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Assessing Acceptable Odour Levels

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ABSTRACT

The objective of the project was to conduct a survey to quantify the level of odour annoyance of individuals living in the vicinity of hog operations. A set of questionnaires was designed to obtain unbiased responses from residents living in the community. In the initial phase of the study, a site (community) was selected for surveying with the criteria that it must have a sufficient population living widespread nearby to a hog facility. Most households indicated odours from the hog facility and manure storage as the source of the odour. Households further away from the hog facility were more likely to identify other odour unrelated to hog odours as the odour source. Odours related to hog production are prevalent in the upper ranges of the odour annoyance levels, while non-hog related odour sources are limited to the lower odour annoyance levels. Evaluation of the relationship between graphical and verbal odour annoyance scales indicated that the scales were strongly correlated. Odour affected the frequencies of having disrupted enjoyment of outdoors and being forced to close household windows. Further surveying is required for sufficient data to make any definitive conclusions about odour tolerability and odour acceptability.

Keywords: Livestock operations, odour annoyance, odour exposure, community survey.

Introduction Odours from intensive livestock operations, such as hog operations, often create annoyance for neighboring residents of the facilities. The odorants that cause hog odours are released from hog facilities during the decomposition of animal by-products; these odorants may enter the atmosphere from hog barns, manure storage, or from manure spreading (Feddes and Clark, 2004).

Odour is the sensation and perception that results from the stimulation of the olfactory organ in the presence of odorants. Due to the negative perception of the odour produced from animal by-products, neighboring communities of intensive livestock operations often complain about odour. This negative perception is often measured as Odour Annoyance. In order to minimize complaints of odour annoyance, numerous methods have been developed to approximate minimum distances that animal livestock operations must be located from residential areas; these distances are also called setback distances. A true science-based method to determine the setback distances requires an accurate definition of Odour Annoyance or the acceptable odour levels.

Unfortunately, it is not easy to determine an acceptable level of odour because odour is very subjective. Odour is usually characterized in terms of its frequency, intensity, duration, offensiveness, and receptor (Sheridan et al. 2003). The offensiveness of an odour can differ from person to person; two individuals can differ on their perception (opinions) of the same odour with the same frequency, intensity, and duration (Feddes and Clark, 2004). Therefore, it is difficult to come to an agreement on what is an acceptable level of odour if different people have different reactions to odour.

To gain a better understanding on what qualifies as an acceptable odour, our study was designed to assess the odour annoyance and the intolerance to odour annoyance of rural communities that live in close proximity to hog facilities. The objective of this study was to quantify odour annoyance and intolerance towards hog facilities by interviewing residents in the communities nearby hog facilities.

MATERIALS AND METHODS

Site Selection Potential study sites were selected amongst several locations in Manitoba based on whether or not these sites met the requirements of this study. Each site required a sufficient population encompassing at least 100 households living in the vicinity of a hog facility. An ideal distribution of households should have residential representation of different levels of odour exposure (odour hours). The initial selection was based on Google satellite maps (Google 2010), and these sites were visited in person to locate and record locations of households and hog facilities in the area with a GPS system.

After the selection of the first community based on the preceding criteria, surveying commenced in September 2010 and concluded in December of the same year. Two hog facilities in this area acted as a pair of odour sources for this surveying area. Households within a maximum distance of eight kilometers (five miles) surrounding the two hog facilities were surveyed.

Questionnaire Design The main objective of the survey was to obtain measurements of odour annoyance and intolerance of odour annoyance within rural communities that accurately reflect the annoyance of neighboring residents. The survey required a questionnaire that would provide unbiased, unexaggerated reactions. Based on this requirement, the overall questionnaire was designed to survey about the quality of life in rural Manitoba. Odour annoyance is a recurrent occurrence in the daily lives of rural Manitobans and is easily integrated into the genre of quality of life.

Odour Annoyance Questions There is extensive research about the use of attitude surveys to measure odour annoyance. The questions employed in this study was based on a method implemented in Verein Deutscher Ingenieure (VDI) 3883/1 (1997) as well as Ministry of Environment (MOE) New Zealand (2003). Questions were added and altered to meet the purpose of this study.

There are two genres of questions that relate to odour annoyance in the questionnaire. The first type of question explicitly mentions odour and specifically asks for details regarding odour annoyance. The second type of question measures odour annoyance through interferences, focusing more on aspects of the individuals' lives that are affected due to the presence of odour.

Explicit Odour Annoyance Questions. An initial question confirms if the interviewee detects odour in their household or around their household. This is modified from the MOE New Zealand (2003) and the VDI 3883/1 (1997) sample questionnaires. A confirmation of odour allows the interviewer to proceed with the following questions. If the interviewees indicate that they do not detect odour, then the following questions are omitted.

Since we are only interested in odours associated with hog operations, it is important to distinguish the sources of the odour. A question specifies the odour source in order to identify if the odours are from the hog facility, manure storage, spreading of hog manure, or other sources unrelated to hogs. The MOE New Zealand (2003) guideline also identifies odour source in their sample questionnaire.

A pair of questions is used to measure annoyance, each using different scales based on VDI 3883/1 (1997). The first question asks on a seven-point scale for a verbal description of the odour annoyance. The second question asks on an eleven-point for a numerical value of the odour annoyance, arranged on a graphical scale that is shown to the interviewee. Sucker et al. (2007) and Steinheider and Winneke (1993) used this approach, while other guidelines such as MOE New Zealand (2003) use the verbal approach alone with different point scales.

Odour annoyance is tolerable to a certain extent; any odour annoyance after this point is intolerable. A question providing information regarding the tolerability of odour annoyance is important for distinguishing an acceptable level of odour exposure for setback distance determination. Sucker et al. (2007) asked for the unacceptability of the odour annoyance for pleasant, neutral, and unpleasant odours and evaluated the percentage of unacceptability based on the interviewee's odour annoyance. The odour tolerability question was inspired from Sucker et al. (2007) and was similarly analyzed. Some interviewees moved to the community when the hog facility was already in existence and they generally "tolerated" hog odour to some extent. An additional question was asked whether or not individuals would oppose the construction of a new farm within their area producing an odour similar in magnitude to the odour already present.

Odour Annoyance via Interference. Interferences are events that interfere with the interviewees' lives due to the presence of odour. Bruvold et al. (1983) identified these types of questions as interferences to everyday activities. These interferences include the frequency of filing official complaints, considering relocation, becoming sick, or having a disrupted outdoor gathering. Sucker et al. (2007) included questions pertaining to somatic symptoms while Steinheider and Winneke (1993) incorporated questions about socio-emotional and somatic effects. These questions consist of symptoms such as sleeping difficulties, waking up in the night, and experiencing headaches.

In this study, interference took into account the definitions supplied by Bruvold et al. (1983), Sucker et al. (2007) and Steinheider and Winneke (1993).

For each type of interference, there were two questions, modified from VDI 3883/1 (1997). The first question inquires about the frequency of the indirect annoyance occurring on a five-point verbal scale from 'never' to 'very often'. The second question asks for the cause of this indirect

annoyance; this question is not included in previous papers or studies but is required in this study to avoid unbiased responses.

PRELIMINARY RESULTS AND DISCUSSION Of the households approached for interview, 51.7% had an occupant willing to participate in the survey. Figure 1 displays the division of interviews between males and females within the community. An unknown percentage exists due to the interviewer not indicating the gender of the interviewee after surveying transpired.

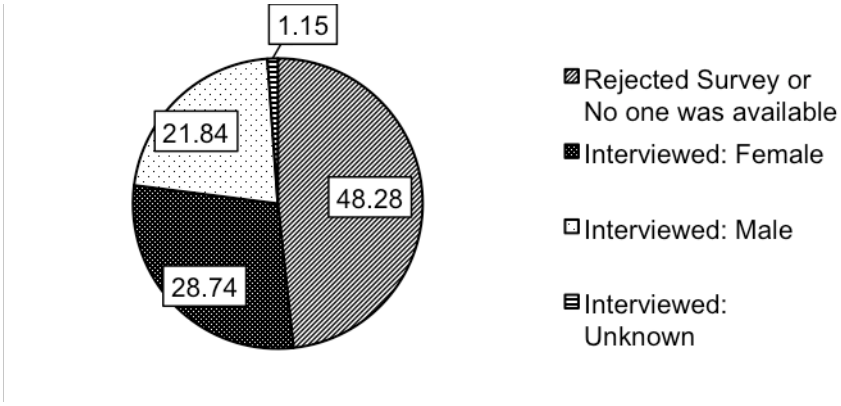

Figure 1. Percentage of households that participated in the categorized by gender.

Odour Sources Households are primarily separated based on occupant odour detection. Interviewees that detected odour are divided categorically into odour sources: odours from spreading and spraying manure, odours from farms or manure storage, and non-hog related odours. Figure 2 displays separation of odour annoyance of households in terms of the identified odour source. Most households indicated that odour from the hog farms and manure storage was the source of the odour. Odours related to hog production in general, including spreading and spraying, are prevalent in the upper ranges of the odour annoyance levels, while non-hog related odour sources are limited to the lower odour annoyance levels. Figure 3 displays a mile-grid map indicating the odour sources of interviewed households. Households that are closer in proximity to the hog facilities identified said facilities, or manure storages, as the odour source; more households recognize the odour source to be unrelated to hogs as the distance between the households and hog facilities increase.

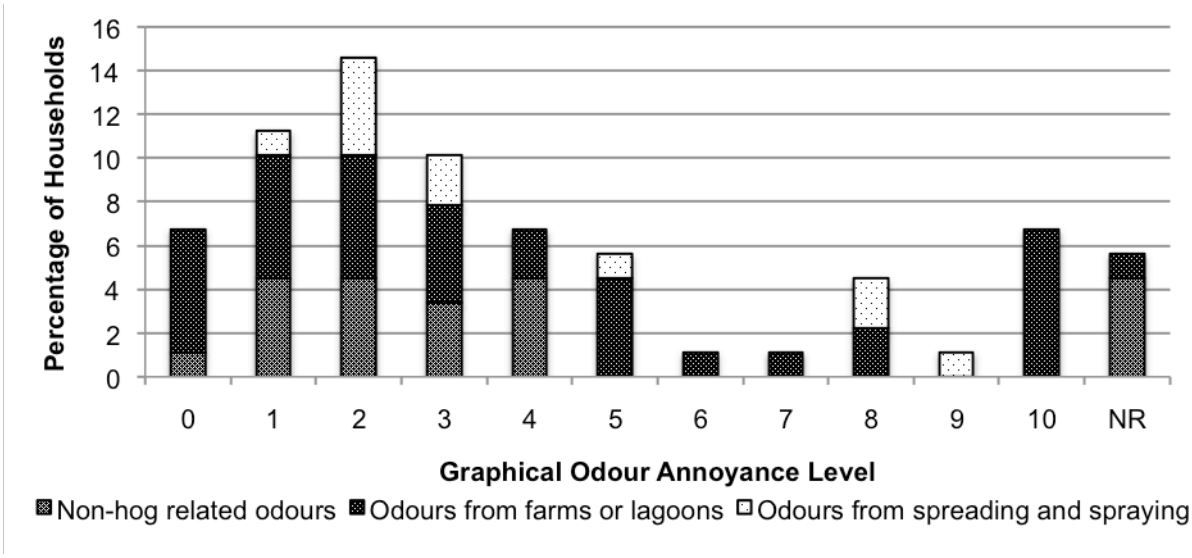

Figure 2. Odour annoyance levels of correspondents categorized by identified odour source.

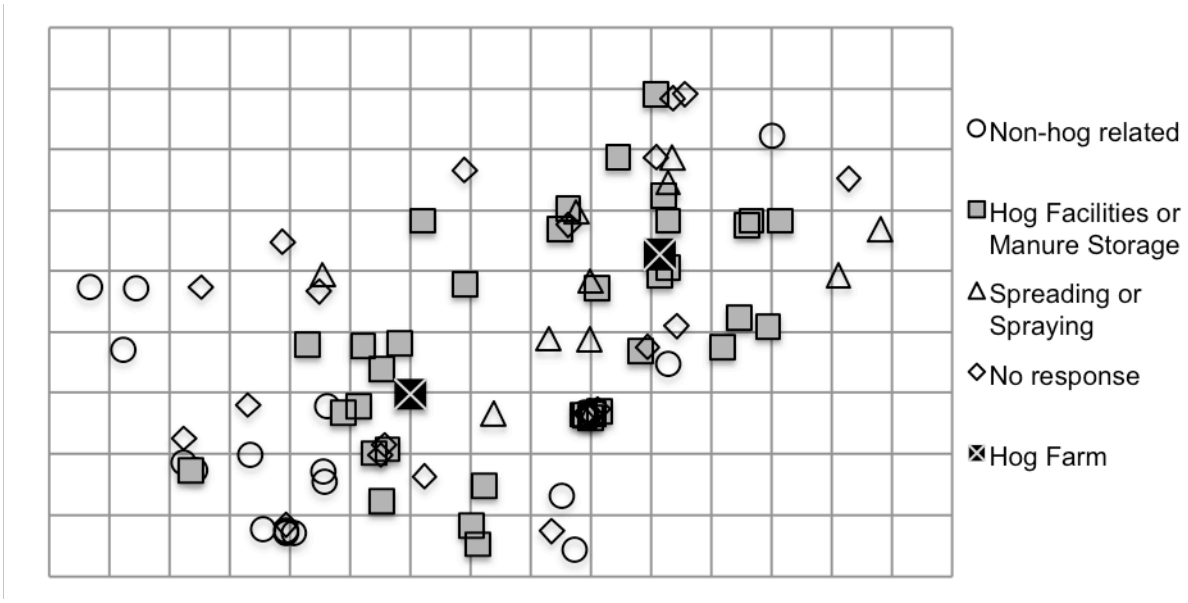

Figure 3: Mile-grid map indicating the location of hog facilities in addition to the identified odour source and location of participating households.

Graphical and Verbal Odour Annoyance Correlation Figure 4 displays the correlation of graphical odour annoyance to verbal odour annoyance. The dashed curve represents the uncorrected set of data including outliers. Inclusion of these outliers leads to an R^2 value of 0.580. The solid curve is the corrected set of data; three outlier data points were removed to gain a more consistent set of data. The outlier points have significant discrepancy between their graphical and corresponding verbal value for odour annoyance, indicating that the interviewee did not have an adequate understanding of the odour annoyance questions. The three points that were removed had graphical and verbal odour annoyance levels of (10, 1), (10, 3), and (0, 3). The number "10" on the graphical scale indicated that the odour annoyance was very high. The numbers "1" and "3" on the verbal scale are equivalent to very slight and distinct annoyance, respectively. The value of 10 on the graphical scale does not correspond to a very slight or distinct odour annoyance. Therefore, these two points were removed. Similarly, a value of "0" indicated an insignificant odour annoyance on the graphical scale and does not coincide with a distinct odour annoyance. Based on this logic, it is justifiable to remove these points. The R^2 value without these data points is 0.805, which is a significant improvement.

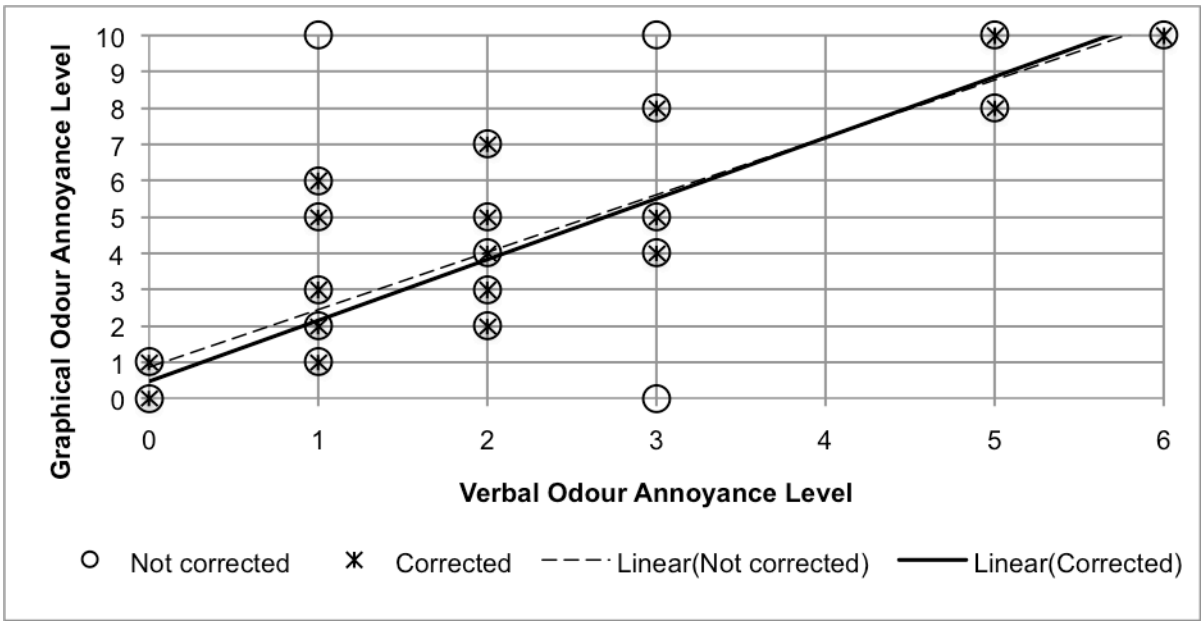

Figure 4. Correlation between Graphical Odour Annoyance and Verbal Odour Annoyance

Intolerance to Odour Annoyance Analysis of intolerance to odour annoyance is based on similar analysis of Sucker et al. (2007). The only households used in this calculation are those that have indicated that the odour source is from hog facilities (including manure storage).

Households are separated into their corresponding graphical odour annoyance levels. Within each level of odour annoyance, the percentage of intolerability is determined from dividing the number of households that find the odour annoyance intolerable by the total number of households in that level of odour annoyance. The basis for this analysis is to determine the primary odour annoyance level that is the boundary between tolerable and intolerable odour annoyance. From Figure 5, we can see there is not enough data to make a clear assessment on what is the limit to tolerance of odour annoyance. It is necessary to obtain more data in order to make any conclusions from this analysis. A similar analysis was performed on opposition to the construction of a new facility of similar odour magnitude in the community (figure 6). Similarly, we need more data to make any definitive conclusions and this will be accomplished with further community surveying.

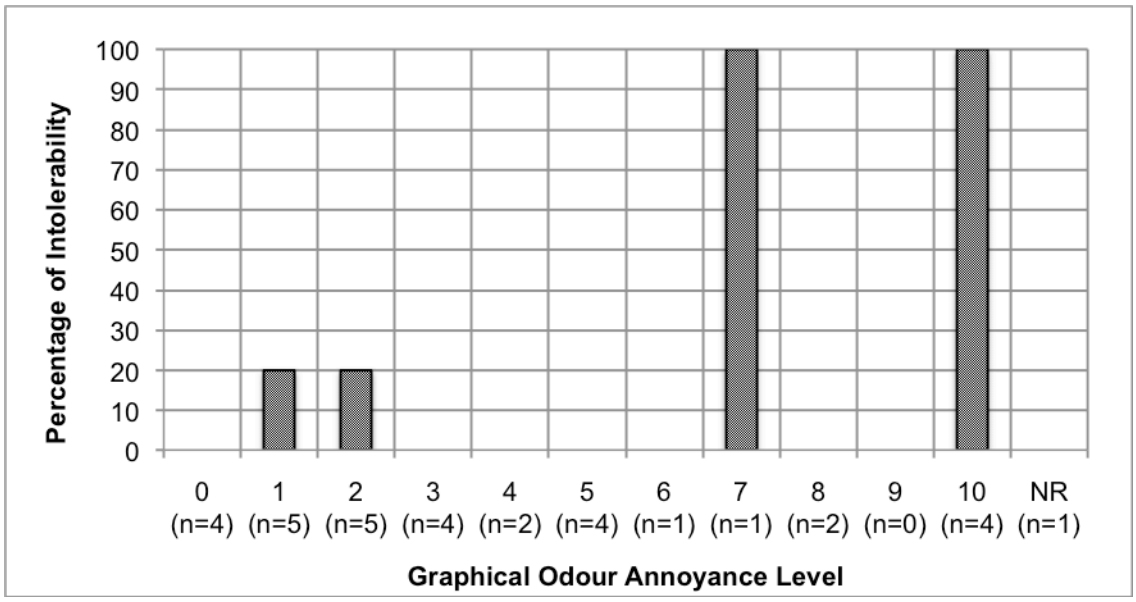

Figure 5. Percentage of intolerability to odour annoyance at different graphical odour annoyance levels

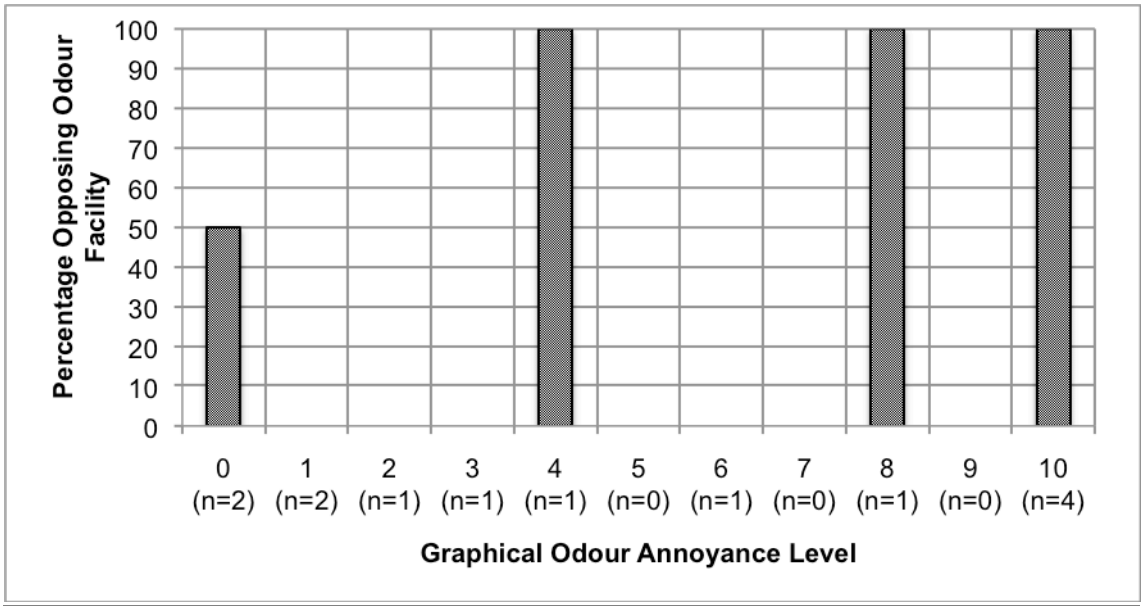

Figure 6. Percentage of households that oppose the addition of a new facility with similar odour magnitude to the existing site

Acceptability of Odour Odour hours of the two hog facilities were estimated using AUSPLUME atmospheric dispersion modeling software. An odour hour was defined as every hour in a year that odour concentration exceeds two odour units. Households were sorted based on number of odour hours that the occupants are exposed to. From this, different trends of acceptability were developed using different levels of odour annoyance as the thresholds for acceptability (fig. 7). All households that did not detect odour or did not identify odours from hog production facilities or manure storages as the odour source had odour annoyances of zero. Odour annoyance values below the threshold are deemed acceptable while those above the threshold are not acceptable. The analysis of intolerance to odour annoyance should provide this threshold; however, more data is required to make any conclusions. As a result of this, three types of acceptability trends are

present in figure 7 to convey how acceptability changes with varying thresholds of odour annoyance. Additionally, the acceptability trends require more data because the sample sizes within the categories of odour hours are inadequate. More data is required to make any conclusions about acceptability of hog odours.

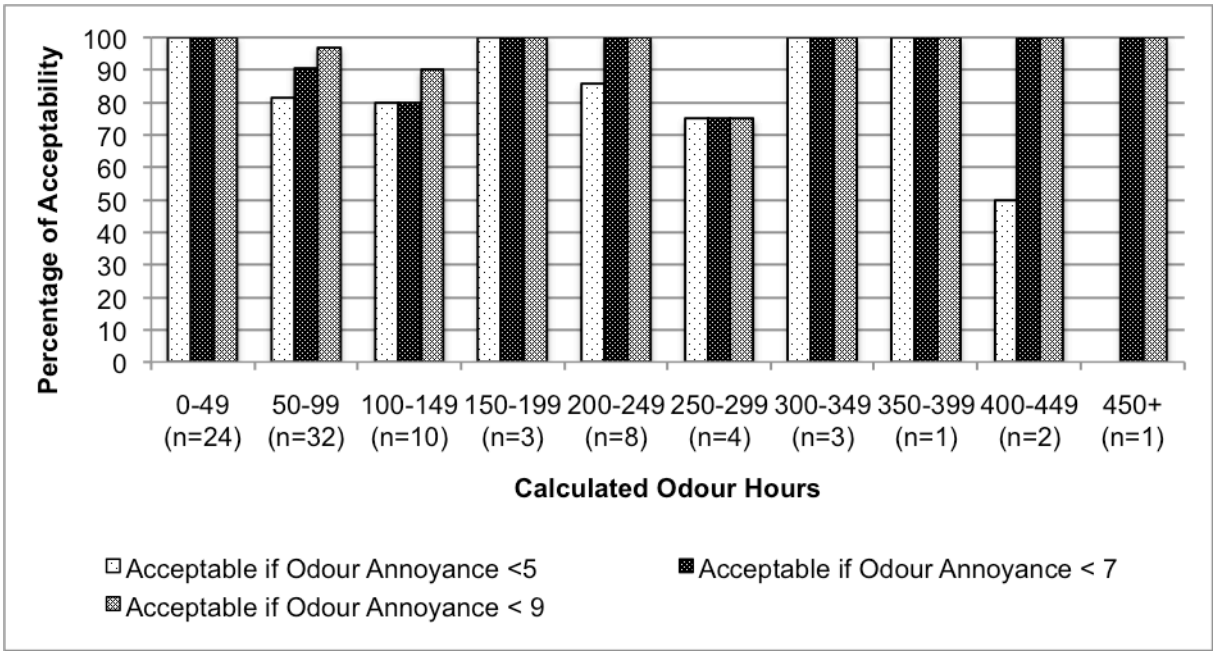

Figure 7. Percentage of acceptability to odour annoyance at odour hours calculated by AUSPLUME.

Frequency of Interferences Odour affects the frequency of two of the six interference factors. Five and eighteen individuals indicated odour to be the reason for having disrupted outdoor enjoyment and being forced to close their windows, respectively. Conversely, the explanation for the occurrence of the other interference factors is unrelated to odour in this community. As seen in figure 8, individuals that indicated that they are rarely or sometimes forced to close their windows identify any of the three odours as the odour source; however, only odours from hog facilities or manure storages are designated as the odour source for individuals that responded that they are often or very often forced to close their windows.

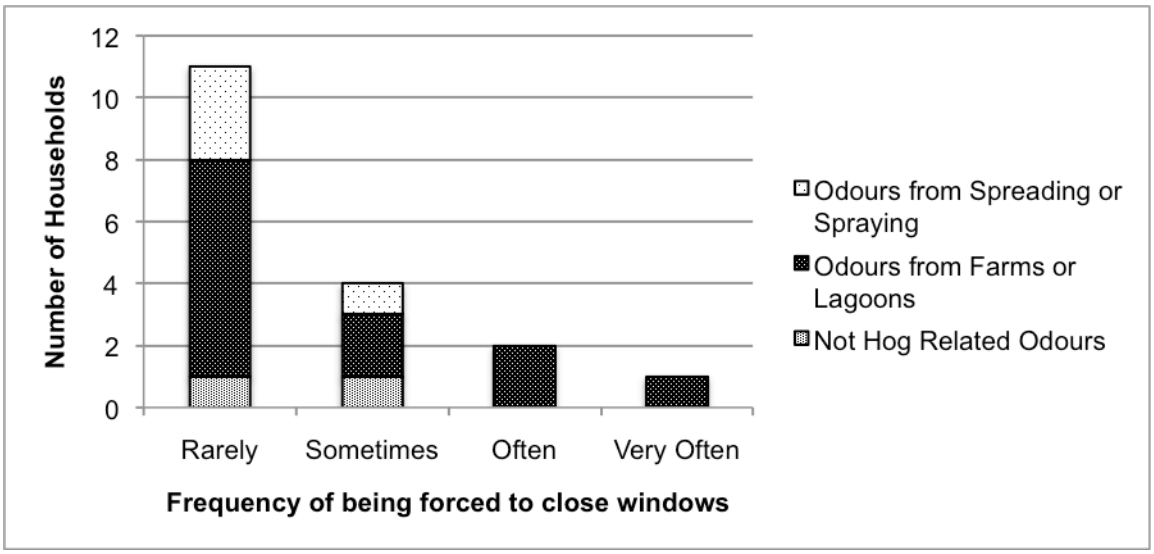

Figure 8. Frequency that individuals are forced to close their windows due to a certain odour source.

PRELIMINARY CONCLUSIONS While the surveying of additional communities is necessary to acquire sufficient data, the preliminary results indicated that designing the questionnaire to focus on quality of life in rural communities was an adequate way to obtain responses by the residents to hog odour. The majority of interviewees identified odour from hog facilities and manure storage as the odour source corresponding to their odour annoyance. The graphical and verbal odour annoyances scales were strongly correlated. Further surveying is required to determine any conclusions about the extent of the tolerance to odour annoyance. It is also beneficial to acquire more information about odour annoyances in the form of interference.

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