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PHYSICAL WELL-BEING AND MALODOUR EXPOSURE: THE IMPACT OF AN INTENSIVE PIG FARMING OPERATION ON A COMMUNITY IN TRINIDAD

Tasha Ragoobar, Wayne Ganpat and Kern Rocke
Department of Agricultural Economics and Extension, Faculty of Food and Agriculture, The University of the West Indies, St. Augustine, Trinidad
Email: wayne.ganpat@sta.uwi.edu

Abstract: There is a high demand for pork products in Trinidad because of its lower cost compared to other meats and its preferential taste. Erin farm in Trinidad is the largest piggery in the country. Intensive livestock production has been shown to produce a large amount of biological waste which can be harmful to human health. This study investigated the impact of malodors from this piggery on the physical health of persons in the surrounding community. Direct measures of gases were done over a 3 month period and community members were surveyed using a questionnaire to determine their perception of the severity of the malodors and the frequency of selected health-related symptoms. Repeat measures were done in a matched community some 5000m away from the piggery. Data were assessed using paired t-tests, chi square and multiple regression analysis. Results showed: significant differences in ammonia and hydrogen sulphide levels between the test and control communities ($p<.001$ level) and significantly higher incidences of health symptoms ($p<.05$ level) between the communities (headaches, eye, nose and throat issues, wheezing, sneezing, shortness of breath, difficulty in concentration and general discomfort. Regression results showed that higher adverse malodour ratings significantly impacted health status of residents living close to the piggery ($P<.001$). Findings suggest intervention by The Environmental Management Agency to mediate in this community to have a solution in which the farm can continue to operate and the residents' health is not further compromised.
Keywords: Physical Well-being; Malodour; Intensive Pig Farming; Caribbean.

Introduction

Food insecurity has continued to increase substantially in middle and low income country settings, and as such, there is need to increase the production of both crops and livestock to feed vulnerable and underprivileged populations. Intensive pig farming refers to a farming system in which pigs are reared using industrial animal agricultural practices; characterised by use of a large input of financial and labour resources to improve production. As pig production increases, one result is the production of a large amount of waste and foul odours[1, 2]. It has been shown that livestock, especially, intensive pig farming operations, produces a large amount of biological waste which can become harmful to human health [3].

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Moreover, farmers' inability to recognize that proper disposal of pig waste has inherent negative effects resulting in a rise in environmental pollution and negative health outcomes to farmers, workers and individuals residing near these farming operations [1].

There is high demand for pork products because of its lower cost and preferential taste in Trinidad. To meet this demand with limited infrastructural resources farmers have developed their intensive commercial units/systems in confined building units. Farmers thus rear large amounts of pigs in a confined space to maximize profits; such operations rear pigs from birth to butchering. This process has benefited the Trinidad population with greater accessibility to pork and pork products.

As the intensity of the rearing process increases, there has been a rise the production of odours as a result of the large quantity of pigs being reared in a small area with limited land space; not preferred for these types of operations [4]. The handling and storage of waste at intensive pig farming operations have further compounded the rise of malodours. These malodours develop from urine, anaerobic decomposition of faeces, spilled feed and, fresh and decaying faecal matter [5, 6]. Gases, which are distinct to pig farming operations, are ammonia (NH_3) and Hydrogen Sulfide (H_2S). These have been shown to produce adverse health events among individuals whom are exposed to these substances for a prolonged period of time. Reynolds et al reported that these gases are commonly above the environmental regulated standards globally and they pose the biggest threat to human health[7]. Pig farming operations are a major source of ammonia emissions which are typically formed in animal housing buildings, manure storage ponds, open feed fields [1, 8-13].

Studies have shown that there are several ill effects which are associated with high exposures to ammonia. These include; coughing, wheezing, nasal complaints, eye irritation and skin malformations. Furthermore, frequent exposure to high levels of ammonia also has been shown to be associated with the development of severe pulmonary illnesses which has inept implications to long term morbidity and possibly mortality [14]. At times, ammonia produced from pig farming operations react with other pollutant gases to form fine particle pollutants which pose a serious public health threat which has been linked to impairment of lung function, cardiovascular health and more seriously premature death. Studies have shown arise of ammonia concentrations has led to an increase in the intensity of ammonia related odours which has increased health illnesses [15, 16].

Another potent gas produced from intensive pig farming operations is hydrogen sulfide which has longed been known to have a detrimental effect on human health. High exposures to this compound have been shown to lead to the development of incidental symptoms such as: nausea, dizziness, headaches, coughing, ocular irritation and difficulty with breathing. Further, studies have been shown that frequent high exposures of this compound are also associated with an increase in the incidence of comas and death [17]. The effect of hydrogen sulfide on the human system is inflammation of the moist membranes of the respiratory tract and eyes. Moreover, mood and neurological have been shown to be impaired due high exposures to hydrogen sulfide from intensive pig farming operations [18]. Exposure to low concentrations of this gas over time has been linked to impaired health outcomes due to the accumulation over a long period of time.

Presently, there are three large intensive pig farms in Trinidad and Tobago that produce approximately 90% of the pork produced locally. The Erin farm is the largest farm and is a vertically integrated farrow to finish operations and supplies 75% of the pork to Trinidad and Tobago's local market and also contributes to regional exports [19].

This study investigated the impact of malodour exposure on the physical health of a community residing near an intensive pig farming operation in a rural area of Trinidad.

Methods

There were two parts to this study. Firstly, the two main odour causing aerial emissions, hydrogen sulfide and ammonia were measured in the community surrounding an intensive pig farming operation which constituted the test area. This was accomplished using a MultiRAE® Gas Meter which detects the gases in parts per million. Secondly, the effects on the health and quality of life of residents around this farm were assessed using a survey methodology. Both parts were also repeated in a control area and population.

Research Design

The present study was that of a case-control design. The study was conducted in the south-west region of Trinidad and Tobago. The study area was separated into two research sites (experimental and control). The experimental area for the study, the village of Erin, is located within a 2000 metre radius from the pig farming operation. The control area was located approximately 5000m away from the nearest pig farming operation in the village of Palo Seco.

<u>Air testing</u>: The air samples were conducted over seven days in the month of April and June. The testing was done at 6 hour intervals over a 12 hour period from 6am to 6pm on each day.

Because the farm is also located close to the sea and experiences high wind conditions and high humidity at times during the day, sampling was done at dawn (sunrise) and sunset, when there were less air movements. The first sample was taken directly outside the farm. A further 4 readings was taken at 500 meter intervals radiating out from the last site. Temperature, humidity and wind speed were also noted, along with prevailing weather conditions on the days the tests were done.

The gases were measured using a multiRAE portable multi gas meter which measures a wide range of Volatile organic compounds, toxic and combustible gases and radiation. Presently the multiRae is the most advanced portable chemical detector of its kind that is available and it allows for speedy field testing with a high precision of accuracy [20]. In this study it was used to measure the ammonia and hydrogen sulfide levels. The meter was held at 2 meters from the ground which was representative of the breathing zone of most residents. The meter was turned on and the reading was allowed to stabilize before it was recorded.

The selection of participantsto be sampled in both the experimental and control group was done by systematic judgmental sampling according to method used by Keith Punch [21].

Sample size-A sample size of 86 residents for both the experiment and control groups was determined using a ninety five percent (95%) confidence level, a Z value of 1.96, a five percentage (5%) margin of error. The sample population consisted of two groups each with 86 possible respondents.

Experiment group-person's over the age of eighteen living within a 2,000 meter radius of the pig farm in Erin village.

Control group- people over the age of eighteen living in the same rural community but who live 5,000 meters and beyond the intensive pig farming activity. The control group, in the village of Palo Secohad, no other environmental concerns and appeared to posses similar socio-demographics as the experiment area.

Survey Instrument and administration

A paper based structured self-administered questionnaire was administered to residents from both the experimental and control area. The questionnaire comprised general socio-demographic questions to assess the physical health of respondents, and questions for respondents to assess the impact of malodours on respondents' everyday life.

The physical health section comprised of questions to assess the frequency of experience of 16 symptoms known to be associated high level exposure to ammonia and hydrogen sulfide such as headaches, nausea, dizziness, tiredness/fatigue, irritation of eyes/nose/throat, breathing difficulty, coughing, wheezing, sneezing, shortness of breath, blurred vision, sinus congestion, difficulty concentrating, pain and discomfort. Response categories were: Never (Score =1); sometimes (score = 2, and often (score=3).

Malodourimpact was assessed using four questions to characterise the odour, These questions focused on odour intensity, irritation, impact on well-being and intensity. Four point scale rating scales were used. These items were used in a similar study [22] which investigated the relationship between foul odours among non-farmers. Response categories were: Never (Score =1); sometimes (score = 2, and often (score=3).

Questionnaires were pretested and administered over a period of 24 weeks by a trained data collector.

Statistical Analysis

Data were analysed using SPSS v21. Means and standard deviations were used to describe continuous outcomes while percentages were used for categorical outcomes. Normality of continuous outcomes were assessed using the Kolmogorov Smirnov test. Comparisons of the levels of ammonia and hydrogen sulfide levels between the control and experimental areas were assessed using a paired sample t test. Differences between socio-demographic and lifestyle variables were assessed using Chi-square.

A physical health score for each respondent was computed by summing the scores obtained from the frequency of symptoms experienced. Individual scores could range between 16- 48.

An odour impact score was calculated for each respondent by summing the scores obtained from responses to four statements if respondents said "yes" to the screening question: 'Do you detect an odour in the air ? The four statements were: How would you describe the odour; How intense is the odour?; Is the odour irritating?; How much does the odour affect our everyday life ?". Individual scores could range between 4-18.

A multiple regression model was constructed with gender, age, smoking habit, length of time living in the area, time spent outdoors and malodour intensity score to study their influence on physical health of respondents.

Results:

Study Area Analysis

A paired t test was used to compare the values of ammonia and hydrogen sulfide found in the Erin and Palo Seco which were sampled 42 times. In the test area, the means for NH_3 and for H_2S was 0.92 ppm and 1.19ppm respectively, whereas the means for both gases in the control area were recorded at 0 (Table 1). Results indicated the presence of both gases only in the test area and a significant difference in levels between the experiment and the control area.

Description of Study Population

The study population comprised 176 participants equally distributed (N= 86) between study area sites. The majority of the sample (Table 2) was under the age of 39 years with most participants living in their area for over 20 years, did not smoke and who spent more than 3 hours per day outside their homes. There were no significant ($p>0.05$) differences between socio-demographic factors across study areas.

Frequency of symptoms experienced

Once established that the gases and odour was present in the test area of Erin, symptoms exhibited by residents were investigated. Table 3 shows the percentage of reported cases of each symptom in both sampled communities of the experimental and control. From the table it can be seen that the test population of farm residents reported a higher occurrence of all symptoms except for dizziness.

The residents close to the farm were found to have a higher occurrence of headache, nausea, tiredness, exhaustion, eye, nose and throat problems, breathing problems, coughing, wheezing, sneezing, shortness of breath, blurred vision, sinus congestion, difficulty concentrating, pain and general discomfort than the control population. This would suggest that the control population is in better physical health than the farm residents and this could be related to the area in which they live.

In looking at individual symptoms, headache also appeared to be the most prevalent symptom reported by the test population whereas cough appeared to be the most prevalent in the control population. The least prevalent for the test population appeared to be blurred vision and the least prevalent for the control appeared to be wheezing.

Differences in symptoms ratings across study areas.

Table 3 also presents the mean symptom score rating across participants residing in different study area sites as well as significant differences tests. Participants residing in the experimental area reported significantly ($p<0.05$) higher rating symptom scores for headaches, nausea, irritation of eye/nose/throat, wheezing, sneezing, shortness of breath, difficulty concentrating and discomfort compared to participants residing in the control area.

Table 4 describes a simple and multiple linear regression models which describe the relationship between explanatory variables and physical health. Unadjusted models showed in a positive association between physical health scores and malodour scores (β= 0.954;

p=<0.001). Individuals residing in the experimental area were also seen to have a significant positive association with a higher severity of physical health symptoms compared with persons residing in the control area (β= 3.081; p=0.004). Conversely, a significant negative association was observed with smokers as compared to non-smokers (β= -2.446; p=0.009). In the adjusted model; it was observed while controlling for study area location, smoking status age, and gender, there was a statistically significant relationship between malodour rating score and physical health symptom rating scores (β= 0.948; p=<.001). Smokers were seen to have significantly reduced rating for their physical health symptoms as compared to non-smokers (β= -2.973; p=0.046).

Discussion

Understanding the relationship between physical health and malodour exposure among individuals living near intensive pig farming operations in Trinidad will be increasingly important as these operations become more popular within the Caribbean as a means of increasing pork production. There are distinct implications to the overall human and environmental health which if left unmanaged can lead to adverse outcomes in the future. We found that ratings for headaches, nausea, irritation of eye/nose/throat, wheezing, sneezing, shortness of breath, difficulty concentrating and discomfort were increased among participants living near pig farming operations. Our study also found that there was a direct relationship between malodour exposure and the severity of adverse physical symptoms associated with malodour exposure.

We are unaware of any previously published study which has sought to link overall symptom health and odour ratings, there is has been consistent literature which has documented this relationship using individual symptom in relation to malodour rating [23-26]. Several studies have also found that hazardous waste site neighbours who are exposed exclusively to malodours via air-borne transmissions did not have more adverse health outcomes as compared to control neighbourhoods [27]. On the other hand out study found that person living near these pig farming operations experienced higher severities of symptoms as compared to their control counterparts. This may be attributed to the fact that individuals residing near these operations may have been exposed for a pro-longed period of time.

Although the prevalence odour-related symptoms and odour perceptions may indicate higher exposures to high exposures to malodours, this has not always been the case as was demonstrated in previous studies. The odour threshold of industrial hydrogen sulfide has a magnitude lower than the level known to cause adverse symptoms by toxicologic or irritative mechanisms; however symptoms are often reported at exposure levels barely exceeding the threshold [28, 29]. Concentrations known to elicit adverse outcomes have been those seen in highly chemical and hazardous waste materials used for various industrial processes. In a study by Satin and colleagues found that neighbours who resided near an industry with high levels of sulphur related compounds could not distinguish these from a control area which had substantially lower levels of these compounds [30].

The levels of ammonia and hydrogen sulfide found in the test community were low compared to international standards however caution should be taken due to persistent effect of these gases to elicit adverse health outcomes. Furthermore, in a study by Merchant and colleagues found that low levels of ammonia and hydrogen sulfide may cause negative health problems [31]. These findings are consistent with the results generated from the present study with the presence of health problems such identified: respiratory irritation, severe cough, eye, nose and throat irritation while hydrogen sulfide was found to cause headache, nausea, dizziness, difficulty concentrating and blurred vision. Prolonged exposure to these gases with continued worsening of symptoms identified may lead to decreased lung function, development of pulmonary related diseases, edema, mental disorders and hindered olfactory disorders. Of major concern is the potential impact to vulnerable populations such as paediatric and the geriatric populations.

This study is not without its strengths and limitations. We are unaware of previously published study which has examined the impact of malodour exposure on physical health in the Caribbean especially in Trinidad and Tobago. We were able to physically measure environmental pollutants which are produced from intensive pig farming operations; however this was only measured during a specified time period and was not measured longitudinally. The instrument used to measure these pollutants had a low specificity therefore the levels ammonia and hydrogen sulfide may have been lower than what was measured. The study was that of a cross-sectional study which is unable to establish a temporal relationship between the outcome and exposure of interest because of the lack of longitudinal data. Odour rating and presence of symptoms were solely based on self-reporting from participants who may have suffered from either under or over reporting of rating characteristics. Furthermore, odour as a measure of malodour exposure should be interpreted with caution because it also captures information on numerous other pollutants with odorant properties which we were unable to quantify for this study.

Conclusion

In a community based, cross-sectional study of participants residing near intensive pig farming operations, we found associations between malodour exposures and increased severity of adverse health-related symptoms. Our findings complement the large body of existing literature and as well address the gap of research in the Caribbean region. Exposures of malodours do appear to tend increase the severity of adverse symptoms which can have future implications to the development fatal conditions later on in the life course among residents living near these operations who are unwillingly exposed at their homes. Effectiveness interventions, policies and regulations should be instituted to address this problem by regulatory agencies locally, regionally and internationally. Consideration must be taken for the residents who may be of low socioeconomic statues who may not be able to afford air conditioning, clothes dryers and access to clean amenities and surroundings. Most industrialized pig farming operations are located in low income rural communities that have limited financial resources to prevent the influx of harmful gases protruding their community and as well cover costs associated with ill health from these emissions. Authorities should consider health is not merely the absence of disease but also includes a state of well-being which is affected by these malodours. Public and environmental health professionals should conduct social and health assessments of these communities and develop effective interventions to eliminate these health disparities.

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Table 1: Results of paired t test for ammonia and hydrogen sulfide levels in Erin (Experimental Area) and Palo Seco (Control Area)

		n	Mean ± Standard Deviation	t	df	p-value
Pair 1	Ammonia levels in Experimental	14	0.92 ± 0.21	16.28	13	<0.001
	Ammonia levels in Control	14	0.00 ± 0.00			
Pair 2	Hydrogen sulfide levels in Experimental	14	1.19 ± 0.25	17.75	13	<0.001
	Hydrogen sulfide levels in Control	14	0.00 ± 0.00			

*p<0.05

Table 2: Socio-demographics of Study Population by Study Area

Variables	Experimental Area n (%)	Control Area n (%)	p-value
Gender			
Male	40 (46.51)	45 (52.33)	
Female	46 (53.49)	41 (47.67)	0.446
Age			
18-28	30 (34.88)	22 (25.58)	
29-39	29 (33.72)	29 (33.72)	
40-50	19 (22.09)	28 (32.56)	
>50	8 (9.30)	7 (8.14)	0.388
Smoking Status			
Smoker	34 (39.53)	23 (26.74)	
Non-Smoker	52 (60.47)	63 (73.26)	0.075
Length of time living in area			
Less than 1 year	6 (6.98)	10 (11.63)	
1-10 years	7 (8.14)	4 (4.65)	
11-20 years	24 (27.91)	33 (38.37)	

>20 years	49 (56.98)	39 (45.35)	0.224
Time spent outdoors			
Two hours	20 (23.26)	10 (11.63)	
Three hours	32 (37.21)	36 (41.86)	
> Three hours	34 (39.53)	40 (46.51)	0.132

Table 3: Percentage of reported health symptoms and mean symptom rating scores in Study areas

Reported Health Symptoms	**Experimental Area % Yes**	**Control Area % Yes**	**Experimental Area Mean symptom rating score**	**Control Area Mean symptom rating score**	**P value**
Headache	87.36	70.93	2.27	1.78	0.009*
Nausea	59.23	43.02	1.34	0.91	0.014*
Dizziness	33.33	39.47	0.77	0.79	0.888
Tiredness	71.26	60.47	1.60	1.38	0.212
Exhaustion	72.41	59.3	1.65	1.37	0.124
Eye, nose and throat problems	45.98	24.42	1.07	0.53	0.002*
Breathing problems	45.98	45.35	1.00	0.97	0.841
Cough	78.16	75.58	1.78	2.16	0.314
Wheezing	48.28	15.12	1.09	0.35	<0.001*
Sneezing	79.31	62.79	1.87	1.49	0.036*
Shortness of breath	55.17	26.74	1.23	0.60	<0.001*
Blurred vision	20.69	16.28	0.47	0.35	0.382
Sinus Congestion	54.02	48.84	1.29	1.13	0.394
Difficulty Concentrating	47.06	23.26	1.18	0.49	<0.001*
Pain	36.78	32.56	0.82	0.70	0.475
General Discomfort	45.98	20.93	1.13	0.47	<0.001*

$p < 0.05$

Table 4: Linear Regression of Selected Factors and Malodour Rating Score on Physical Health among Study Participants

Variable	Unadjusted β	p-value	Adjusted β	p-value
Malodour Rating Score	0.954	<0.001*	0.948	0.001*
Gender				
Male	Reference		Reference	
Female	1.097	0.309	1.031	0.537
Age (years)				
18-28	Reference		Reference	
>50	2.241	0.101	3.813	0.053
Smoking Status				
No	Reference		Reference	
Yes	-2.446	0.009*	-2.973	0.046*
Study Area				
Control	Reference		Reference	
Experimental	3.081	0.004*	N/A	N/A

*Dependant Variable= Physical Health Symptom Rating Score; *p<0.05; N/A= Not applicable due to perfect fit.*