.5 and 70 DNL, and a single outlier in the range of 65-67.5 dB. This outlier does not, however, distort the dose-response curve shown in Fig. 3. If there were a bias toward highly-annoyed people at this noise level, it would be expected a higher “%H.A.” at this noise level. Inspection of the noise-response curve shows that the percent of highly-annoyed people at this noise level is even lower than the general trend of the curve. The same rationale can be used to analyze the under-representation of residents living in lower noise areas (between 47.5 and 52.5 DNL), since the dose-response curve exhibits no trend to lower annoyance levels at these noise levels

Another possible source of bias may be associated with self-selection for participation in the study. Some may argue that people who are highly-annoyed by aircraft noise may have greater interest in participating in the study, so that their opinions will influence potential mitigation efforts. The same argument further suggests a bias toward participation in the survey when more information about noise issues is available to the general public, or when communities are already mobilized against the airport as a noise source.

In the case of Guarulhos airport, however, the low number of complaints registered by the Brazilian Civil Aviation Authority, and the lack of organized reactions to the airport operations, argues otherwise. Any self-selection bias in the present sample that might lead to over-estimation of community response to aircraft noise is small, as may also be the case in other developing countries.

The advertisement soliciting participation in the study identified opinions about “quality of life” in Guarulhos city, and included the logo of the research institute responsible for the survey. These precautions may also have limited the likelihood of a biased sample, due to the well-known reputation of the institute in Brazil.

It therefore seems likely that the higher-than-average annoyance levels observed in this study are due to other factors beyond the survey methodology. For example, Kroesen *et al.*27 discuss the influence of the survey context on results. They suggest that an upward shift in some recent exposure-response curves may be at least partly explained by a trend for aircraft noise to be greater when it is measured in the context of other noise sources. The matrix question of the current questionnaire, however, followed the ISO 15.666 recommendations.

The operational changes recently observed at the Guarulhos airport might also explain the relatively high levels of annoyance observed. Such an influence has been asserted in other studies.28 In the present case, this effect was also detected with the responses to another question of the survey: Form number 14 asked the respondents if they noticed an increase in the aircraft noise levels at their residences. 76% of the “highly annoyed” respondents answered “yes” to this question, suggesting that the increase in aircraft movements did have an influence in the reported annoyance.

The effect of changes in noise environment in reported annoyance was also studied by Gjestland *et al.*29, who classified the results of 57 surveys in terms of the existence of recent or expected high rate of change in aircraft noise exposure. Gjestland *et al.* showed that surveys conducted at 'high rate of change' airports presented, on average, 8 dB less tolerance for noise.

The number of aircraft movements illustrated in Fig. 1 show that the air traffic at Guarulhos airport increased about 45% on the last 5 years before the survey. Guarulhos airport was privatized in 2012, in a process with great media coverage and discussions on the operational improvements expected after the privatization.

As such, GRU is classified as a “high rate of change” airport. It therefore seems more likely than not that the higher level of annoyance shown by the dose-response curve was caused by this effect, and not by a bias on the responses.

1. CONCLUSIONS

This work presents a novel method for the execution of social surveys, based on online responses obtained with the aid of social media advertisement to recruit and interview survey respondents. Despite the fact that this method may yield a less-than-fully representative sample of respondents, a detailed demographic and socio-economic analysis of the obtained sample suggests that it is reasonably similar of the overall population of Guarulhos City. These analyses do not exclude the possibility of bias among respondents, but neither do they demonstrate any clear bias or distortion in the findings. These results show that this may be a valuable scheme to be used, especially in developing countries, due to the lower cost involved and the possible lower risk of bias associated with the voluntary responses, as compared with developed countries.

For future research, a compromise solution to reduce the possibility of bias could be the simultaneous execution of a traditional mail or phone survey together with the web-based survey. With this scheme, the traditional survey results could be used to validate the results of the web-based results, which could then yield a mid-term solution in terms of cost and results reliability.

The results were used to obtain an aircraft noise dose-response curve in the Guarulhos airport. The results show that the communities living around this airport are less tolerant to aircraft noise when compared with average results obtained in other world surveys. Evidence indicates that this was probably caused by the recent changes registered at this airport (high increase in the air traffic, and a well-publicized privatization process), and not by an eventual bias caused by the non-randomness of the survey methodology.

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