

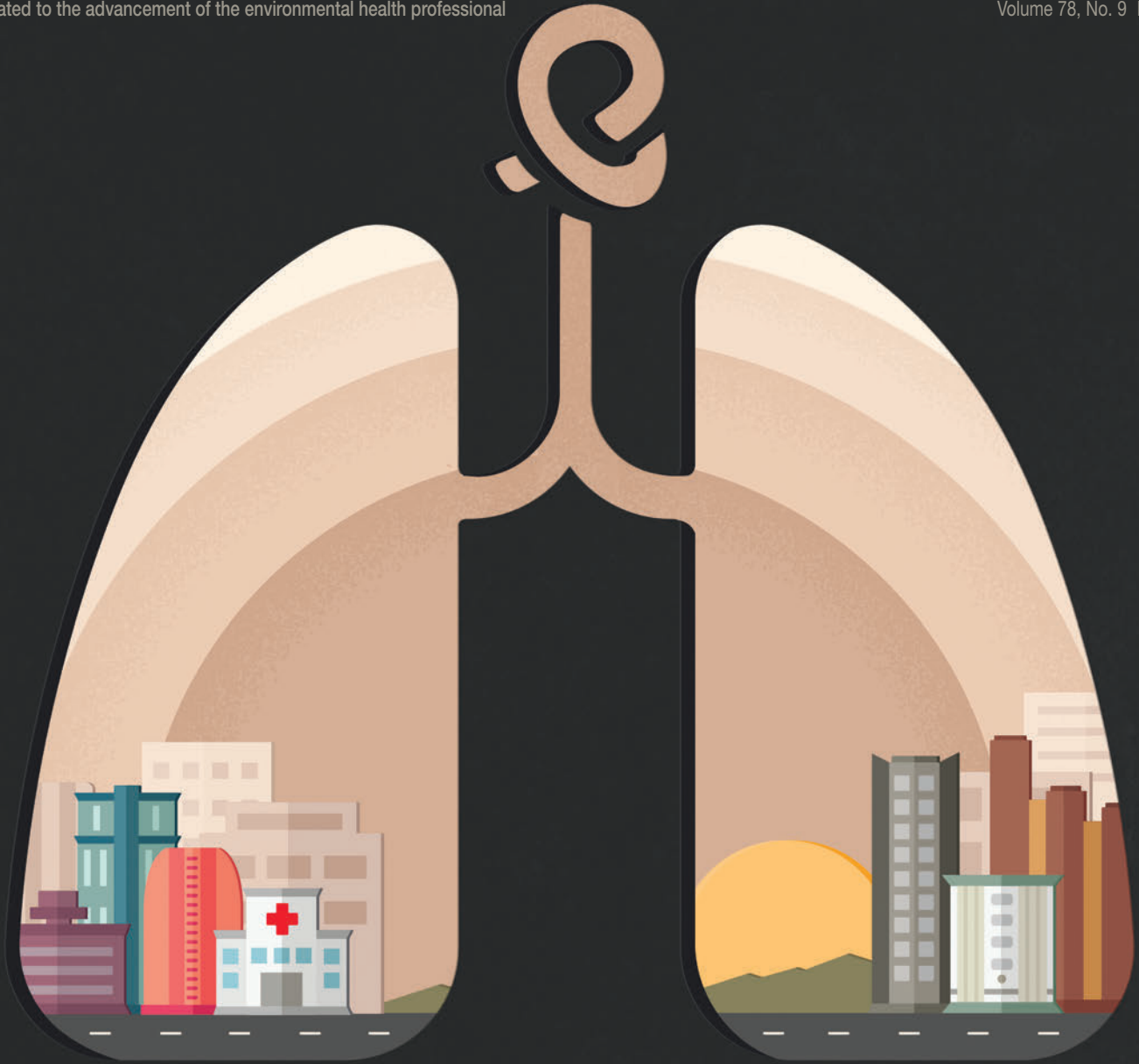
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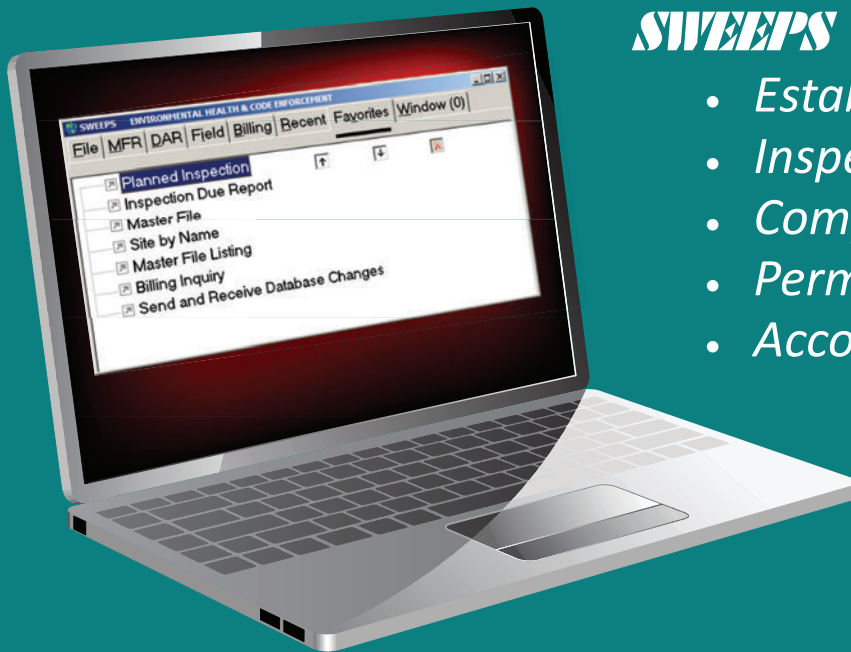
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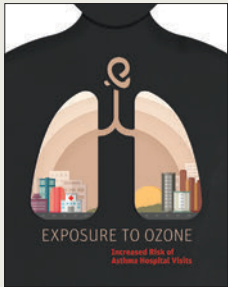
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**ABOUT THE COVER**



In this month's cover feature, "Association Between Asthma Hospital Visits and Ozone Concentration in Maricopa County, Arizona (2007–2012),"

the authors evaluated the association between asthma hospital visits and ozone concentrations using time plots and distributed lag non-linear models while accounting for potential confounders including temperature and day of the week. The findings suggest exposure to ozone is associated with increased relative risk of asthma hospital visits lasting several days.

See page 8.

Cover illustration © Cognition Studio, Inc.

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## ► PRESIDENT'S MESSAGE



Bob Custard,  
REHS, CP-FS

## Lead From Where You Are

From time to time colleagues tell me that they are looking for an opportunity to be promoted into a leadership position. I ask them if they mean they want to be a leader or if they are seeking a position in management that has more responsibility and authority. I go on to explain that being a leader is not at all dependent on position.

In fact, the history of environmental health is replete with leaders who emerged from obscurity and made an enormous difference. For example, consider Lemuel Shattuck (1793–1859). Shattuck was a school-teacher and bookseller with a great interest in genealogy and vital statistics. In 1845, he organized a census of Boston. (Later, the U.S. Census Bureau adopted many of his methods.) He was appalled by the high mortality rate, especially among children and women giving birth. Review of birth, marriage, and death records for Boston neighborhoods revealed significant disparities in life expectancy between working class neighborhoods and more affluent neighborhoods. To address this issue, Shattuck convinced the state legislature to appoint a commission to conduct a sanitary survey of Massachusetts.

The commission, with Shattuck as its chairman, completed its survey and published the *Report on the Sanitary Condition of Massachusetts* in 1850. The commission concluded that sanitary conditions affected the mortality rate and recommended the creation of a state health department and local boards of health in each town. The local boards of health Shattuck and the commission envisioned would be responsible for

*Being a leader  
is not at  
all dependent  
on position.*

- developing environmental health ordinances,
- appointing inspectors to identify offensive sanitary conditions,
- conducting periodic sanitary surveys of communities, and
- carrying out public works projects to improve sanitary conditions.

Sadly, like many pioneers, Shattuck was ahead of his time. The recommendations of Shattuck's commission were not implemented in Massachusetts for many years. The commission's report, however, provided a public health framework for others to follow over the next hundred years as the science of environmental health developed. Shattuck, as a volunteer with no medical or environmental health training, led from where he was.

Another great example of environmental health leadership is Ann Reeves Jarvis (1832–1905). Jarvis was a stay-at-home mother and lived in a rural area of Virginia (now West Virginia) prior to the Civil War. She had 13 children. Tragically, nine of her 13 children died before reaching adulthood, many of them from infectious diseases such as measles, typhoid fever, and diphtheria.

The loss of so many of her children in epidemics that were common at that time in rural Appalachian communities inspired Jarvis to take action to address unsanitary conditions and to prevent infectious childhood diseases. In 1858, Jarvis organized women in five communities near where she lived into Mothers' Day Work Clubs. Club members visited households in their communities to educate mothers and their families about improving sanitation. They developed a program to inspect milk for wholesomeness. If a mother suffered from tuberculosis or other health problems, the local club raised money to buy medicine or hired women to assist the ill mother with household chores.

After the start of the Civil War in 1860, the area where Jarvis lived was deeply divided with neighbors joining both the Union and Confederate armies. Jarvis convinced her clubs to declare their neutrality in the conflict and to provide aid to ill soldiers on both sides. Members of Jarvis' clubs nursed soldiers quartered nearby when typhoid fever and measles broke out in their camps. The Mothers' Day Work Clubs also clothed and fed soldiers in need. After the Civil War, Jarvis worked tirelessly to heal her divided community and bring reconciliation between the soldiers who had recently fought each other in the many bloody battles and skirmishes in the area.

Jarvis saw environmental health needs in her community and, with no formal medical or environmental health training, tackled them head on. In 1907, Jarvis' daughter organized a private commemoration to celebrate the life of her mother. Today we celebrate Mother's Day each year in May to recognize

devoted mothers everywhere. Few people know that Mother's Day began as a celebration of the life for Jarvis, an obscure environmental health hero who worked tirelessly to improve sanitation in rural West Virginia.

So, what can we learn about leadership from Shattuck and Jarvis? To me, seven things stand out about these two individuals.

1. Shattuck and Jarvis cared deeply about their communities. Each was willing to selflessly invest themselves in helping others. Neither one of them sought position, power, wealth, or recognition. Both of them embodied the characteristics of servant leaders.
2. Shattuck and Jarvis saw specific problems in their communities and took ownership of them. The world is full of people who see problems and say, "Somebody ought to...." Shattuck and Jarvis identified problems and concluded, "I ought to...."
3. Shattuck and Jarvis realized that they did not know how to solve the problem and made a commitment to educate themselves on the causes of child and maternal mortality. Shattuck learned from the efforts of sanitary reformers in England and other parts of Europe. Jarvis consulted her brother, a physician who had worked to control outbreaks of typhoid fever in their area.

4. Shattuck and Jarvis took decisive personal action. Many people have great ideas. Far fewer have the gumption and grit to roll up their sleeves and implement them.

5. Shattuck and Jarvis clearly articulated a vision for a better future. Their passion inspired people who had previously accepted things as they were to share their vision. They persuaded others of the necessity of change.

6. Shattuck and Jarvis organized and motivated people in their communities to work for change. As leaders they led by example. Sadly, although Shattuck was successful in organizing support for the study of sanitary conditions in the Boston area, he failed to win support for implementation of the study's sweeping recommendations for reform. Perhaps his report proposed more change than the state government could accept at one time. In contrast, Jarvis created small teams of women and led them to successfully make incremental changes in the surrounding communities.

7. By definition, leaders of change challenge the status quo. Shattuck and Jarvis led without fear of failure or criticism. Their courage to persevere, despite the naysayers around them, marked them as true leaders.

They instinctively knew what my friend Larry Gordon often says, "Dogs never bark at parked cars."

Leaders are not focused on what is in it for them, but rather on solving problems for the common good. Leaders identify problems, take personal ownership of them, and then act decisively to solve them. Leaders inspire others with their vision for a better future and motivate them to join in the work.

There is a vast difference between being a manager or supervisor and being a leader. You can be a leader where you are right now. No promotion is required. Problems needing resolution (opportunities) and good ideas needing implementation are all around you. Pick an issue you are passionate about and take action. That is how environmental health heroes are born. 🐶

*Bob Custard*

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P.S. Don't forget to tell Jarvis' story at the dinner table on Mother's Day. You can read more about her at [https://en.wikipedia.org/wiki/Ann\\_Jarvis](https://en.wikipedia.org/wiki/Ann_Jarvis).

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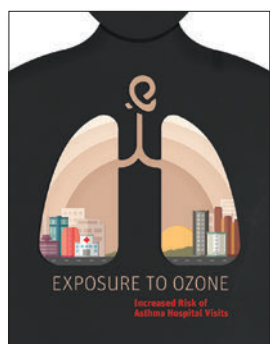
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# Association Between Asthma Hospital Visits and Ozone Concentration in Maricopa County, Arizona (2007–2012)

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**Abstract** The objective of this study was to evaluate the association of asthma hospital visits with ozone concentrations in Maricopa County, Arizona. We used time plots and distributed lag nonlinear models to achieve these objectives while accounting for some potential confounders including temperature and day of the week. A total of 90,381 asthma hospitalizations were retrieved from the dataset (daily median = 39, range: 8–122). Asthma hospitalizations were highest in 2008 (16,949), during the months of November through December, and lowest in 2011 (13,213), during the months of June through July. By contrast, the average daily ozone concentration ranged from 27.05 parts per billion (ppb) in 2012 to 30.15 ppb in 2008 and from 13.96 ppb in December to 40.58 ppb in May. The association between asthma hospitalizations (relative risk [RR/per 10 ppb increase of ozone]) start at ~1.046 (95% confidence interval [1.029, 1.064] at lag 0) and gradually decrease over several days. Our findings suggest exposure to ozone is associated with increased RR of asthma hospital visits in Maricopa County lasting several days. This study used recently developed methods that are freely available and could be used to evaluate other health events that are measured over time.

## Introduction

Asthma is a chronic disease that affects a considerable number of adults and children. It has been a growing public health challenge in industrialized countries for the last few decades where it has reached epidemic levels, despite the introduction of new medications (Eder, Ege, & von Mutius, 2006; Le Moual et al., 2013). While there is a general consensus that, based on available data, the prevalence of asthma has been on the rise in western coun-

tries, the underlying causes of this increase are much less clear. On the one hand, it could be partially attributed to the advent of diagnostic tools and improved reporting; on the other hand, the role of air pollution, other environmental factors, genetics, and lifestyle changes cannot be ignored (Ebi & McGregor, 2008; Sheffield, Knowlton, Carr, & Kinney, 2011). Nonetheless, based on available evidence, it is now accepted that air pollution is a risk factor for asthma (Oosterlee, Marjon, Lebret, &

Brunekreef, 1996; Venn, Lewis, Cooper, Hubbard, & Britton, 2001). Not only has this effect been found to be statistically significant, the biological mechanism through which exposure to air pollutants exacerbates the severity of asthma symptoms has been explained (Ciencewicki, Trivedi, & Kleeberger, 2008; Gent et al., 2003; Slaughter, Lumley, Sheppard, Koenig, & Shapiro, 2003).

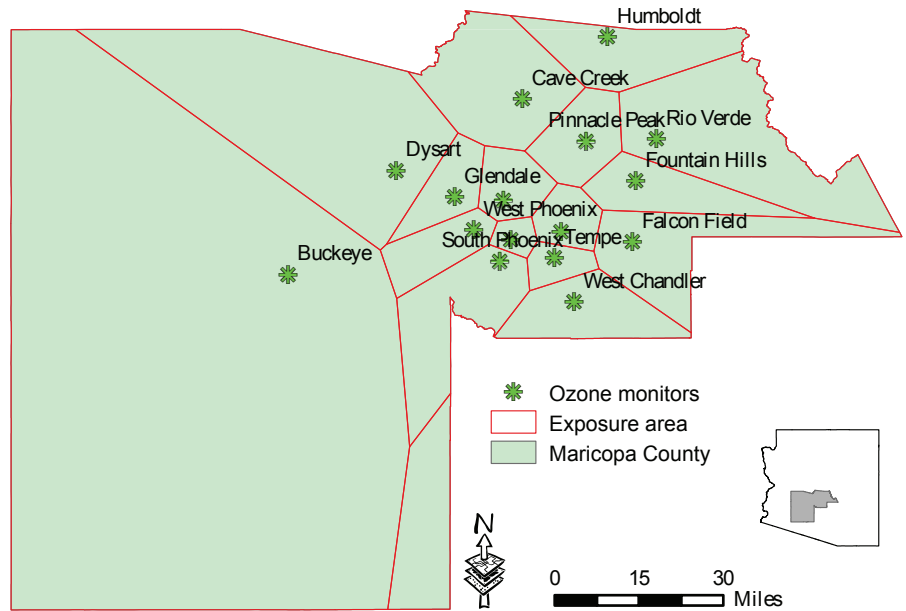
Ozone is one of the pollutants that was found to be associated with increased risk of asthma hospitalizations and deaths in studies worldwide, including in the United States (Babin et al., 2007; Centers for Disease Control and Prevention, 2014; Delfino, Gong, Jr., Linn, Pellizzari, & Hu, 2003; Delfino et al., 2014; Jerrett et al., 2009; Mortimer, Tager, Dockery, Neas, & Redline, 2000). Additionally, ozone was found to be associated with development of new asthma cases in some studies (Künzli et al., 2009; McDonnell, Abbey, Nishino, & Lebowitz, 1999; Modig, Torén, Janson, Jarvholm, & Forsberg, 2009).

Although there is a general consensus in the literature on the adverse effect of ozone on asthma symptoms and hospitalizations (Burnett, Brook, Yung, Dales, & Krewski, 1997), some studies have produced inconclusive or conflicting results. This discordance is not completely unexpected and can be partly explained by differences in study population, designs, and analytic approach (Akinbami, Lynch, Parker, & Woodruff, 2010; Delamater, Finley, & Banerjee, 2012). Several studies have examined the association between asthma hospitalizations and/or emergency department visits in some metropolitan areas including Los Angeles and Seattle because



FIGURE 1

**Geographic Distribution of Location of Ozone Monitors Throughout Maricopa County With Illustration of Thiessen Polygons Used to Identify Ozone Exposure Areas for Each Monitor**



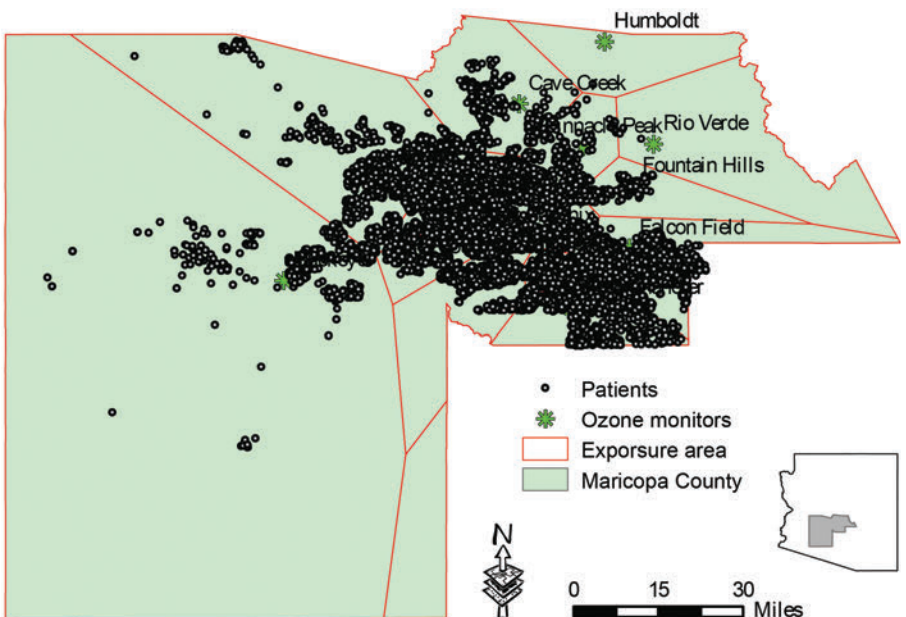
of the known link between air pollution in highly populated areas and asthma hospital visits and admissions (Akinbami et al., 2010; Delamater et al., 2012).

Maricopa County has grown considerably in the recent decades from less than a million inhabitants to one of the most populous counties in the nation with close to four million residents (U.S. Census Bureau, 2013). This rapid growth probably was accompanied by a comparable increase in traffic volume producing high levels of volatile organic compounds, which are one of the main precursors of ozone (Ebi & McGregor, 2008; Hodnebrog et al., 2012). Consequently, epidemiological studies have found a higher risk of asthma hospitalizations and admissions among those living in close proximity to highways and streets with high traffic volume (Oosterlee, Drijver, Lebet, & Brunekreef, 1996; van Vliet et al., 1997). Given this reality and the fact that the Phoenix metropolitan area is among the most polluted cities in the nation (American Lung Association, 2013), it is important to examine the potential effect of ozone level on hospital visits and admissions among Maricopa County residents.

Therefore, the objective of this study was to evaluate the association between ozone concentration and asthma hospitalization from inpatient hospitalizations and emergency department visits in Maricopa County for the period from January 2007 through December 2012.

FIGURE 2

**Geographic Distribution of Asthma Patients Visiting Hospitals in Maricopa County (2007–2012)**



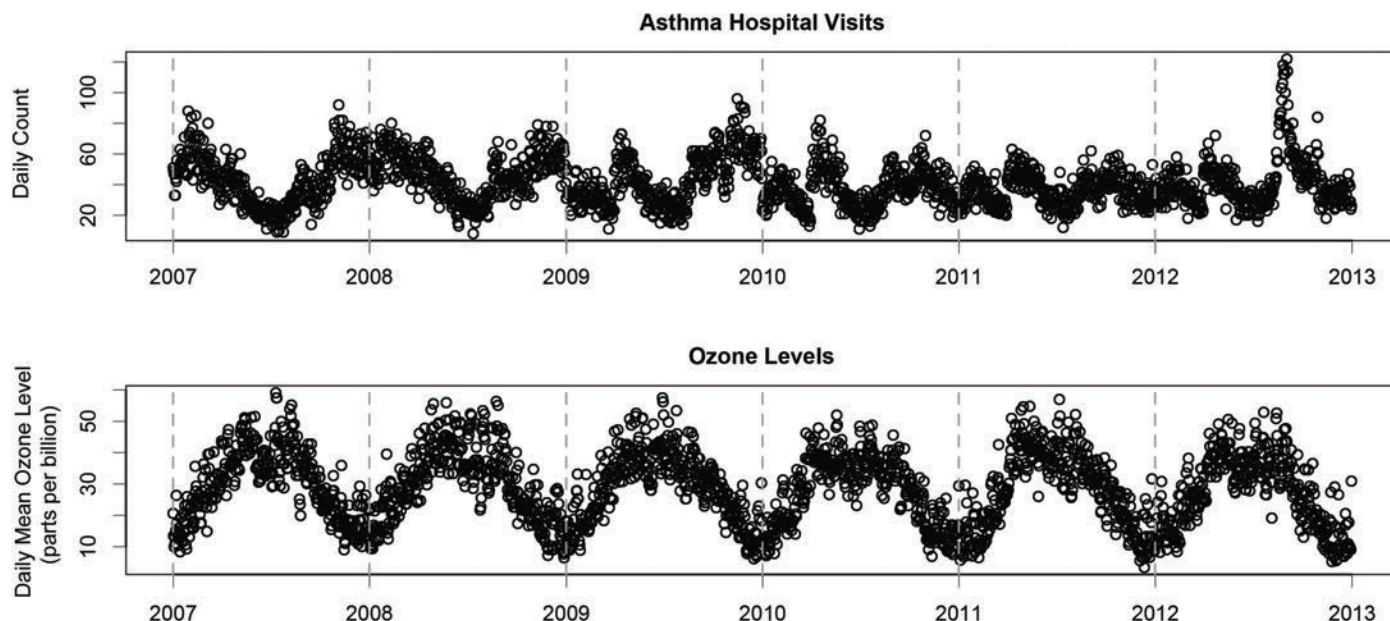
**Materials and Methods**

**Data Sources**

Inpatient and emergency department visits occurring in Maricopa County with an asthma diagnosis code (49300, 49301, 49302, 49310, 49311, 49320, 49321, 49322, 49381, 49382, 49390, 49391, and 49392) from January 1, 2007, through December 31, 2012, were extracted from the hospital discharge database accessible to the Maricopa County Department of Public Health. Extracted data include the date of visit (the day of the visit but not the time was available) and the patient's address, which was used to geocode the records. The Maricopa County Air Quality Department provided hourly ozone and temperature measurement from 16 monitoring stations distributed throughout Maricopa County urban and suburban areas (Figure 1).

FIGURE 3

**Time Plots of the Count of Asthmatic Patient Hospital Visits and Ozone Levels in Maricopa County (2007–2012)**



**Data Management**

Thiessen polygons were drawn around each air quality monitoring station to determine the most plausible source of exposure for each individual patient. Thiessen polygons are generated to ensure that any point (an asthma patient) inside the polygon is closer to the polygon center (ozone monitor) than any other polygon center (ozone monitor) in the area. This approach was used to ensure that all patients were assigned an ozone reading from the closest monitor.

Mean daily ozone and temperature measurements were calculated from hourly measurements in preparation to merge them with patient data. Daily measurements were chosen to match the time scale of hospitalization records, which were available only in daily format. Patient data were then divided by location into subsets corresponding to each Thiessen polygon, as previously discussed. Each patient subset was merged with daily ozone and temperature data from the corresponding monitoring station by date, and all subsets were appended together to form the full dataset containing the patient’s admission date along with ozone and temperature

measurements. Lastly, the total patient daily counts indexed by visit date (days) and the overall daily mean of ozone and temperature measurement were calculated, along with the day of the week, to prepare the dataset for time-series analysis. Hospitalization records and ozone/temperature readings in two exposure areas (Cave Creek and Rio Verde) had very small numbers of asthma visits during the study period and therefore were excluded from the analysis (Figure 2).

**Statistical Analysis**

We used time plots and the distributed lag linear and nonlinear model (Bhaskaran, Gasparrini, Hajat, Smeeth, & Armstrong, 2013; Gasparrini, 2011) to evaluate the association between asthma hospital visits and ozone levels while accounting for trend, season, temperature, and day of the week. Time plots were used to illustrate the overall pattern over time. The association between the daily number of asthma hospital visits and ozone concentration was evaluated using a Poisson model, taking into account the effect of seasonality, long-term trend, temperature, and day of the week. Also, a lag component was

added to the model to evaluate how long the effect of ozone exposure on the number of asthma hospitalizations lasts. Distribution of the model residuals over time was checked for sign of anomalies or indications for deviation from the model assumptions.

**Results**

A total of 90,381 asthma hospitalizations were retrieved from the dataset (daily median = 39, range: 8–122). Asthma hospitalizations were highest in 2008 (16,949), from November through December, and lowest in 2011 (13,213) and from June through July (Figure 3). By contrast, the average daily ozone concentration ranged from 27.05 parts per billion (ppb) in 2012 to 30.15 ppb in 2008 and from 13.96 ppb in December to 40.58 ppb in May (Figure 3). Additionally, the median number of daily asthma hospitalized visits during weekdays [median = 39; range (16–115)] did not vary considerably from the number of visits during weekends [median = 40; range (14–122)]. Similarly, mean daily ozone concentration ranged from 29.34 ppb on weekdays to 30.09 ppb in weekends (Table 1).

TABLE 1

**Descriptive Statistics**

Variable	# of Observations	Mean	Median	SD	Minimum	Maximum
Asthma hospitalizations count (per day)	2192	41.23	39	15.37	8	122
Mean daily temperature (°F)	2192	74.05	73.7	15.9	35.11	102.62
Mean daily ozone (ppb <sup>a</sup> )	2192	28.67	29.53	11.39	3.37	59.09
Year					2007	2012

<sup>a</sup>ppb = parts per billion.

TABLE 2

**Ozone Coefficients and Relative Risk (RR) for Asthma Hospital Visit Counts Obtained From Poisson Model**

Model	Coefficient	SE	z-Score	p-Value	RR	95% CI <sup>a</sup>
Model 1 <sup>b</sup>	-0.051	0.007	-7.404	<.0001	0.95	0.937, 0.963
Model 2 <sup>c</sup>	1.046	0.009	5.107	<.0001	1.047	1.029, 1.065
Model 3 <sup>d</sup>	1.045	0.008	5.386	<.0001	1.047	1.029, 1.064

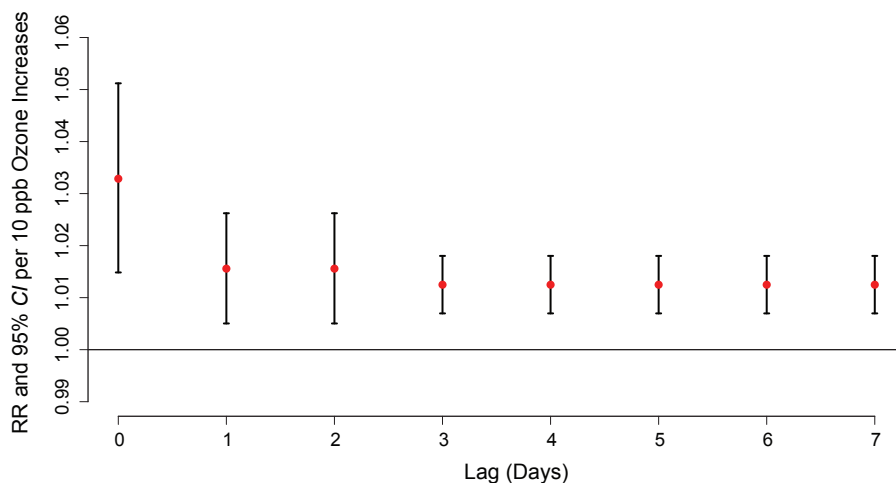
<sup>a</sup>CI = confidence interval.<sup>b</sup>Not adjusted.<sup>c</sup>Adjusted for trend and seasonality.<sup>d</sup>Adjusted for trend, seasonality, temperature, and day of the week.

The final model was Poisson regression with daily asthma hospitalization count as the dependent variable and ozone as the independent variable adjusted for temperature and day of the week (Table 2). There was a significant association between the daily count of asthma hospitalizations and ozone concentration with a relative risk (RR) of 1.046; 95% confidence interval [1.029, 1.064] or equivalently 4.6% for every 10 ppb increase in ozone level. The ozone effect seemed to decrease gradually after the first day of exposure and level off by lag day 5 (Figure 4).

**Discussion and Conclusions**

Our findings suggest that ozone level is positively associated with asthma hospital visits and that this effect lasts for several days after the exposure. Our results are in agreement with other studies that reported comparable, but slightly varying, effect size or RR estimates (Barnett et al., 2005; Cakmak, Dales, & Coates, 2012; Fauroux, Sampil, Quenel, & Lemoullec, 2000; Holmen et al., 1997). These variations are not surprising and probably could be due to the differences in study population and statistical modeling methods (Akinbami et al., 2010; Delamater et al., 2012; Mar & Koenig, 2009). For instance, a study conducted in Seattle reported an approximate 10% increase in asthma emergency department visits per 10 ppb increase in ozone, which may seem substantially higher from the estimate (RR = 4.6%) reported here in Maricopa County. A closer look, however, reveals that the Seattle study used data only from May through October, months characterized by high ozone levels, which may explain the higher RR estimates.

FIGURE 4

**Relative Risk (RR) of Asthma Hospital Visits in Maricopa County for Ozone Lags 1–7**

CI = confidence interval; ppb = parts per billion.

Maricopa County has been growing noticeably over the past decades and its ozone concentrations often exceed the national ambient air quality standards (NAAQS). Accordingly, it is important from a public health standpoint to estimate the effect of ozone concentrations on asthma hospital visits. This is the first study, to our knowledge, to evaluate this effect in Maricopa County.

Two of the main challenges in environmental and time-series analysis pertain to the method of exposure assessment and the time scale of the analysis. To increase the validity of the exposure variable and account for geographic variation, we chose to assign individuals to the closest air monitoring station rather than use a countywide average over all stations. We were particularly interested in the lag time from exposure to hospitalization, so we wanted to use a finer time scale than monthly or weekly. Additionally, the hospitalization information did not have time of admission, which prevented us from examining a time scale smaller than daily.

The range of daily average ozone measurements reported in this study was within the acceptable standards set by the U.S. Environmental Protection Agency (U.S. EPA). Data presented here, however, are based on a daily average, which is an aggregation of the hourly

recordings. This means that an individual station could have exceeded the U.S. EPA limit at a given hour of the day and that would not be discernable from the data presented here. In fact, there were 12 high ozone days (8-hour maximum ozone >75 ppb) in the Phoenix metropolitan area in 2012 alone.

Similarly, the daily number of asthma hospital visits probably varied by admission type, age groups, and other demographic characteristics not considered here. It has been reported, however, that for asthma and respiratory disease, children are more sensitive to ozone concentrations compared with adults (Delfino et al., 2014; Künzli et al., 2009; Oosterlee et al., 1996) and were probably affected disproportionately (Mar & Koenig, 2009). Day of the week did not have any considerable effect on the asthma RR, indicating that ozone's persistence in the ambient environment does not—in general—vary by different day of the week over our study area. This is supported by known temporal dynamics of ozone, which tends to follow a diurnal pattern within urban areas, even on weekends, and a more constant pattern in suburban and rural areas (Gregg, Jones, & Daws, 2003; Seinfeld & Pandis, 2006).

Currently, the NAAQS list ozone concentrations higher than 75 ppb in an 8-hour average

as unhealthy for sensitive groups. According to some advocate groups, however, the current standards need to be reviewed and updated (American Lung Association, 2013); this review is currently in progress by the U.S. EPA in accordance with requirements in the 1990 Amendment to the Clean Air Act (U.S. EPA, 1990).

Future areas for research include examining the number of high ozone days as well as the magnitude of ozone levels and their impact on asthma hospital visits among the local population. As with other hospital discharge data, it should be acknowledged that some asthmatic patients might not seek treatment at hospitals depending on the severity of their conditions and the influence of socioeconomic factors on healthcare access. Consequently, the actual number of people with asthma as well as the magnitude of symptoms experienced in Maricopa County is probably higher than reported here. 🐼

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# Associations Between Ultrafine Particles and Co-Pollutant Concentrations in the Tampa Bay Area

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**Abstract** Ultrafine particles (UFPs) are ubiquitous in urban air and have been recognized as a risk to human health. The aim of this study was to measure the relationships among ultrafine particles and other ambient air pollutants and meteorological factors in the Tampa Bay Area. This study measured continuous UFPs, black carbon, oxides of nitrogen ( $\text{NO}_x$ ), nitrogen dioxide ( $\text{NO}_2$ ), nitric oxide (NO), carbon monoxide (CO), ozone ( $\text{O}_3$ ), sulfur dioxide ( $\text{SO}_2$ ), particulate matter having an aerodynamic diameter of 10 microns or less ( $\text{PM}_{10}$ ), relative humidity, wind speed, and ambient temperature during January to March 2014. Moreover, the study compared the relationship between UFPs and various co-pollutants daily, including during morning rush hour periods. This study found a moderate correlation among UFPs and black carbon,  $\text{NO}_x$ ,  $\text{NO}_2$ , and NO during hourly continuous measurements and rush hour periods, and a low level of correlation among UFPs and CO,  $\text{O}_3$ ,  $\text{SO}_2$ ,  $\text{PM}_{10}$ , relative humidity, wind speed, and ambient temperature. This study indicates that co-pollutants should not be used as a surrogate to assess the human health risk from ultrafine particles exposure.

## Introduction

Ultrafine particles (UFPs) are defined as particles that have a size  $\leq 100$  nanometers in diameter ( $\leq 100$  nm or  $\leq 0.1$   $\mu\text{m}$ ). They are an essential component of atmospheric particulate pollution and are a part of larger particulate air pollutants (particulate matter 10 microns or less [ $\text{PM}_{10}$ ] and 2.5 microns or less [ $\text{PM}_{2.5}$ ] in diameter). Based on their size, UFPs contribute little to the mass concentration of particulate matter in the ambient air, but they are a dominant contributor to the particle number (Health Effects Institute Review Panel on Ultrafine Particles [HEI], 2013; Kumar et al., 2014; Morawska,

Bofinger, Kocis, & Nwankwoala, 1998; Oberdörster, 2001). UFPs, which are a part of  $\text{PM}_{10}$ , likely are responsible for the adverse health effects of ambient  $\text{PM}_{10}$  and may also be associated with occupational exposure and related health hazards (Donaldson, Stone, Clouter, Renwick, & MacNee, 2001).

Several epidemiological and experimental studies have demonstrated the significant health outcomes associated with exposure to ambient UFPs. Toxicological inhalation studies conducted by Oberdörster and co-authors (2000) and Elder and co-authors (2000a, 2000b) have suggested that UFPs can induce more toxic airway inflammation

on rats than larger (fine) particles of similar chemical composition and mass. An experimental study conducted by Stoeger and co-authors (2006) in mice found an increase in pulmonary toxicity associated with the surface area of UFPs. This dose-response assessment of UFPs suggests that the surface area concept is an important measurement to assess the inflammatory potential of UFPs. Various experimental animal studies have suggested that UFPs at high concentrations have the potential to induce airway inflammation (HEI, 2013). Experimental studies conducted by Li and co-authors (2003) demonstrated that UFPs are more potent among all particulate matters and can induce cellular heme oxygenase-1 (HO-1) expression and deplete intracellular glutathione. HO-1 expression is a marker of oxidative stress and is correlated with the high carbon and polycyclic aromatic hydrocarbon (PAH) content of UFPs. The HO-1 expression and the PAH content are also related to the reactive oxygen species (ROS) formation that induces oxidative stress on the macrophages and epithelial cells. Due to their size, UFPs easily penetrate tissue and localize in the mitochondria, where they can cause structural damage that in turn can induce oxidative stress on the cells. Li and co-authors (2003) also suggested that the biological potency of UFPs depend on the generation of redox cycling organic chemicals and their ability to damage mitochondria. The exact mechanisms of UFP-induced mitochondrial damage are not well understood, but one possibility is that ROS generated outside of a mitochondrion can damage organelles and allow for the passage of UFPs.

Khandoga and co-authors (2010) found that exposure to carbon UFPs of 72–74 nm in diameter for 24 hours showed thrombogenic effects in the vascular system of healthy mice without showing inflammatory activity in the respiratory system. Possible mechanisms of atherosclerotic activity of UFPs are attributed to decreased anti-inflammatory capacity of plasma high-density lipoprotein, and an increased level of systemic oxidative stress (HEI, 2013). These experimental studies have suggested that the UFPs' ability to penetrate tissues and induce oxidative stress makes UFPs more harmful on the cellular level.

Numerous epidemiological studies have shown that ambient particulate pollution is associated with adverse health effects (Donaldson et al., 2001). These adverse health effects are more significant in people who have pre-existing respiratory or heart diseases (Oberdörster, 2001). Penttinen and co-authors (2001) found that higher numbers of UFPs in the ambient air were associated with exacerbation of pre-existing cardiopulmonary illnesses. They also suggested that higher numbers of UFPs are negatively associated with peak expiratory flow among adult asthmatic patients. The studies, conducted in London on 60 adult asthmatic patients, suggested that UFPs are associated with a decrease in the forced expiratory volume in the first second and forced vital capacity, and increased airway inflammatory markers in sputum. Respiratory changes in these subjects were significantly associated with exposure to UFPs (McCreanor et al., 2007; Zhang et al., 2009). A small number of experimental human studies have shown that exposure to UFPs is associated with adverse health effects on the respiratory system ranging from a decrease in lung function to an increase in airway inflammatory responses.

There are few population-based studies that have examined the association between UFPs and mortality, and these studies have limitations because they measured only short-term exposure to UFPs and associated health effects. Stölzel and co-authors (2007) conducted a study in Erfurt, Germany, during 1995–2001 and found an association between UFPs and total mortality, and combined cardiopulmonary mortality for a 4-day lag period. Breitner and co-authors (2009), however, found an association for longer lag periods (i.e., 6 days and 15 days). In these studies, temporal effects of UFPs on daily mortality were examined

using lag models. The lag models were used to help estimate the exposure effects of UFPs on daily mortality over a period of time and allow the estimation of the cumulative effects of UFPs on the outcome of mortality instead of single-day exposure assessments (Zeka, Zanobetti, & Schwartz, 2005).

Delfino and co-authors (2005), in a review of different epidemiological studies, has suggested that high exposure to UFPs might induce systemic inflammatory response through oxidative stress responses to ROS, which eventually stimulates the formation of atherosclerosis. This can lead to acute cardiovascular system responses ranging from increased blood pressure to myocardial infarction. In 2009, the U.S. Environmental Protection Agency (U.S. EPA) published the final report on the "Integrated Science Assessment for Particulate Matter." The report reviewed approximately 40 published research articles during 2000–2009 to evaluate the effects of UFPs on human health. The report considered all toxicological studies' findings and suggested that evidence of a causal relationship between short-term exposure of UFPs and respiratory and cardiovascular health effects exists (U.S. EPA, 2009; HEI, 2013). Most of the studies to understand the emission, formation, and health effects of UFPs have been conducted in European cities (Kumar, Pirjola, Ketzel, & Harrison, 2013), with only a few conducted in U.S. cities (Kumar et al., 2014). Currently, there are no air quality standards for UFPs, so UFPs do not receive appropriate attention from regulatory agencies around the world (Kumar, Robins, Vardoulakis, & Quincey, 2011).

Atmospheric UFPs are generated from numerous sources, including the combustion of fossil fuel in motor vehicles, cooking, and other anthropological activities such as the burning of wood and other biomass. A major source of UFPs is automobile emissions in urban environments (Kumar, Robins, Vardoulakis, & Britter, 2010). The increase in urbanization and road traffic is expected to increase UFP exposure to the populace (Buccolieri, Sandberg, & Di Sabatino, 2010; Molnar, Janhall, & Hallquist, 2002; Zhu, Hinds, Kim, Shen, & Sioutas, 2002). In addition to the primary source of UFPs in the environment, a secondary source of UFPs is photochemical reactions in the atmosphere (Dunn et al., 2004; Van Dingenen et al., 2004; Wehner, Bir-

mili, Gnauk, & Wiedensohler, 2002). Secondary UFP formation is the result of nucleation and cluster/particle growth following condensation of photo-oxidized vapors occurring sometime after their primary emission (Dunn et al., 2004; Morawska, Ristovski, Jayaratne, Keogh, & Ling, 2008). Kulmala and co-authors (2004) showed that secondary UFP formation is significant in the summertime. Studies conducted by Shi (2003) and Birmili and co-authors (2003) also have suggested that UFP formation increases during the summer season. Secondary UFP formation intensifies in urban areas with high solar radiation, which is favorable for the nucleation process (Johnson, Ristovski, D'Anna, & Morawska, 2005; Moore, Ning, Ntziachristos, Schauer, & Sioutas, 2007). These findings show that automobile exhaust and biomass combustion are major sources of UFPs, with contribution from secondary processes.

Automobile exhaust and biomass burning are major sources of co-pollutants, like black carbon,  $\text{NO}_x$ , and CO in the ambient air (Cyrus et al., 2003; Hamilton & Mansfield, 1991; Kim, Shen, Sioutas, Zhu, & Hinds, 2002; Sandradewi et al., 2008). A study conducted in central Copenhagen found a significant correlation of UFPs with co-pollutants  $\text{NO}_x$  and CO (Wahlin, Palmgren, & Van Dingenen, 2001). In addition, the adverse health effects of UFPs are exacerbated in the presence of co-pollutants such as  $\text{O}_3$ ; several experimental animal studies have shown this also (Elder, Gelein, Finkelstein, Cox, & Oberdörster, 2000a; Oberdörster, 2001). Sardar and co-authors (2004) conducted a study in the Los Angeles area that found low to moderate correlation of UFPs and other gaseous co-pollutants. Reche and co-authors (2011) suggested that higher concentrations of  $\text{SO}_2$  might also favor the formation of UFPs in specific industrial or shipping areas in Europe. Secondary UFP formation increased during specific meteorological conditions such as extreme solar radiation, low wind speed, and low relative humidity (Rimnacova, Zdimal, Schwarz, Smolik, & Rimnac, 2011). Reche and co-authors (2011) found that the southern European cities show a higher nucleation process compared to northern Europe. This finding suggests that high sunshine level is a key factor in increasing secondary UFP formation in these cities. These studies have suggested that there are correlations between UFPs and gaseous co-pollutants, and ambient conditions

resulting from UFPs' mechanism of formation or source of emission.

UFPs are generated from different sources and by different formation mechanisms and environmental processes, leading to different correlations with different gaseous co-pollutants and atmospheric conditions. Distance from the emission source is also a contributing factor in relation to other co-pollutants. Low to moderate associations among co-pollutants might be found at or near the source of emission, as different combustion mechanisms will affect the emission of different pollutants in different manners (Sardar, Fine, Yoon, & Sioutas, 2004).

A primary source of UFPs is automobile exhaust and UFP formation from combustion mechanisms is related to certain conditions such as noncombusted lubricating oil, engine load, engine temperature, ambient temperature, ambient relative humidity, and wind speed (Buccolieri et al., 2010; Kittelson, 1998; Kreisberg, Stolzenburg, Hering, Dick, & McMurry, 2001; Park, Cao, Kittelson, & McMurry, 2003; Wahlin et al., 2001). Also, UFP formation in the environment is affected by a secondary photochemical and nucleation processes (Kulmala et al., 2004). Thus, several combustion mechanisms and situations, and environmental conditions can affect the relationship between co-pollutants and atmospheric conditions.

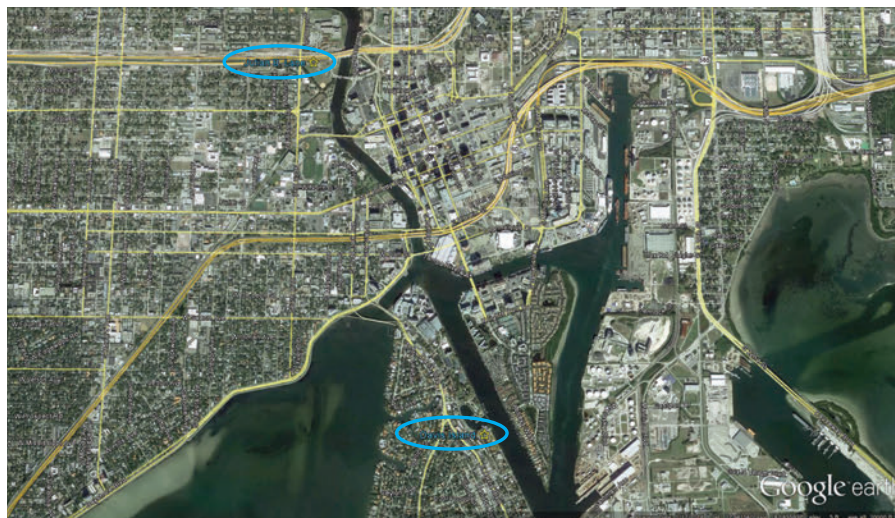
The objective of this study was to identify the relationship between UFPs and other gaseous co-pollutants and atmospheric conditions in the Tampa Bay Area between January and March 2014. This study also looked at the relationship of UFPs with other co-pollutants during the morning rush hour period (5–8 a.m.) in the Tampa Bay Area.

## Methods

Air monitoring data of UFPs, black carbon,  $\text{NO}_x$ ,  $\text{NO}_2$ ,  $\text{NO}$ ,  $\text{CO}$ ,  $\text{O}_3$ ,  $\text{SO}_2$ ,  $\text{PM}_{10}$ , and meteorological conditions such as relative humidity, wind speed, and ambient temperature for this study were collected from two air-monitoring stations within the City of Tampa, Florida: 1) the well-established Davis Island Station and 2) the new Julian B. Lane (JBL) Park Station (Figure 1). These stations are part of the State of Florida Air Monitoring Network, operated and maintained by the Environmental Protection Commission of Hillsborough County.

FIGURE 1

### Locations of Monitoring Stations



The Davis Island Station is located in an urbanized residential area along the shipping channel on the west side of the Port of Tampa Bay and was established in 1973 to collect air pollution data in the urban area. Continuous air quality data were collected for ground-level  $\text{O}_3$ ,  $\text{SO}_2$ , and  $\text{PM}_{10}$ .

The JBL Park Station was established in January 2014 pursuant to the federal requirement (40 CFR Part 58, Appendix D) for air monitoring of the near-road environment. In addition to collecting meteorological conditions data such as relative humidity, wind speed and direction, and ambient temperature, this site collects continuous air quality data for the number of UFPs, black carbon,  $\text{NO}_2$ , and  $\text{CO}$ . In order to collect air pollution data from automobile combustion, this site is located approximately 20 m south of an elevated roadway to a heavily traveled road segment (I-275) in Tampa, Florida. In 2011, according to the Florida Department of Transportation, the annual average daily traffic count for this segment of I-275 was 190,500 vehicles per day.

The JBL Park Station is in the central Tampa residential community and within 1 mile of the downtown business district and about 2 miles northwest of the Davis Island Station. As I-275 is elevated through much of the city of Tampa, the JBL Park Station

represents the highest near-road exposures throughout the metropolitan area.

UFPs have negligible mass as compared to larger particulate matter; therefore, UFPs preferably are assessed by the measurement of the particle number of concentrations (Harrison et al., 2000; Kumar et al., 2010). For this study, UFPs were measured by a Teledyne-Advanced Pollution Instrument (T-API), UFP Monitor Model 651, a continuous laminar flow condensation particle counter that measures particles from 3  $\mu\text{m}$  to 7 nm. This instrument is based on the principle of an optical particle counter and counts high-precision measurements of UFPs. It is a water-based condensation particle counter that measures particles <7 nm at a sample flow rate of 0.12 L/min. This model uses two modes for counting particles.

- 1) Concentration mode: This mode is commonly used for most applications in order to count the average number of UFPs over a period of time. It counts real-time, continuous UFPs over the range from 0 to  $1 \times 10^6/\text{cm}^3$ .
- 2) Totalizer mode: In this mode, total particle counts are collected and presented each second.

Currently, the U.S. EPA does not recommend specific ambient air monitoring standards for UFPs for regulatory purposes.



TABLE 1

**Hourly Atmospheric Pollutant Parameters in Tampa Bay Area**

Parameter	Mean	SD	Quartile 1 (25th Percentile)	Quartile 3 (75th Percentile)	Interquartile Range	Median
UFPs <sup>a</sup> (n/cm <sup>3</sup> )	8188.15	5978.84	3884.77	11397.63	7512.86	7361.44
Black carbon (µg/m <sup>3</sup> )	1459.5	1286.656	576.05	1975.86	1399.81	1134.59
NO <sub>x</sub> <sup>a</sup> (ppb <sup>b</sup> )	26.84	22.95	11	37	26	21
NO <sub>2</sub> <sup>a</sup> (ppb)	14.72	8.85	7	21	14	14
NO <sup>a</sup> (ppb)	12.11	16.6	2	15	13	7
CO <sup>a</sup> (ppm <sup>b</sup> )	0.1738	0.19	0.24	0.397	0.149	0.314
O <sub>3</sub> <sup>a</sup> (ppb)	25.29	12.75	16	34	18	25
SO <sub>2</sub> <sup>a</sup> (ppb)	0.844	1.84	0	1	1	1
PM <sub>10</sub> <sup>a</sup> (µg/m <sup>3</sup> )	17.27	12.89	10	23	13	16
Relative humidity (%)	72.354	22.6	59.75	90.8	31.05	77.8
Wind speed (mph)	4.7	2.64	3	6	3	4
Ambient temperature (°C)	17.27	6.03	13.8	21.6	7.8	18.1

<sup>a</sup>UFPs = ultrafine particles; NO<sub>x</sub> = oxides of nitrogen; NO<sub>2</sub> = nitrogen dioxide; NO = nitric oxide; CO = carbon monoxide; O<sub>3</sub> = ozone; SO<sub>2</sub> = sulfur dioxide; PM<sub>10</sub> = particulate matter.

<sup>b</sup>ppb = parts per billion; ppm = parts per million.

Nitrogen dioxide was measured by a T-API Model T200UP, which is a photolytic nitrogen oxide analyzer. Carbon monoxide measurements were collected by a T-API Model T300U CO Analyzer, and black carbon concentrations were measured by a T-API Model 633 Aethalometer<sup>®</sup> BC Monitor. Ozone concentrations were measured by a Thermo Environmental Instruments, Inc. (TEI) Model 49C O<sub>3</sub> Analyzer. Sulfur dioxide was measured by a TEI Model 43C SO<sub>2</sub> Analyzer, and particulate matter was measured using a Thermo Scientific tapered-element oscillating microbalance Model 1400ab PM<sub>10</sub> Monitor. Continuous UFP numbers, gaseous co-pollutants, and meteorological conditions were calculated to 1- and 24-hour average concentrations for the statistical analysis. Primary and secondary ambient criteria pollutants were collected according to CFR 40 Part 50 requirements.

## Results and Discussion

Table 1 shows ambient air pollution data collected in the Tampa Bay Area including the mean, standard deviation, median, 25th percentile, 75th percentile, and interquartile range of air pollution data between January and March 2014. For CO, however, we

collected data for March 2014 only. Table 2 shows the rush hour data at the monitoring sites. We analyzed air pollutants and other ambient conditions data for the morning rush hour period (5–8 a.m.).

Table 3 shows the Pearson correlation coefficient (*r*) of UFPs with other co-pollutants and meteorological conditions. The Pearson correlation coefficient (*r*) is calculated based on the average daily and rush hour (5–8 a.m.) concentrations of co-pollutants and meteorological conditions between January and March 2014. At the JBL Park Station, the correlations for black carbon, NO<sub>x</sub>, NO<sub>2</sub>, NO, and CO were found to be 0.73, 0.6, 0.64, 0.62, and 0.68, respectively, for the average daily concentrations. For the rush hour concentrations, correlations for black carbon, NO<sub>x</sub>, NO<sub>2</sub>, and NO were 0.8, 0.77, 0.67, and 0.73, respectively, with CO being deemed not significant.

The moderate relationships among UFPs and black carbon, NO<sub>x</sub>, NO<sub>2</sub>, NO, and CO were found in this study at the JBL Park Station and indicated that motor vehicle emissions are a major source of UFPs. Morawska and co-authors (1998) also found a significant relationship of UFPs with NO<sub>x</sub> and CO in Brisbane, Australia, which suggested that

automobile combustion was the main source of UFPs in their study. UFPs are also generated from secondary photochemical activity. This mechanism is not well understood, but secondary formation occurs when higher gaseous pollutant concentrations or solar radiations are present in the atmosphere (Rimnacova et al., 2011; Sardar et al., 2004). These conditions also favor the formation of O<sub>3</sub> in the atmosphere, which suggests that a higher number of UFPs in the environment are associated with a higher concentration of O<sub>3</sub> in the atmosphere (Sardar et al., 2004). This study, however, found a lower relationship (*r* = .092) between UFPs and O<sub>3</sub>. The reason for the weak relationship between UFPs and O<sub>3</sub> might have been because approximately 1 to 3 hours are required for the strengthening between UFPs and O<sub>3</sub> following secondary photochemical processes (Pandis, Harley, Cass, & Seinfeld, 1992; Sardar et al., 2004; Shi & Harrison, 1999). In addition, relationships among UFPs and other meteorological conditions are ambient temperature and wind speed, which were .085 and .27, respectively. The low relationship between UFPs and each of these two meteorological condition results suggested that the relationship among these parameters is insufficient in the prediction of

TABLE 2

**Rush Hour (5–8 a.m.) Data for Atmospheric Pollutant Parameters**

Parameter	Mean	SD	Quartile 1 (25th Percentile)	Quartile 3 (75th Percentile)	Interquartile Range	Median
UFPs <sup>a</sup> (n/cm <sup>3</sup> )	10853.00241	8614.659	4591.125	14966.986	10375.86101	9682.611
Black carbon (µg/m <sup>3</sup> )	2339.24	1889.396	872.657	3550.0275	2677.37	1894.26
NO <sub>x</sub> <sup>a</sup> (ppb <sup>b</sup> )	43.73	35.16	17	60	43	36.5
NO <sub>2</sub> <sup>a</sup> (ppb)	18.1	9.283	11	24	13	18
NO <sup>a</sup> (ppb)	25.6305	28.6358	5	35	30	17.5
CO <sup>a</sup> (ppm <sup>b</sup> )	0.4122	0.178	0.273	0.492	0.21875	0.379
O <sub>3</sub> <sup>a</sup> (ppb)	14.32	11.16	3	23	20	13
SO <sub>2</sub> <sup>a</sup> (ppb)	0.86	3.2	0	1	1	1
PM <sub>10</sub> <sup>a</sup> (µg/m <sup>3</sup> )	18.352	13.23	9	26	17	17
Relative humidity (%)	81	20.36	75.5	94.775	19.275	87.95
Wind speed (mph)	4.05	2.128	2	5	3	4
Ambient temperature (°C)	14.61	5.46	11.125	18.85	7.725	15.3

<sup>a</sup>UFPs = ultrafine particles; NO<sub>x</sub> = oxides of nitrogen; NO<sub>2</sub> = nitrogen dioxide; NO = nitric oxide; CO = carbon monoxide; O<sub>3</sub> = ozone; SO<sub>2</sub> = sulfur dioxide; PM<sub>10</sub> = particulate matter.  
<sup>b</sup>ppb = parts per billion; ppm = parts per million.

secondary formation of UFPs. Reche and co-authors (2011) suggested that SO<sub>2</sub> generated from sources other than automobiles also contribute to secondary UFPs formation. Charon and co-authors (2007) suggested that the formation of secondary UFPs increases in the presence of higher concentrations of SO<sub>2</sub> and relative humidity. These conditions favor a higher number of UFPs because of the nucleation processes involving sulfuric acid and water. This study found a low relationship ( $r = .174$ ) between SO<sub>2</sub> and UFPs, although the monitoring site was located near a shipping channel where diesel powered vessels generated significant SO<sub>2</sub> emissions. These findings suggested that there are low to moderate relationships among UFPs, other gaseous co-pollutants, and meteorological conditions in this study. A limitation of this study is that the data were collected over a three-month period; we recommend future studies to collect data over a longer duration.

**Conclusion**

Several studies have confirmed the physiological effects of atmospheric UFPs. Initial studies considered these particles mainly generated from automobile exhaust. Thus, other co-pollutants such as black carbon,

TABLE 3

**Hourly Pearson Correlation Coefficient for Ultrafine Particles Versus Atmospheric Pollutant Parameters in the Tampa Bay Area<sup>a</sup>**

Parameter	All Hours	During Rush Hours (5–8 a.m.)
	<i>r</i>	<i>r</i>
Black carbon	.735	.802
NO <sub>x</sub> <sup>b</sup>	.6	.776
NO <sub>2</sub> <sup>b</sup>	.646	.674
NO <sup>b</sup>	.621	.737
CO <sup>b</sup>	.686	NS*
O <sub>3</sub> <sup>b</sup>	.092	.319
SO <sub>2</sub> <sup>b</sup>	.174	.125
PM <sub>10</sub> <sup>b</sup>	.182	.224
Wind speed	.27	.296
Ambient temperature	.085	.142

<sup>a</sup>*p*-values <.05, 95% confidence interval.  
<sup>b</sup>NO<sub>x</sub> = oxides of nitrogen; NO<sub>2</sub> = nitrogen dioxide; NO = nitric oxide; CO = carbon monoxide; O<sub>3</sub> = ozone; SO<sub>2</sub> = sulfur dioxide; PM<sub>10</sub> = particulate matter.  
 \*NS = not significant.

NO<sub>x</sub>, NO, and CO may be used as surrogates of UFPs to assess human health effects. In addition, several other studies have confirmed that UFPs are generated from sec-

ondary processes in the atmosphere; thus, UFPs are correlated with other co-pollutants such as O<sub>3</sub>. To evaluate the role of surrogate pollutants for UFPs, this study examined

the relationships among UFPs, other co-pollutants, and meteorological conditions in the Tampa Bay Area.

The outcome of this study has suggested that there are low to moderate relationships among UFPs, other gaseous co-pollutants, and meteorological conditions in the Tampa

Bay Area for daily average and rush hour concentrations (5–8 a.m.) during January to March 2014. Our results suggest that other co-pollutants should not be used for monitoring UFPs either for compliance purposes or in epidemiological studies of effects on health for people in the Tampa Bay Area. 🐼

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# Swine Worker Precautions During Suspected Outbreaks of Influenza in Swine

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**Abstract** To assess the behavior and precautions that swine workers take during suspected influenza outbreaks in swine, six commercial swine farms in the Midwest U.S. region were visited when influenza outbreaks were suspected in herds during the fall/winter of 2012–2013. Use of personal protective equipment (PPE) and type of task performed by swine workers were recorded based on farm representative reports. Between one to two workers were working on the day of each visit and spent approximately 25 minutes performing work-related tasks that placed them in close contact with the swine. The most common tasks reported were walking the aisles (27%), handling pigs (21%), and handling equipment (21%). The most common PPE were boots (100%), heavy rubber gloves (75%), and dedicated nondisposable clothing (74%). Use of N95 respirators was reported at three farms. Hand hygiene practices were common in most of the farms, but reportedly performed for only 20% to 25% of tasks.

## Introduction

Each year influenza A viruses (IAV) circulate and cause infection in both humans and animals. IAV transmission between humans and swine has been the subject of speculation since at least the 1918 influenza pandemic when influenza outbreaks were observed in swine herds as well as in human populations (Taubenberger & Morens, 2006). Recent studies have documented that contact with infected pigs can lead to human infection. A 2011 investigation of an outbreak among attendees at an agricultural fair in Pennsylvania found an increased risk for contracting IAV H3N2 variant (H3N2v) among children

<13 years of age who visited the fair, especially among those children who reported touching swine (Wong et al., 2012). From August 2011 through April 2012, 13 cases of IAV H3N2v were identified, of which seven had some type of swine exposure, including one occupational exposure (Epperson et al., 2013). These events highlight the risk of IAV infection from pigs to humans and the possibility of subsequent person-to-person transmission.

Swine workers may have higher levels of exposure to swine influenza viruses compared to the general public. In commercial swine production, pigs often are reared in enclosed facilities with a high density of animals. In

the United States, swine production is concentrated in particular geographic locations, which increases the probability of IAV transmission among pigs, and between pigs, workers, and communities (Key & McBride, 2007; Saenz, Hethcote, & Gray, 2006). Swine workers in northwestern Mexico were determined to have significantly higher swine influenza antibody titers compared to individuals with no exposure to swine, odds ratio = 3.05; 95% confidence interval [1.65, 5.64] (López-Robles, Montalvo-Corral, Caire-Juvera, Ayora-Talavera, & Hernández, 2012). Similarly, it has been shown that U.S. swine workers and their spouses had elevated antibody titers to swine IAV compared to veterinarians, meat processing workers, or other community controls (Gray et al., 2007; Myers et al., 2006). Therefore, swine workers might not only be at personal risk for occupational infection, but might also act as a source for influenza transmission between swine and the community—thereby contributing to the emergence of novel influenza viruses (Krueger & Gray, 2013). As swine workers are at risk of zoonotic influenza transmission, it has been recommended that swine workers be a priority focus in influenza pandemic emergency preparedness planning (Gray & Baker, 2007).

Following the 2009 H1N1 influenza pandemic, governmental agencies and industry groups developed a number of guidelines with the aim of reducing the risk of influenza transmission in swine production facilities. The Centers for Disease Control and Prevention (CDC), in cooperation with the U.S. Depart-

TABLE 1

**Farm Characteristics**

Characteristic	Farm ID						Total
	1	2	3	4	5	6	
Suspected IAV <sup>a</sup> outbreaks	1	1	3	1	1	4	11
Confirmed IAV outbreaks	1	0	2	0	0	3	6
Average number of workers entering affected barn during a visit	2	2	1	2	1	1	1.5 <sup>b</sup>
Total number of barns	4	2	3	4	3	8	24
Total number of pigs	2400	2400	3400	3840	2480	12000	26520
Number of pigs inside affected barn	315	1023	1133	940	1000	2012	6423
Age of pigs within affected barn at time of infection onset (weeks)	18	8	10	20	19	5	13 <sup>b</sup>
Area of barn (m <sup>2</sup> )	241	763	1046	1508	821	892	879 <sup>b</sup>
Volume of barn (m <sup>3</sup> )	530	1860	2233	3218	1877	2039	1960 <sup>b</sup>

<sup>a</sup>IAV = influenza A viruses.

<sup>b</sup>Average.

ment of Agriculture and other agencies, published a guidance document that stressed when pigs appeared ill, swine workers should use hand hygiene practices; personal protective equipment (PPE) including gloves, goggles, head coverings, and masks; as well as routine seasonal influenza vaccination (CDC, 2011). The Occupational Safety and Health Administration (OSHA) has recommended that workers in commercial swine facilities specifically use “disposable N95 or higher NIOSH-certified filtering face piece respirators” as the lowest level of respiratory protection when “in contact with known or suspected flu-infected pigs” (OSHA, 2010). Despite the existence of these guidelines, low awareness about influenza prevention guidelines and low rates of PPE use such as masks has been reported among U.S. swine farm workers in large and small U.S. farms (Rabinowitz, Fowler, Odofin, Messinger, Sparer, & Vegso, 2013). In general, little is known about the infection control practices in swine farm facilities, especially during active IAV infections.

We report here on precautions taken by swine workers in farms with known or suspected acute infections of swine IAV during the 2012–2013 influenza season. Our field study involved questioning farm representatives about the use of PPE, hand hygiene practices, type of tasks performed, and total time spent inside the barn by workers during suspected outbreaks of IAV in swine herds. We conducted the study to determine

the degree of concordance between reported worker behavior and published recommendations for workers working with pigs suspected of influenza infection.

## Methods

### Study Location

The survey of swine work practices was part of a larger study to examine the persistence of IAV in swine production facilities during IAV outbreaks. The study was conducted during the 2012–2013 influenza season (fall/winter) on six swine farms located in rural Minnesota. Study farms were commercial farms with 2,400 to 12,000 pigs on site and constituted a convenience sample of farms where members of the study team knew the supervising veterinarian. Swine veterinarians or producers notified research team members when an IAV infection in pigs was suspected; therefore, farm managers and owners were aware of suspected influenza infection at each farm visited. Researchers obtained permission from a person in charge of the farm to perform a visit and collect information. The Human Research Protection Program at Yale University reviewed the study protocols related to human subjects and determined they did not pose a risk to human subjects.

### Data Collection

During farm visits, sampling was performed of air, surfaces, and swine oral fluids to confirm

the presence of influenza infection. For a particular farm experiencing a suspected outbreak of influenza in the swine herd, viral sampling as well as survey of work practices was performed every 3 to 4 days until swine oral fluid samples tested negative. At the initial farm site visit, information was collected about the age of the pigs, the size of the barn, and the presence of clinical signs in the swine herd. A study team member completed a survey regarding worker behaviors and interactions with the animals at the initial and follow-up farm site visits through interviews with a farm representative (such as a supervisor or owner). This information covered the day of the site visit, and included number of workers entering the affected barn that day, time spent inside the barn by each worker, task(s) performed during the day of the visit, shortest distance between human and pigs including direct contact (0 ft), use of PPE, and hand hygiene practices.

### Data Analysis

Data were entered into an MS Excel database and analyzed using SAS version 9.3. Frequency tables were calculated for reported swine worker behaviors, and univariate statistics were performed for continuous variables.

## Results

A total of six farms were visited during 11 suspected IAV outbreaks (Table 1). Several farms experienced more than one outbreak during the study period. Six of the 11 suspected out-

TABLE 2

**Workers Tasks and Infection Control Practices per Farm**

Task/Infection Control Practice	Farm ID						Total # (%)
	1	2	3	4	5	6	
Workers observed during all visits	3	6	11	2	1	21	44
Visits with worker-collected information	2	3	9	1	1	17	33
Average time workers spent inside barn when doing tasks (min)	22	25	20	37	20	27	25 <sup>a</sup>
Task(s) performed (N = 152) <sup>b</sup>							
Barn maintenance	0 (0)	0 (0)	2 (5)	0 (0)	0 (0)	9 (12)	11 (7)
Feeding pigs	1 (13)	0 (0)	0 (0)	0 (0)	0 (0)	4 (5)	5 (3)
Handling equipment	2 (25)	3 (25)	10 (24)	3 (30)	1 (25)	12 (16)	31 (21)
Handling pigs	0 (0)	5 (42)	9 (22)	2 (20)	1 (25)	14 (18)	31 (21)
Moving pigs	0 (0)	0 (0)	9 (22)	2 (20)	1 (25)	12 (16)	24 (16)
Walking aisles/pens	2 (25)	3 (25)	10 (24)	3 (30)	1 (25)	22 (29)	41 (27)
Other	3 (38)	1 (8)	1 (2)	0 (0)	0 (0)	4 (5)	9 (6)
Total tasks performed	8	12	41	10	4	77	152
Closest distance between workers and pigs when doing these tasks (N = 152) <sup>b</sup>							
Close contact (0–<1 ft)	5 (71)	9 (75)	34 (83)	9 (100)	4 (100)	54 (79)	115 (76)
1–2 ft away	0 (0)	2 (17)	5 (12)	0 (0)	0 (0)	10 (15)	17 (11)
≥4 ft away	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (3)	2 (1)
Outside activities	2 (29)	1 (8)	2 (5)	0 (0)	0 (0)	2 (3)	7 (5)
PPE <sup>c</sup> and biosafety practices used when doing tasks (N = 152) <sup>b</sup>							
Footwear/boots	8 (80)	11 (31)	41 (29)	10 (20)	4 (20)	77 (24)	151 (100)
Heavy rubber gloves	0 (0)	8 (23)	28 (20)	0 (0)	4 (20)	74 (23)	114 (75)
Disposable gloves	0 (0)	0 (0)	0 (0)	10 (20)	0 (0)	0 (0)	10 (7)
Dedicated clothes	0 (0)	0 (0)	30 (21)	0 (0)	4 (20)	77 (24)	111 (74)
N95 respirators	0 (0)	10 (29)	28 (20)	10 (20)	0 (0)	0 (0)	48 (32)
Cartridge respirators	2 (20)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (1)
Hand sanitizer	0 (0)	3 (9)	4 (3)	10 (20)	4 (20)	10 (3)	31 (21)
Hand washing	0 (0)	3 (9)	11 (8)	10 (20)	4 (20)	10 (3)	38 (25)
On-site showering	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	76 (23)	76 (50)

<sup>a</sup>Average time inside barns across all farms.  
<sup>b</sup>Column percentages in parentheses.  
<sup>c</sup>PPE = personal protective equipment.

breaks were confirmed positive for influenza infection by polymerase chain reaction testing in aerosols, surfaces, and/or swine oral fluid samples. The six positive outbreaks took place in farms 1, 3, and 6. On the days when site visits were performed, farm representatives reported between one to two employees entering a particular building to perform work-related activities. Sampled farms varied in size of barns and number and ages of pigs housed in each barn. There were between 315 to 2,012 pigs ages 5 to 20 weeks per affected barn. Farms 3 and 6, with the greater number of IAV outbreaks, had a greater number of younger

pigs compared to the other farms. The area of the barns ranged from 241 m<sup>2</sup> to 1,508 m<sup>2</sup> and the interior building volume ranged from 530 m<sup>3</sup> to 3,218 m<sup>3</sup>.

The researchers tallied work-related activities and behaviors for a total of 44 workers during 33 visits (Table 2). Overall, they reported that workers spent an average of 25 minutes per day inside a barn. They reported a total of 152 tasks across farms during site visits, of which the most common tasks were walking through the aisles and pens (27%), handling pigs (21%), and handling equipment (21%). Less common tasks included moving

pigs through aisles and between units, and feeding the pigs. Barn maintenance activities were reported only in farms 3 and 6. For most of the tasks (76%), workers were reported to be in close contact (0–<1 ft) with pigs.

Boots were the most common type of PPE used across all farms for all tasks (Tables 2 and 3). Use of heavy rubber gloves by workers was reported in four out of six farms for 75% of the tasks. Dedicated nondisposable clothing was worn by workers at half of the farms for 74% of the total tasks. Similarly, half of the farms used N95 respirators for 32% of the total number of tasks. While heavy rub-



TABLE 3

**Use of Personal Protective Equipment by Task**

Task	# of Times Task Performed	Footwear/Boots # (%)	Heavy Rubber Gloves # (%)	Disposables Gloves # (%)	Dedicated Clothes # (%)	N95 Respirator # (%)	Cartridge Respirator # (%)	Hand Sanitizer # (%)	Hand Washing # (%)
Barn maintenance	11	11 (100)	9 (82)	0	11 (100)	0	0	2 (18)	2 (18)
Feeding pigs	5	5 (100)	4 (80)	0	4 (80)	0	0	0	0
Handling equipment	31	31 (100)	21 (68)	3 (10)	20 (65)	13 (42)	1 (3)	8 (26)	10 (32)
Handling pigs	31	31 (100)	26 (84)	2 (6)	22 (71)	13 (42)	0	7 (23)	8 (26)
Moving pigs	24	24 (100)	20 (83)	2 (8)	20 (83)	9 (38)	0	6 (25)	7 (29)
Walking aisles	41	41 (100)	32 (78)	3 (7)	30 (73)	13 (32)	1 (2)	8 (20)	10 (24)
Other	9	8 (89)	2 (25)	0	4 (50)	0	0	0	1 (13)

ber gloves and dedicated clothing were used for all types of tasks, N95 respirators were most frequently used when handling equipment, handling pigs, moving pigs, and walking the aisles (Table 3). Less common types of PPE were disposable gloves and cartridge respirators. No dust masks, eye protection, or hair covering were used by workers at any of these farms during any visit. Hand washing and use of hand sanitizer were practices performed in five out of the six farms for about 20% to 25% of the tasks. The researchers reported on-site showering practices at only one farm.

### Discussion

This pilot survey of swine workers' task-related behavior during suspected outbreaks of influenza in swine herds showed that workers were not uniformly using PPE to the degree recommended in national guidelines. Although workers commonly used boots, heavy rubber gloves, dedicated clothes, and hand hygiene practices, use of an N95 respirator was rare, and the researchers did not observe eye protection in use. The use of PPE varied between tasks, with certain tasks such as direct handling of pigs being associated with higher rates of N95 respirator use. These findings underscore the importance of feasibility, accessibility, and training regarding measures to reduce transmission of IAV between pigs and humans in swine production facilities, especially during outbreaks of swine influenza infections.

While workers reportedly spent only a limited amount of time in the affected swine barns each day, and the number of workers enter-

ing each barn daily was small, the fact that half of the farms tested positive for influenza virus in aerosols, surfaces, and/or swine oral fluids suggests that exposure to swine influenza viruses was taking place and may be significant enough to result in infection. Workers in this study interacted with pigs an average of 25 minutes per day and performed work-related tasks that placed them in close contact with pigs (including sick pigs). Such close contact could involve risk of influenza transmission either through direct contact, short-range droplet exposure, contact with infected surfaces, or breathing of infectious aerosols. Therefore, use of PPE has implications for swine workers' risk of zoonotic influenza. Ramirez and co-authors (2006) showed that swine workers who smoked and rarely wore gloves at the farms were more likely to have higher H1N1 IAV antibody titers than workers who did not smoke and almost always used gloves. Additionally, use of PPE could impact the risk of "reverse zoonotic" transmission of influenza from an infected worker to a susceptible pig. The fact that boots, protective covering, and rubber gloves were used routinely by the workers during study site visits underlines the fact that organized programs for protective equipment use are already in place in large swine production facilities. Such programs could serve as a basis for enhanced influenza prevention activities in the future.

In our study, the reported use of N95 respirators was low and not uniform across farms. Our results are consistent with results of previous studies in which swine workers in the U.S. and Romania reported low use of N95

respirators and none of them had a formal respiratory protection program in the workplace (Rabinowitz, Fowler, Odofin, Messinger, Sparer, & Vegso, 2013; Rabinowitz, Huang, Paccha, Vegso, & Gurzau, 2013). Previous surveys have not assessed workers' behaviors during the time of active suspected outbreaks. This study therefore adds to the literature by providing additional direct confirmation of discrepancies between national guidelines and the use of PPE and other protective measures to prevent influenza in practice. In addition, it was not clear that the workers who were using N95 respirators were doing so as part of an organized respiratory protection program that included medical clearance, training, and fit testing. To the best of our knowledge, none of the farms visited in this study had such a formal respirator program.

Our study was limited by the small number of farms surveyed in only one geographic area, the Midwest, and by the fact that we relied on supervisor reports of worker behaviors. We chose the sites for this study because a suspected influenza outbreak was taking place in the swine herds at these sites. We therefore did not perform site visits during times when pigs were not observed to have been recently ill. Therefore, we were unable to assess whether swine workers varied their level of precautions depending on perceptions about the health of the swine. Future studies should follow a larger number of workers over time and assess the correlation between protective behaviors and occurrence of influenza infections in humans and animals. Better understanding

of the environmental transmission routes and viral loads of influenza in swine facilities can help define the risk of occupational exposure and the benefit of PPE use; it might also encourage behavior changes. Enhanced prevention programs for workers that include influenza vaccination and improved hygiene practices also hold potential for reducing reverse zoonotic transmission of influenza from humans to pigs. Pork producers as well as swine workers should be fully aware that influenza viruses can be transmitted between pigs and people and that annual seasonal influenza vaccines can decrease the transmission of influenza viruses from workers to pigs (CDC, 2012).

### Conclusion

Overall, the findings of this study indicate that many of the recommendations of occupational health agencies regarding protective measures to be taken by swine workers around sick animals in order to prevent influenza transmission are routinely not followed in practice. The reasons for this noncompliance are not clear, but could include low perceived risk, practical barriers to the use of PPE such as comfort and cost, and extent of worker education about influenza prevention. Further research is necessary to develop practical guidelines for the use of PPE and other protective measures for influenza prevention in swine work. Better understanding

of the degree of exposure risk faced by workers and the most effective measures to reduce such risks could help protect the health of both workers and animals. Such measures could also reduce the possibility of generating novel influenza viruses and prevent future influenza pandemics. 🐷

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Douglas Sackett  
Council for the Model  
Aquatic Health Code

## Update From the Council for the Model Aquatic Health Code (and Why You Should Join)

**Editor’s Note:** NEHA strives to provide up-to-date and relevant information on environmental health and to build partnerships in the profession. In pursuit of these goals, we feature a column from the Environmental Health Services Branch (EHSB) of the Centers for Disease Control and Prevention (CDC) in every issue of the *Journal*.

In these columns, EHSB and guest authors share insights and information about environmental health programs, trends, issues, and resources. The conclusions in this article are those of the author(s) and do not necessarily represent the views of CDC.

Douglas Sackett is the executive director of the Council for the Model Aquatic Health Code.

The last week of May is Healthy and Safe Swimming Week. Eleven years ago, public health, the aquatics industry, and academia came together to recommend that the Centers for Disease Control and Prevention (CDC) develop a Model Aquatic Health Code (MAHC) to promote healthy and safe swimming. From the beginning, these partners also recognized the importance of keeping the MAHC up to date. To accomplish this task, the Council for the Model Aquatic Health Code (CMAHC) was established. The CMAHC is

- a non-profit 501(c)(3) organization;
- a conduit for recommending data- and science-based MAHC changes to CDC; and
- comprised of public health and aquatics industry professionals committed to keeping the MAHC current, sustainable, and easily understood and implemented.

The CMAHC solicits requests for changes, updates, or improvements to the MAHC and holds a Vote on the Code conference every other year. CMAHC established a Technical Review Committee (TRC) that reviews and makes recommendations about all submitted change requests (CRs), which CMAHC members can review and comment on before the conference. CMAHC member voting results are forwarded to CDC for review and final acceptance. The second edition of the MAHC will incorporate CDC-approved changes, and we anticipate its release in May 2016.

### First Vote on the Code Conference a Success

The first biennial Vote on the Code conference was held October 2015. It had more than 100 in-person attendees and more than 80 Livestream sites connected. Breakout cau-

cus sessions allowed discussion within the sectors, e.g., public health. During the conference, CMAHC members discussed and gave input on the CRs. After the conference, CMAHC the members had additional time to submit comments, which were posted online to inform voting.

CMAHC members voted on all 159 submitted CRs electronically. Voting is weighted to ensure that public health concerns are prominent: public health has 50% of the weighted vote while the other 50% is split between three aquatics sector categories (Figure 1). Ninety-two of the 159 submitted CRs passed. Of those 92, about half were of a clarifying or editorial nature. Some CRs addressing safety or health related issues did not pass. For many of these, members felt there was insufficient data to support the proposed change. The CMAHC encourages the collection of additional data, discussion, and resubmission of modified CRs to address these issues in the next Vote on the Code conference in 2017.

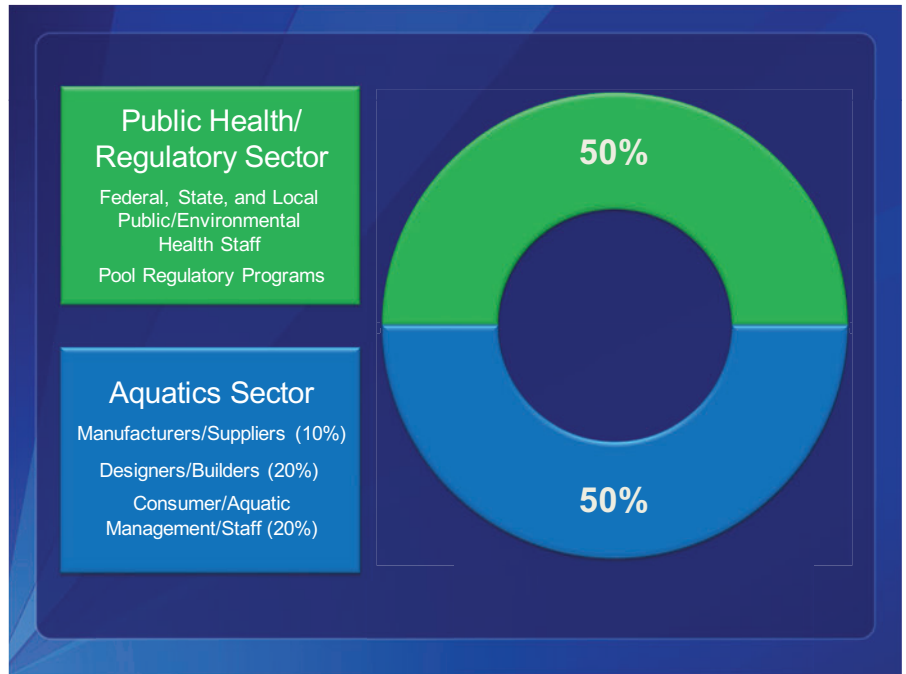
### Improving and Planning for the Next MAHC Update Cycle

We have identified important areas for improvement during this MAHC update cycle.

- We need to continue to grow membership. The CMAHC is driven by member expertise, so more members mean more available expertise! We strongly encourage public and environmental health staff to become members—your perspective is needed! Even if you are not considering adopting all or parts of the MAHC, your participation is still essential in helping to make the MAHC the best model it can be.

FIGURE 1

### Weighting of the Council for the Model Aquatic Health Code Member Votes



### Healthy Swimming and Model Aquatic Health Code Quick Links

- Council for the Model Aquatic Health Code: [www.cmahc.org](http://www.cmahc.org)
- Healthy and Safe Swimming Week: [www.cdc.gov/healthywater/observances/hss-week](http://www.cdc.gov/healthywater/observances/hss-week)
- Model Aquatic Health Code: [www.cdc.gov/mahc/](http://www.cdc.gov/mahc/)
- Model Aquatic Health Code Network: [www.naccho.org/programs/environmental-health/hazards/water](http://www.naccho.org/programs/environmental-health/hazards/water)

tion, and others. The vision committees should consider where we want U.S. aquatics health and safety to be 10, 20, and 30 years from now, with a long range goal to improve the overall system.

- We don't want to just tweak the MAHC wording. We want to consider innovative ideas, processes, and products to move it ahead. The MAHC should not be used as the basis to say, "no, that's not how we've always done it," but rather as a process to encourage and promote evidence-based progress rooted in health and safety.

- We need to reestablish technical committees (TCs) to provide subject matter expertise to the TRC. Many CRs addressed items that required in-depth expertise to thoroughly understand the proposal and assess potential impacts on other areas of the MAHC. We want to identify members with the needed expertise and have the respective TCs in place and ready to provide technical support to the TRC for the 2017 code change cycle.
- The aquatics community needs to start preparing now for developing CRs for the 2017 Vote on the Code MAHC update opportunity. As previously mentioned, we encour-

age members to identify additional data and resubmit items that did not initially pass.

- Members want the opportunity to listen in on TRC conference calls discussing and vetting submitted CRs. Allowing members to listen in will also help members be more aware of the pros and cons the TRC must consider. Members can subsequently transmit additional information to the TRC in response to issues the committee discussed on the call.
- We want a proactive strategy to advance the MAHC and are considering establishing vision committees for various topics such as water treatment, injury preven-

### Join Us!

We encourage environmental health practitioners to join the CMAHC. Your input is critical and a strong voice for public health is essential. We also encourage you to join the new MAHC Network that is designed to provide health departments with resources and peer-to-peer networking to increase awareness and use of the MAHC. 🐼

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## Did You Know?

You can share your event with the environmental health community by posting it directly on our community calendar at [www.neha.org/news-events/community-calendar](http://www.neha.org/news-events/community-calendar). Averaging 2,000 page views a month, you are sure to bring a lot of attention to your event. Make sure to check it often, and you might find a new event happening in your area!

► **DIRECT FROM CDC** ENVIRONMENTAL PUBLIC HEALTH TRACKING NETWORK



Alex E. Charleston, MPH



CAPT Richard Sullivan

## Exploring Environmental Health Gaps in Native American Populations

**Editor's Note:** As part of our continuing effort to highlight innovative approaches and tools to improve the health and environment of communities, the *Journal* is pleased to publish a bimonthly column from the Centers for Disease Control and Prevention's (CDC's) Environmental Public Health Tracking Network (Tracking Network). The Tracking Network is a system of integrated health, exposure, and hazard information and data from a variety of national, state, and city sources. The Tracking Network brings together data concerning health and environmental problems with the goal of providing information to help improve where we live, work, and play.

Environmental causes of chronic diseases are hard to identify. Measuring amounts of hazardous substances in our environment in a standard way, tracing the spread of these over time and area, seeing how they show up in human tissues, and understanding how they may cause illness is critical. The Tracking Network is a tool that can help connect these efforts. Through these columns, readers will learn about the program and the resources, tools, and information available from CDC's Tracking Network.

The conclusions of this article are those of the author(s) and do not necessarily represent the views of CDC.

Alex Charleston is the acting deputy branch chief for the Environmental Public Health Tracking Program and has worked at CDC for almost 23 years. CAPT Richard Sullivan has been a commissioned officer with the U.S. Public Health Service for 29 years and has served in the Navajo, Portland, and Tucson areas of the Indian Health Service, and at CDC.

some of the most prevalent environmental issues affecting communities include contamination of traditional foods, indoor air pollution, mining, poor housing conditions, sludge sites, and wood stoves. These environmental issues affect pollution levels in two of the most vital areas: air and water quality. In addition, linking exposure to environmental hazards, like water and air pollution, to chronic diseases is difficult.

In 2002, Congress began funding the Centers for Disease Control and Prevention (CDC) to develop a program and system to track health problems that may be associated with environmental health hazards. The Environmental Public Health Tracking Network (Tracking Network) was created to provide information to a variety of audiences from a nationwide network of integrated health and environmental data that drive actions to improve health outcomes. Since the Tracking Program launched its network in 2009, it has continued to evolve in content and functionality. The program currently maintains cooperative agreements with health departments in 25 states and one city that contribute data to the network. A limitation of the Tracking Network, however, is its lack of information specific to Native Americans.

### The Bemidji Area Tracking Pilot Project

In the summer of 2014, CDC contracted with the Great Lakes Inter-Tribal Epidemiology Center (GLITEC) to conduct the Bemidji Area Environmental Health Tracking Program pilot project. GLITEC serves the 34 tribes in the Bemidji Area. Its staff supports tribal communities in their efforts to improve

The Midwestern U.S. is home to the Bemidji Area Indian Health Service. This area includes the states of Michigan, Minnesota, and Wisconsin, and the city of Chicago. Tribes included in the service area are the Chippewa (Ojibwe), Dakota, Ho-Chunk, Menominee, Mohican, Odawa, Onei-

da, and Potawatomi nations, among others (Great Lakes Inter-Tribal Council, Inc., 2016).

Many environmental issues persist in tribal lands despite efforts to combat them, such as the tribal implementation of parts of the U.S. Environmental Protection Agency's Clean Air and Clean Water Acts. In the Bemidji Area,

health by building capacity to collect and use data, while advocating on the local, state, and national levels to improve data quality. The Wisconsin Tracking Program, Minnesota Tracking Program, and Michigan Tracking Program provided additional resources to assign a GLITEC epidemiologist to lead the project and provide monetary awards to each participating community. The Bemidji Area environmental health advisory group provided oversight for the pilot project.

The overall goals of the pilot project were to identify available data and to assess the quality of those data. The three tribal communities that participated were the Bad River Band of Lake Superior Tribe of Chippewa Indians in Wisconsin, the Fond du Lac Reservation in Minnesota, and the Detroit Urban Indian Community in Michigan.

### Pilot Project Findings

The GLITEC epidemiologist conducted in-person visits to the three different communities in order to establish and facilitate relationships among the tribes, CDC, and the participating state tracking programs as well as to outline the project goals and objectives. In meeting with each tribe, themes emerged that were similar to those experienced by grantees during the early stages of development for the national Tracking Program. For example, the isolation of data across departments and sectors was surprising and often frustrating for tribal partners. The tribes lacked consistency in the ways they were collecting and recoding data. Different departments sometimes collected data on the

same indicator based on funding sources or requirements. Tribal partners stated a desire to collect environmental data in a meaningful way that would be useful for everyone in the community. The lack of interdepartmental local coordination coupled with the lack of substantial and reliable funding, however, has created a patchwork of available environmental data in these communities. A member of one tribal community said that the group wanted this project to lead to an “in-house way to deal with data.” This type of system can only be accomplished with significant direct investment in data collection and utilization by tribes across tribal lands.

Through the cooperative efforts of participating tribes and tribal communities, GLITEC, and state tracking programs, the participants accomplished their first-year objectives by assessing ongoing environmental monitoring occurring at the tribal level and developing environmental priorities, including indoor and outdoor air quality, radon, and well water testing.

### Working With Tribes: Lessons Learned

In order for partnerships and projects with tribes to be successful, relationships with Native American communities must be built upon trust. The Tracking Program has worked with GLITEC to build a relationship with Native American communities and to explore existing environmental public health data. By the end of the pilot, CDC, GLITEC, and Tracking Program grantees established a foundation for tribal involvement within the Track-

ing Program. State tracking programs and CDC learned the importance of tribal cultural awareness, customs, flexibility, and respect for tribal sovereignty by allowing communities to ultimately decide the course of the project. This awareness led to new established connections among the tribes, an urban Native American community, the Tribal Epidemiology Center, and state tracking programs.

With the success of the pilot project, the Tracking Program has begun to look at next steps in working with tribal communities. The objective for the future is to have standardized environmental health data that tribal populations can use to drive public health action within their communities.

To learn more about the Tracking Program's work, visit <http://ephtracking.cdc.gov>. To stay connected with the Tracking Program and get updates on the newest data, tools, and resources, join our listserv by e-mailing [eph@cdc.gov](mailto:eph@cdc.gov).

**Corresponding Author:** Richard Sullivan, CAPT, USPHS, Project Officer, Environmental Health Tracking Branch, Environmental Hazards and Health Effects, National Center for Environmental Health, CDC, 4770 Buford Highway, MS F-60, Building 106, Chamblee, GA 30341-3717. E-mail: [rsullivan@cdc.gov](mailto:rsullivan@cdc.gov).

### Reference

Great Lakes Inter-Tribal Council, Inc. (2016). *Great Lakes Inter-Tribal Epidemiology Center service area*. Retrieved from <http://www.glitc.org/programs/epi-servicearea/>

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## EH CALENDAR

### UPCOMING NEHA CONFERENCE

June 13–16, 2016: NEHA 2016 Annual Educational Conference & Exhibition and HUD Healthy Homes Conference, presented by Green & Healthy Homes Initiative, San Antonio, TX. For more information, visit [www.neha.org/aec](http://www.neha.org/aec).

### NEHA AFFILIATE AND REGIONAL LISTINGS

#### Florida

July 13–17, 2016: Annual Education Meeting, hosted by the Florida Environmental Health Association, Sarasota, FL. For more information, visit [www.feha.org/events](http://www.feha.org/events).

#### Georgia

June 28–July 1, 2016: Annual Education Conference, hosted by the Georgia Environmental Health Association, Savannah, GA. For more information, visit [www.geha-online.org/conferences](http://www.geha-online.org/conferences).

#### Indiana

September 26–28, 2016: Fall Conference, hosted by the Indiana Environmental Health Association, Michigan City, IN. For more information, visit [www.iehaind.org/Conference](http://www.iehaind.org/Conference).

#### Kansas

September 28–30, 2016: Fall Conference, hosted by the Kansas Environmental Health Association, Manhattan, KS. For more information, visit [www.keha.us](http://www.keha.us).

#### Minnesota

May 11–13, 2016: Spring Conference, hosted by the Minnesota Environmental Health Association, Brainerd, MN. For more information, visit [www.mehaonline.org/events](http://www.mehaonline.org/events).

#### Montana

September 27–28, 2016: MEHA/MPHA Conference, hosted by the Montana Environmental Health and Public Health Associations, Billings, MT. For more information, visit [www.mehaweb.org](http://www.mehaweb.org).

#### North Dakota

October 18–20, 2016: Fall Education Conference, hosted by the North Dakota Environmental Health Association, Bismarck, ND. For more information, visit <http://ndeha.org/wp/conferences>.

#### Texas

October 10–14, 2016: Annual Educational Conference, hosted by the Texas Environmental Health Association. For more information, visit [www.myteha.org](http://www.myteha.org).

#### Washington

May 26–27, 2016: Annual Education Conference, hosted by the Washington State Environmental Health Association, Vancouver, WA. For more information, visit [www.wseha.org](http://www.wseha.org).

#### West Virginia

May 24–26, 2016: Sanitarian's Mid-Year Conference, hosted by the West Virginia Association of Sanitarians, Ripley, WV. For more information, visit [www.wvdhhr.org/wvas/events/index.asp](http://www.wvdhhr.org/wvas/events/index.asp).

### TOPICAL LISTING

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October 19–21, 2016: 13th Annual World Aquatic Health Conference, hosted by the National Swimming Pool Foundation, Nashville, TN. For more information, visit [www.thewahc.org](http://www.thewahc.org). 🐾



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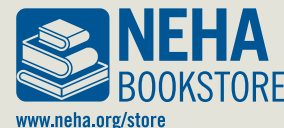


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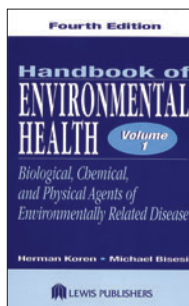
# RESOURCE CORNER

Resource Corner highlights different resources that NEHA has available to meet your education and training needs. These timely resources provide you with information and knowledge to advance your professional development. Visit NEHA's online Bookstore for additional information about these, and many other, pertinent resources!



## Handbook of Environmental Health, Volume 1: Biological, Chemical, and Physical Agents of Environmentally Related Disease (Fourth Edition)

Herman Koren and Michael Bisesi (2003)



A must for the reference library of anyone with environmental health concerns, this book focuses on factors that are generally associated with the indoor environment. It was written by experts in the field and copublished with the National Environmental Health Association. A variety of environmental issues are covered such as food safety, food technology, insect and rodent control, indoor air quality,

hospital environment, home environment, injury control, pesticides, industrial hygiene, instrumentation, and much more. Environmental issues, energy, practical microbiology and chemistry, risk assessment, emerging infectious diseases, laws, toxicology, epidemiology, human physiology, and the effects of the environment on humans are also covered. Study reference for NEHA's REHS/RS exam.

790 pages / Hardback

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Edited by David L. Heymann, MD (2015)



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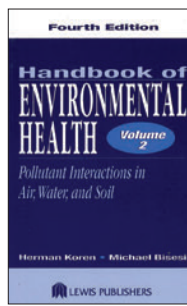
experts. New disease variants have been included and some chapters have been fundamentally reworked. This edition is a timely update to a milestone reference work that ensures the relevance and usefulness to every public health professional around the world. The *CCDM* is a study reference for NEHA's REHS/RS and CP-FS exams.

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problems and controls; safe drinking water problems and standards; onsite and public sewage problems and control; plumbing hazards; air, water, and solid waste programs; technology transfer; GIS and mapping; bioterrorism and security; disaster emergency health programs; ocean dumping; and much more. Study reference for NEHA's REHS/RS exam.

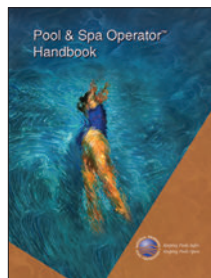
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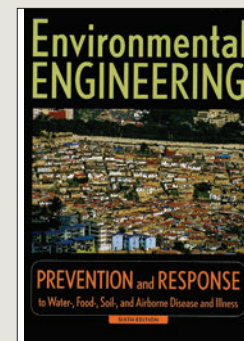
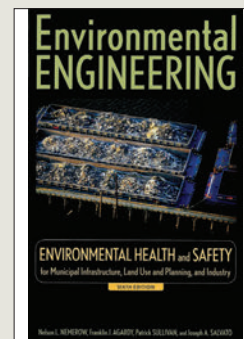
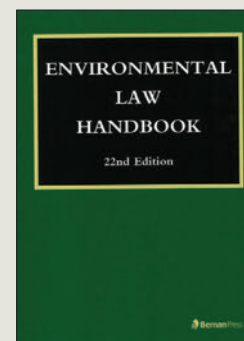
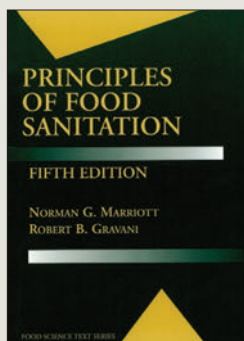
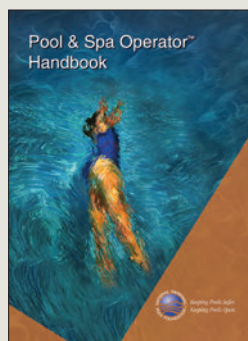
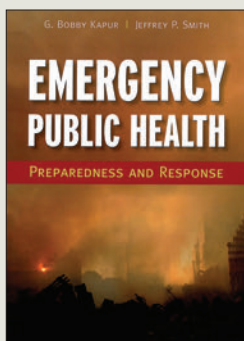
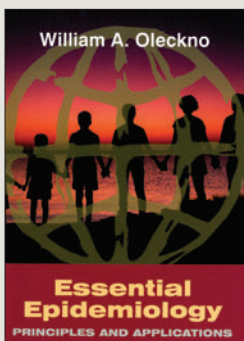
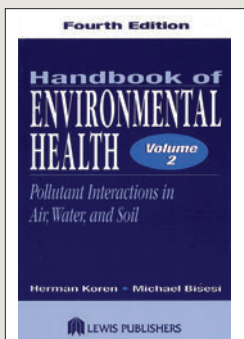
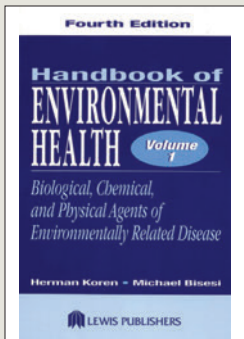
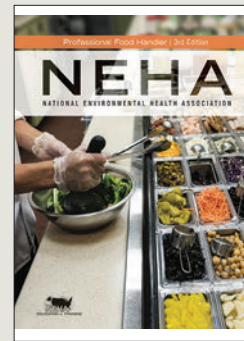
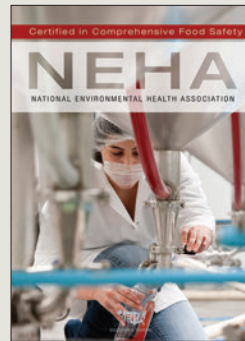
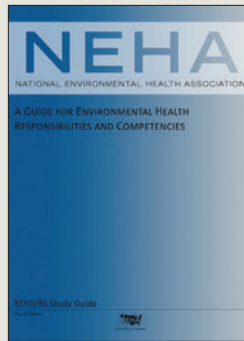
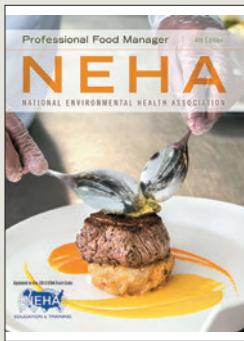



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www.cityofracine.org/Health

**San Jamar**  
www.sanjamar.com

**Seattle & King County Public Health**  
www.kingcounty.gov/healthservices/health.aspx

**Shat-R-Shield, Inc.**  
www.shat-r-shield.com

**Skillsoft**  
www.skillssoft.com

**Sonoma County Permit and Resource Management Department, Wells and Septic Section**  
www.sonoma-county.org/prmd

**Starbucks Coffee Company**  
www.starbucks.com

**StateFoodSafety.com**  
www.statefoodsafety.com

**Stater Brothers Market**  
www.staterbros.com

**Steton Technology Group, Inc.**  
www.steton.com

**Sweeps Software, Inc.**  
www.sweepssoftware.com

**Taylor Technologies, Inc.**  
www.taylor technologies.com

**Texas Roadhouse**  
www.texasroadhouse.com

**The Steritech Group, Inc.**  
www.steritech.com

**Tri-County Health Department**  
www.tchd.org

**Underwriters Laboratories, Inc.**  
www.ul.com

**Waco-McLennan County Public Health District**  
www.waco-texas.com/cms-healthdepartment

**Washington County Environmental Health (Oregon)**  
www.co.washington.or.us/HHS/EnvironmentalHealth

**Waukesha County Public Health Division**  
sward@waukeshacounty.gov

**West Virginia Office of Economic Opportunity**  
www.oeo.wv.gov

**Williams Comfort Products**  
www.wfc-fc.com

**XTIVIA**  
www.xtivia.com

## Educational Institution Members

**American Public University**  
www.StudyatAPU.com/NEHA

**Baylor University**  
www.baylor.edu

**East Central University**  
www.ecok.edu

**East Tennessee State University, DEH**  
www.etsu.edu

**Eastern Kentucky University**  
http://ehs.eku.edu

**Illinois State University**  
www.ilstu.edu

**Michigan State University, Online Master of Science in Food Safety**  
www.online.foodsafety.msu.edu

**The University of Findlay**  
www.findlay.edu

**University of Illinois Springfield**  
www.uis.edu/publichealth

**University of Wisconsin-Oshkosh, Lifelong Learning & Community Engagement**  
www.uwosh.edu/llce

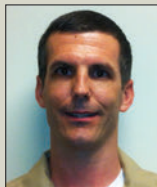
**University of Wisconsin-Stout, College of Science, Technology, Engineering, and Mathematics**  
www.uwstout.edu 

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Vice President



LCDR James Speckhart,  
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Destination

# San Antonio



## NEHA 2016 AEC and HUD Healthy Homes Conference

SAN ANTONIO, TX ★ JUNE 13-16, 2016



PRESENTED BY

Green & Healthy Homes Initiative®

## Register

**This month is your last chance to pre-register** to attend the NEHA 2016 AEC and HUD Healthy Homes Conference, presented by Green & Healthy Homes Initiative! After May 30, attendees must register on site in San Antonio. We hope to see you there!

Full Conference	\$675 member/\$850 nonmember
Full Conference + 1-year NEHA Membership	\$770
Single Day Registration	\$310 member/\$365 nonmember

## Hotel

**The conference will take place at two locations** with both hotels being within walking distance of one another along the Riverwalk. Discounted room rates are available at [neha.org/aec/hotel](http://neha.org/aec/hotel) until our room block is sold out.

- San Antonio Marriott Rivercenter  
*June 12-13: Education, Exhibition*
- Hyatt Regency San Antonio  
*June 14-15: Education*

## Enjoy

### Get Your Tickets for the Annual UL Event!

June 14 at 5:30 pm, \$45 per person

Join us for a boat ride along the San Antonio River, which will take you to dinner at the elegant Pearl Stable, within the historical Pearl Brewery District, a 22-acre brewery complex. The price includes boat ride with tour guide, dinner, and bus transportation back to the hotel. This always-popular event is not included in conference registration. If you want to attend, purchase your tickets in advance as this event is limited to 200 people and is expected to sell out!



Pearl Stable



# Conference at a Glance

## The State of Big Ideas: Moving Environmental Health Outside the Box

	SATURDAY/SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY
		Hotel: <b>Marriott Rivercenter</b>	Hotel: <b>Marriott Rivercenter</b>	Hotel: <b>Hyatt Regency</b>	Hotel: <b>Hyatt Regency</b>
<b>AM</b>		Travel to San Antonio  Exhibitor Setup	Education  Exhibition  <i>(lunch on your own)</i>	Education  <i>(lunch on your own)</i>	Education  <b>11:30 am</b> Closing Session
<b>PM</b>	Pre-conference Credential Review Courses	<b>4 pm</b> Opening & Keynote Session  <b>6 pm</b> Exhibition Grand Opening & Party	Education  Exhibition  <b>4 pm</b> Exhibitor Move-Out  <b>5:30 pm</b> Annual UL Event <i>(off site: advance ticket purchase required)</i>	Education  <b>6:30 pm</b> Texas Social <i>(off site)</i>	Return Travel

**Note: We are going green this year** by not printing a large program of educational sessions. We will provide a much smaller pocket guide for the program with an outline of each day's sessions. You can find printable links at [neha.org/aec/sessions](http://neha.org/aec/sessions) if you wish to print all the sessions to take to the conference.

**For full educational session descriptions** while at the conference, you'll need to get those online (desktop or mobile device).

**Build your schedule online before you go**—see the next page for information on the conference meeting app!

**All 2016 registered attendees receive access to recorded sessions** after the conference to get additional continuing education once they return from San Antonio.

### Can't Make It to San Antonio?

There will be approximately 30 sessions from the conference that will be recorded in full for viewing and continuing education after the conference. Purchase 2016 AEC Recorded Sessions at [neha.org/aec/recorded-sessions](http://neha.org/aec/recorded-sessions). \$149 member/\$249 nonmember.

# Build Your Schedule Before You Go!

Use the conference meeting app to build your schedule of educational sessions **before** you get to San Antonio! You can view all the educational session descriptions and add the ones you want to attend to your personal **online** schedule.

All registered attendees are e-mailed a link to a unique login using the e-mail address provided to us at registration. Look for an e-mail from [aec@neha.org](mailto:aec@neha.org).

You can also access the information on the app from your desktop by visiting [nehaaec.zerista.com](http://nehaaec.zerista.com). You will use your login information provided in the e-mail **meeting app invite** after you register.

## What Can You Do With the Meeting App?

- Build a personalized schedule from over 150 educational sessions, events, and activities.
- Quickly exchange contact information with others by scanning their conference badge with your smartphone.
- Message other attendees and set up meetings.
- Access maps and floor plans to navigate hotels, the Exhibition, and special events.
- Play the Connect4 NEHA game to enhance your experience and be entered to win prizes.

## Why Use the App?

We are going **green** for the 2016 conference and **printing a much smaller program guide with only an outline for each day's sessions.**

For full educational session descriptions while at the conference, you'll need to get those online (desktop or mobile device).

If you build your schedule in advance before you go, you will have all of the details on sessions, maps, speakers, etc., ready at your fingertips!

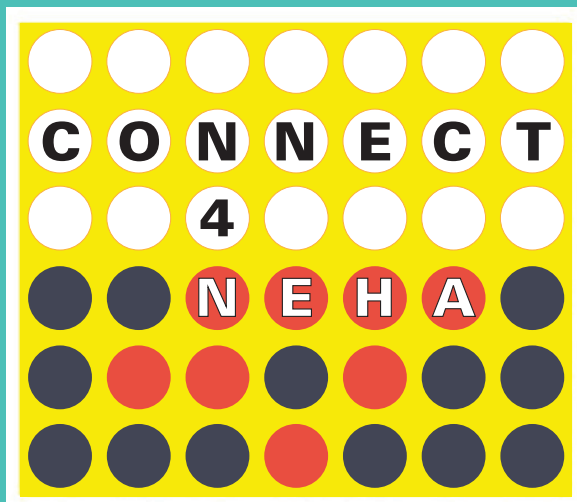
Plus, the meeting app is a fun way to connect with others and earn points as part of the Connect4 NEHA game!

## Are You Ready to Take on Last Year's Leaders?

We are throwing down the gauntlet to see who will take up the challenge to beat last year's Connect4 NEHA leaders. These individuals racked up the top points in Orlando and will need to up their game in San Antonio to defend their titles. Who will be San Antonio's Master of the AEC Universe? AEC Leader? AEC Champion?

### 2015 AEC Leaders

- |                                  |                                 |
|----------------------------------|---------------------------------|
| 1. Stephen Gilman (1,536 points) | 4. Janie Cambron (1,252 points) |
| 2. Sara Coly (1,459 points)      | 5. Andrew Roszak (1,206 points) |
| 3. Lavonne Lee (1,295 points)    |                                 |



## What Is Connect4 NEHA?

It is an online game where attendees earn different points for a variety of conference activities such as creating their profile, building their conference schedule, visiting exhibitor booths, scanning colleague name badges, attending sessions, and more! The use of the meeting app greatly contributes toward our efforts to green the conference by reducing paper use and encouraging more interactions using technology. Plus, it is a ton of fun! More details online at [neha.org/connect4neha](http://neha.org/connect4neha).

# 2016 Educational Sessions

Here is a sample of the exciting educational sessions we are preparing for the 2016 conference!

You will find more than 22 environmental health tracks covered in 150 sessions. View all sessions in advance so you can build your schedule by visiting [neha.org/aec/sessions](http://neha.org/aec/sessions).

## Air Quality

- Understanding Indoor Particulate Matter and Risk Reduction Strategies for Healthy Housing
- Assessing the Nation's Proximity to Roadways Using the Transportation and Health Tool
- Impact of Weatherization on Indoor Environmental Quality in Low Income Homes
- Monitoring of Indoor Air Quality in Tangipahoa Parish Schools

## Children's Environmental Health

- Preventing Children's Exposures to Environmental Health Hazards in Early Care
- Replacing Windows Reduces Childhood Lead Exposure
- From Hospital to Home: Changing the Paradigm of Asthma Care

## Climate Change

- Climate Change Is Here Now: We Are the Ones to Act
- Asthma & Climate Change: A Community and Healthy Homes Perspective
- Preparing Environmental Health for Climate Change Through Cross-Program Collaboration
- Arctic Policy, Sustainability, & Governance: Roles for Environmental Health Practitioners

## Emerging Environmental Health Issues

- Filling the Void: Safely Opening the Market to the Micromanufacturer
- Addressing Contemporary Challenges for Women in Environmental Health
- Smoke-Free Policies in Selected Texas Public Housing Authorities

## Environmental Health & Policy

- Everything You Wanted to Know About Politics In Our Capital But Were Afraid to Ask

## Environmental Health Impact Assessment

- Environmental Health Science: Tools & Approaches for a Changing World
- Integration of a Built Environment Unit in Environmental Public Health
- Health Impact Assessments & Extreme Weather: A New Approach for Environmental Health
- Asthma Home Visiting Programs: From Research to Sustainability

## Food Safety & Defense

- Tools and Resources for Building a Quality Retail Food Protection Program
- Employee Training: Expense or Investment?
- Using Social Media to Predict Foodborne Illness and Drive Inspections
- Implementation of Federal Menu Labeling Requirements in Harris County, Texas
- The A+ Cutting Edge Program: A Food Safety Partnership
- Pushing Through the Hurdles: Advice to Meet the FDA Retail Program Standard
- Making the Grade: Exploration of Retail Food Establishment Scoring & Grade Systems
- Deli Sleuths: Pursuing *Listeria monocytogenes*

## Healthy Homes & Communities

- How the National Healthy Housing Standard Can Improve Housing Codes for Health
- Preserving Affordable Housing Through Healthy Home Repairs
- Healthy Home Assessments: Rapid, Intuitive Visual Methods of Risk Characterization in Homes
- Proper Ventilation Really Does Matter to Indoor Air Quality and Health
- Integrating Health and Housing Inspections: A Collaboration for Healthy Living
- Is Substandard Housing Compromising the Health and Education of Indigenous Children?

## In the News

- The Zika Virus
- Water Crisis in Flint, Michigan
- Government Accountability Office Speaks on Climate Change
- One Health and EH: Perfect Partners in Securing Global Health
- Pesticide Contamination of Marijuana

(Educational Sessions continued next page)



# 2016 Educational Sessions (cont.)

## Leadership & Management

- Selecting the Best: 25 Questions Environmental Health Managers Want Answered About Job Candidates
- Engaging Your Customer Base to Maximize Your Environmental Health Program
- Using the Media as a Strategic Partner

## Onsite Wastewater

- H<sub>2</sub>O & M—The Online Tool to Create Customized Septic System Owner Guides
- Community Septage Disposal: Do You Have a Plan?
- Creating Healthy Homes and Healthy Septic Systems With HUD, CDBG, & SepticSmart

## Pathogens & Outbreaks

- Valley Fever Disease: The Zebra Among Horses
- Poo Fighters Diarrhea and Vomit Tour
- Where Are the Ticks? Solving a Tickborne Relapsing Fever Mystery

## Poster Sessions

- Tattoo Ink Outbreak Investigation: The Unknown of Tattoo Inks
- Airborne Emissions and Potential Health Effects From Consumer 3D Printers
- Retail Deli Slicer Cleaning and Inspection Practices
- Food Allergy Practices of Restaurant Managers and Staff
- Cultivate a Culture of Preparedness: Promoting Emergency Water Storage and Food Safety
- Cleaning the Air: Protecting Washington, DC, Residents Through Smoke-Free Multi-Unit Housing Policies
- Restart Healthy Homes: Providing Specialized Education to the Homeless
- Changing the Environment: Using Whole-Community-Based Interventions to Increase HPV Vaccination Rates
- *Legionella* in North Texas Cooling Towers: The City of Garland's Unique Response
- Bacteriological Contamination in Reusable Water Bottles: A Cross-Sectional Study in Washington State

## Recreational Waters

- Lessons Learned From Mass Chlorine Exposures at Recreational Swimming Pools
- Local Aquatics Inspection Data as National Surveillance Data
- The Future of Aquatics Health & Safety: Data Needed to Improve the Model Aquatic Health Code
- Drought Concerns, Water Conservation, and Maintaining Healthy Swimming Pool Water
- Helping Crack the Code: Model Aquatic Health Code Speed Mentoring

## Schools & Institutions

- Innovative School Health & Safety: Break the Mold and Achieve Results
- Food Safe Schools: Norovirus Prevention & Control
- Food Safe Schools: Managing Food Allergies
- Food Safe Schools: Produce Safety

## Technology & Environmental Health

- Buyer Beware: A Modern Day Consumer Food Safety Mobile App
- Mapping the Mysteries of Food Safety Regulations
- Using Virtual Conferences to Disseminate Scientific/Medical Information and Expand Workforce Training

## Vector Control & Zoonotic Diseases

- Keeping the Bugs Out: Promoting Environmental Health in Sensitive Environments
- CDC and NEHA Partner to Support Vector Control Programs
- Taking Control of Bed Bug Management: Lowering Costs With Nonchemical Controls
- Bed Bugs & Baseball: How Social Media Transformed Kansas City's Lodging Ordinance

## Water Quality

- Thinking Outside the Cooling Tower Box: *Legionella* & Raw Water Industrial Processes
- What's in the Water: Drinking Water Performance Improvement Project

# JEH QUIZ

## FEATURED ARTICLE QUIZ #6

### Swine Worker Precautions During Suspected Outbreaks of Influenza in Swine

Available to those holding an individual NEHA membership only, the *JEH Quiz*, offered six times per calendar year through the *Journal of Environmental Health*, is an easily accessible means to accumulate continuing-education (CE) credits toward maintaining your NEHA credentials.

1. Read the featured article carefully.
  2. Select the correct answer to each *JEH Quiz* question.
  3. a) Complete the online quiz at [www.neha.org/publications/journal-environmental-health](http://www.neha.org/publications/journal-environmental-health) (click on the May 2016 issue in the left menu),  
b) Fax the quiz to (303) 691-9490, or  
c) Mail the completed quiz to *JEH Quiz*, NEHA  
720 S. Colorado Blvd., Suite 1000-N  
Denver, CO 80246.
- Be sure to include your name and membership number!
4. One CE credit will be applied to your account with an effective date of May 1, 2016 (first day of issue).
  5. Check your continuing education account online at [www.neha.org](http://www.neha.org).
  6. You're on your way to earning CE hours!

#### Quiz Registration

Name

NEHA Member No.

E-mail

#### JEH Quiz #4 Answers January/February 2016

- |      |      |      |       |
|------|------|------|-------|
| 1. c | 4. a | 7. a | 10. a |
| 2. e | 5. b | 8. b | 11. b |
| 3. c | 6. c | 9. c | 12. a |

#### → Quiz deadline: August 1, 2016

1. Recent studies have documented that contact with infected pigs can lead to human infection.
  - a. True.
  - b. False.
2. Recent studies also indicate that swine workers
  - a. are at personal risk for occupational infection.
  - b. might act as a source for influenza transmission between swine and the community.
  - c. might contribute to the emergence of novel influenza viruses.
  - d. all the above.
3. In a study of swine workers in northwestern Mexico, swine workers were determined to have \_\_ swine influenza antibody titers compared to individuals with no exposure to swine.
  - a. significantly lower
  - b. similar
  - c. significantly higher
4. Federal guidance stresses that when pigs appear ill, workers should
  - a. use hand hygiene practices.
  - b. obtain routine seasonal influenza vaccinations.
  - c. use personal protective equipment including gloves, goggles, head coverings, and masks.
  - d. all of the above.
  - e. none of the above.
5. For this study, a total of \_\_ farms were visited during \_\_ suspected influenza A viruses (IAV) outbreaks.
  - a. 6; 11
  - b. 4; 11
  - c. 11; 6
  - d. 11; 11
6. Farms 3 and 6 had the greatest number of IAV outbreaks and had a \_\_ number of younger pigs compared to the other farms.
  - a. lower
  - b. similar
  - c. greater
7. Swine workers spent an average of \_\_ per day inside a barn.
  - a. 15 minutes
  - b. 25 minutes
  - c. 1 hour
  - d. 2 hours
8. The most common task across the farms during site visits was
  - a. handling pigs.
  - b. walking through the aisles and pens.
  - c. barn maintenance.
  - d. handling equipment.
9. Swine workers were reported as not wearing the following personal protective equipment:
  - a. eye protection.
  - b. heavy rubber gloves.
  - c. dust masks.
  - d. all the above.
  - e. a and c.
10. \_\_ were most frequently used when handling equipment, handling pigs, moving pigs, and walking the aisles.
  - a. N95 respirators
  - b. Hair coverings
  - c. Dust masks
  - d. Safety glasses
11. Study limitations include all of the following except
  - a. small number of farms surveyed.
  - b. only one geographic area surveyed.
  - c. site visits were not performed.
  - d. relied on supervisor reports of worker behavior.
12. The study was able to assess whether swine workers varied their level of precautions depending on perceptions about the health of the swine.
  - a. True.
  - b. False.

► **DirectTalk** MUSINGS FROM THE 10TH FLOOR



David Dyjack, DrPH, CIH

## Environmental Health Is a Contact Sport

We hired Sandra Whitehead, PhD, in January 2016 to provide vision, energy, and leadership to our association programs portfolio. Sandra brings extensive governmental and academic environmental health experience to our growing menu of grants and contracts, which in turn provides us the bandwidth to offer additional capacity building and continuing professional education to you. She is based in Washington, DC, and will develop partnerships with lawmakers, associations, and agencies located in the nation's capital.

In July 2013, the NEHA board adopted new definitions for environmental health and environmental health professional or specialist. Recently in this column, Dr. Dyjack has written on how our profession and *your association* are changing. The opening of a Washington, DC, office doesn't just represent a seat at the table legislatively, but also programmatically. What you have known as NEHA's Research and Development department has become Program and Partnership Development. The name change comes with a shift in focus. We are more member-centered, concentrating on developing and delivering quality technical assistance and capacity building as well as creating and cementing partnerships with funders and other national networks. My presence in Washington, DC, means you now have a program person who can nimbly respond to opportunities to lead as they arise.

Even though I am new to the NEHA staff, I am not new to NEHA. I have been a Technical

*The mission is to build capacity among environmental health professionals.*

Adviser and peer reviewer for the *Journal of Environmental Health* for several years. I also served on the Florida Environmental Health Association's executive committee. I bring these experiences to my new role as well as a background in capacity building for environmental health professionals. I have been developing, delivering, and evaluating efforts to support environmental health professionals for the past ten years, first at the Florida Department of Health's Division of Environmental Health and then at the National Association of County and City Health Officials. I have also worked in local government creating healthy housing programs and creating and implementing comprehensive plans and building codes. I ran a small city's drinking and wastewater treatment plants and was in charge of the animal control program for several years. The purpose of every program I led, worked on, or created was to protect and preserve the health of the residents.

The mission of the newly renamed Program and Partnership Development team is to

build capacity among environmental health professionals and to support you in the work you do every day. You have a team of subject matter experts on staff to assist you with any issue from climate change and sustainability to safe drinking water and integrated pest management. We've been working hard to develop useful resources for NEHA's Web site and to develop opportunities for you to be engaged in to inform this work. We will be working with members to gather data about your workforce development needs and how we can help meet them. Additionally, NEHA staff is developing resources to bring you ongoing technical assistance and toolkits that will assist you in your work.

My vision is for the Program and Partnership Development team to become your "go to" for a deeper dive on emerging environmental health issues, best practices, and success stories you can use. We will be reaching out to members about your needs and engaging you in these efforts. This is your association and our team is here to support you.

Environmental health is indeed a contact sport. We welcome Sandra to our growing presence in Washington, DC, with the aim of being in contact with decision makers who influence our profession. The sun never sets on our passion to unleash the right talent at the right time and place. 🐞

*Dave*

ddyjack@neha.org  
Twitter: @DTDyjack



# Congratulations

## NEHA 2016 AEC Scholarship Winners!

Accela recently awarded 15 scholarships to Environmental Health professionals to attend the NEHA 2016 AEC and HUD Healthy Homes Conference, presented by the Green & Healthy Homes Initiative.

Our scholarship recipients represent the best in the industry. For a peek at their thoughts on the industry's latest trending topics, visit <http://www.accela.com/nehascholarship>



For more information, visit [www.accela.com](http://www.accela.com) or call (888) 722-2352, ext 8.

Last year Angie Clark did **700** routine inspections, **200** complaint inspections, **30** Court dates, logged **3,000** travel miles and quite possibly prevented dozens of illnesses.

She doesn't take chances. The communities she serves depend on her to do more inspections under an increasingly difficult work load and conditions. In the office or on the road, she demands the most from her tools and equipment.

That's why she is never without her tablet and HealthSpace EnviroIntel Manager.

**Enviro**intel  
MANAGER

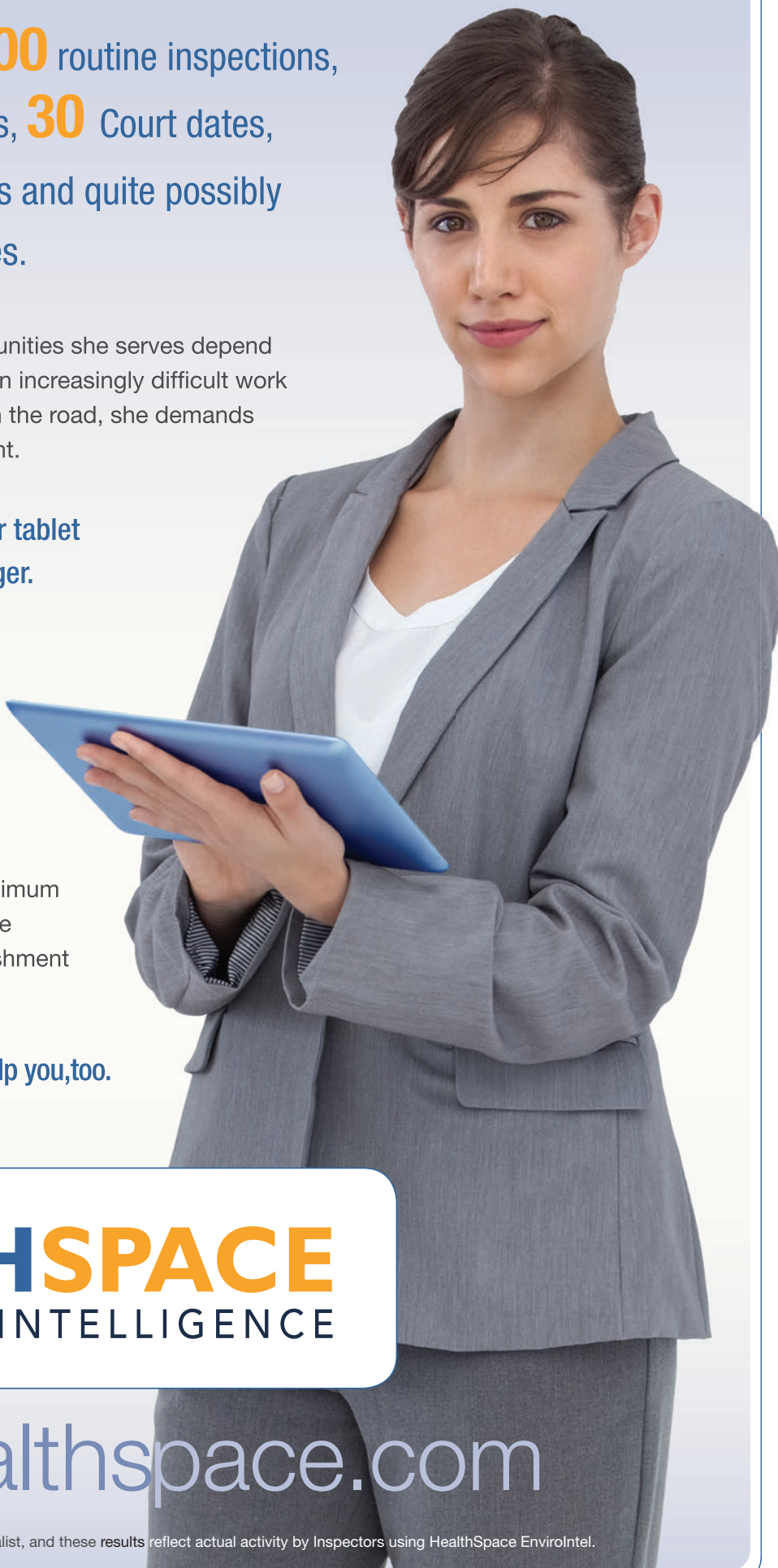
When Angie makes a call, her work is available to the department and the public within minutes. She always has the information she needs for maximum productivity and accuracy. Facilities are never missed and high-hazard establishment inspections are never late.

EnviroIntel helps Angie, and it can help you, too.

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**ANGIE** = A Nom-de-plume Genuine Inspector Environmentalist, and these results reflect actual activity by Inspectors using HealthSpace EnviroIntel.





## ▶ INTERNATIONAL PERSPECTIVES

# Human Waste as a Tool in Biogeochemical Surveys From Mangampeta Barite Mining Area, Kadapa District, Andhra Pradesh, India

Vangeepuram Raghu, MSc, PhD  
Andhra Pradesh Space  
Applications Centre

**Abstract** Biogeochemical interactions between humans and their surrounding environment were studied through fecal material and urine of mine laborers at the Mangampeta barite mining area in India. For the purpose of comparison, feces and urine were also collected from males of Sri Venkateswara University campus at Tirupati. Ten trace elements were analyzed by atomic absorption spectroscopy on ash weight basis. Barium, nickel, chromium, and cadmium were found to be 3 times higher in feces of men at Mangampeta than of men at Tirupati. Cobalt was also found to be marginally higher in the feces of men at Mangampeta than men at Tirupati. Barium and chromium were absent in the urine of men at Tirupati, and strontium, zinc, cobalt, and nickel were 1.5 times higher in the urine of men at Mangampeta than men at Tirupati. Heavy metals, namely copper, lead, zinc, manganese, and strontium, in feces and lead and manganese in urine of men at Tirupati were higher than men at Mangampeta. In contrast to the Western world, people in rural areas of India derive their dietary materials from their surrounding habitat. Therefore, fecal material and the urine of human beings from rural areas can be used as tools in biogeochemical surveys, as these waste materials reflect their immediate geochemical environment.

## Introduction

Living organisms, plants, animals, and human beings are conditioned in greater or lesser degree by the chemistry of their environment, as the chemical elements are derived primarily from the Earth. In recent decades there has been an increase in awareness of the importance of the interaction of mammalian systems with their natural environment. Hence, biogeochemistry has gained importance and its scope in recent years has been extended to the health aspects of the environment, which

has paved the way for a new field of science called “geo-medicine” or “medical geology.” Geo-medicine is defined as “the science dealing with the influence of ordinary environmental factors on the geographical distribution of pathological and nutritional problems of human and animal health” (Lag, 1983). Many workers have discussed trace element imbalances in soil-water-plant-animal systems and their eventual effects on human health (Bowie & Webb, 1980; Thornton, 1983; Underwood, 1971). In this context, the con-

cept of “biogeochemical province” was introduced (Vinogradov, 1964). It consists of two categories, 1) zonal, i.e., strongly influenced by climate and soil type and 2) intrazonal, which is influenced by local enrichment of elements due to the existence of ore bodies and their associated dispersion halos. In such provinces, plants and animals conspicuously exhibit indicator characteristics, which may be morphological or physiological. On this basis, termites, cattle, dogs, fish, and birds can also be employed as bioindicators in mineral exploration (Brooks, 1983).

## Methods

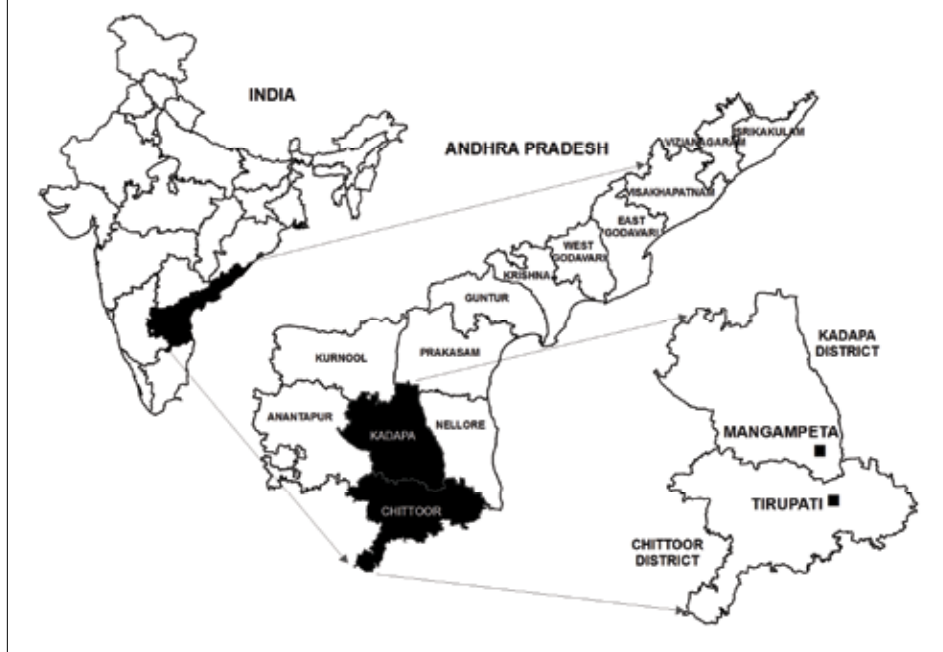
In the present study, we attempted to study the biogeochemical interactions between humans and their environment by analyzing fecal material and urine in an intrazonal biogeochemical province and to distinguish the bioindicator characteristics of human beings for use in different problems of applied environmental geochemistry.

## Study Area

The Mangampeta (latitude 14°01' N and longitude 79°19' E) barite area, an intrazonal biogeochemical province, is located in Kadapa District in the Indian state of Andhra Pradesh (Figure 1). It is the world's largest bedded barite deposit, contributing to approximately 28% of the total known reserves of barite in the world. Mangampeta is a rural area in a semiarid tract and is included in the Survey of India toposheet No. 57 N/8. The ore is being excavated through open-cast mining. This area consists of quartzites, shales, and dolomites of Proterozoic age. This deposit is also

FIGURE 1

## Location Map of the Study Area



associated with minor occurrences of quartz, pyrite, chalcopyrite, azurite, and malachite.

In the Mangampeta mining area, the predominantly occurring plants are *Tephrosia purpurea*, *Tridax procumbens*, *Ocimum sanctum*, *Anisomeles malabarica*, *Cissus quadrangularis*, *Kirganelia reticulata*, and *Citrillus colocynthis*. Some important tree species in this area include *Pongamia pinnata* and *Prosopis juliflora*. Agricultural lands with paddy and plantations such as banana, lemon, orange, and mango cover the plains around Mangampeta (Raghu, 2001). The hilly areas and some portions of the plains are covered with scrub vegetation.

Mangampeta, which is at 180 m above mean sea level (MSL), experiences a tropical climate throughout the year. During summer season, temperatures range from 34°C to 43°C and in winter the minimum temperatures range between 14°C and 29°C. Generally, summer season is from March to June and the rainy season starts with arrival of the southwest monsoon in June and ends by September. The influence of the northeast monsoon (October to December) is due to cyclonic depressions formed in the Bay of Bengal. Due to vagaries of the monsoon, rain-

fall in the Mangampeta area is precarious and erratic. After the rainy season, the winter season starts and continues till the end of February. During the southwest monsoon, relative humidity is high, reaching 100%. The wind velocity ranges from 12–25 km/h. The soil moisture content varies from 30% to 42%. The average annual rainfall of Mangampeta is 840 mm. The monsoon failing to happen generally has a disastrous effect on the agriculture sector, as a large share of population is dependent on agriculture for their livelihood.

For the purpose of comparison, Tirupati (latitude 13°38' N and longitude 79°24' E) urban area of Chittoor District (Figure 1) was chosen as a nonmineralized area. Within the Tirupati area, Sri Venkateswara University campus was selected. This area is included in the Survey of India toposheet No. 57 O/6. The Tirupati area consists of granites and granite gneisses of Archean age traversed by dyke swarms. In the north of the Tirupati area, these granites are overlain by Nagari quartzites, which form part of the Cuddapah Supergroup.

Sri Venkateswara University campus is located in the Tirupati urban area. The dominant plant species on the campus are *Leucas aspera*, *Celosia viridis*, *Acalypha indica*, *Mimosa*

*pudica*, and *Sida cardifolia*. The important tree species present on the campus are *Limonia acidissima*, *Melia azedarach*, *Bauhinia purpurea*, and *Pterocarpus marsupium*.

Tirupati also has a tropical climate throughout the year, with temperatures ranging from 32°C to 45°C during the summer. In winter, the temperatures range between 13°C and 33°C. Usually, summer lasts from March to June and the rainy season starts with the advent of the southwest monsoon in July and ends with the receding of the northeast monsoon by November. The rainfall received from the northeast monsoon is comparatively more due to depressions formed in the Bay of Bengal. Tirupati, which is at 160 m above MSL, has precarious, uneven, and erratic rainfall. The rainy season is followed by winter, which lasts till the end of February. During the southwest monsoon, relative humidity is high, reaching 99%. The remaining period of the year, the air generally is dry; the summer season is the driest part of the year. The average wind velocity ranges from 10–18 km/h and occasionally goes up to 22 km/h. The average annual rainfall in Tirupati is 1,088 mm. The soil moisture content varies from 28% to 45% (Kavitha, 2010).

### Sampling

Mangampeta barite mine laborers consisting of 15 male and 15 female members in the age group of 25–35 years were chosen. The fecal and urine output of each member were separately collected in plastic containers. Samples from all members of each sex were combined to obtain a composite sample of feces and urine. Similarly, composite samples of feces and urine were collected from 15 male hostel students of the same age group from Sri Venkateswara University campus, Tirupati.

The human beings selected for sample collection did not exhibit any physically detectable signs of disease. Further, the sample collection in both the mineralized and non-mineralized areas was made within a week to avoid seasonal variations.

### Trace Element Analysis

Moisture from the feces and water content from the urine was eliminated by keeping the samples at 110°C in a hot air oven for eight hours. Further, organic matter from the moisture-free samples was expelled by placing the samples at 500°C in a muffle furnace

TABLE 1

## Trace Elements (Parts per Million) in Human Feces and Urine

Sample	Elements (Detection Limits)									
	Barium (0.10)	Strontium (0.04)	Copper (0.03)	Lead (0.20)	Zinc (0.02)	Manganese (0.03)	Nickel (0.08)	Cobalt (0.07)	Chromium (0.05)	Cadmium (0.006)
Mangampeta barite mining area										
Feces (men)	555	844	138	372	560	514	600	98	138	20
Feces (women)	553	927	136	1134	560	624	ND <sup>a</sup>	50	58	5
Urine (men)	102	97	8	ND	31	36	124	50	39	1
Urine (women)	127	112	ND	ND	31	47	76	61	20	ND
Tirupati area										
Feces (men)	156	1633	530	1200	2444	904	200	82	37	6
Urine (men)	ND	56	10	17	16	51	67	30	ND	3
<sup>a</sup> ND = not detected.										

for three hours. Each ashed sample weighing 0.5 g was digested in 2M hydrochloric acid and analyzed for barium, strontium, copper, lead, zinc, manganese, nickel, cobalt, chromium, and cadmium by atomic absorption spectrophotometry (Table 1).

## Results and Discussion

Feces (555 parts per million [ppm]) and urine (102 ppm) of Mangampeta men contained a higher concentration of barium than Tirupati men, reflecting the concentration of barium in the surrounding environment. Barium, nickel, chromium, and cadmium were found to be 3 times higher, while cobalt was found to be marginally higher in feces of Mangampeta men than those of Tirupati men. Barium and chromium were not detected in the urine of Tirupati men, but were present in the urine of Mangampeta men. Strontium, zinc, nickel, and cobalt were 1.5 times higher in the urine of Mangampeta men than in Tirupati men.

In Mangampeta, the concentration of copper, nickel, cobalt, chromium, and cadmium in feces and these compounds in urine were higher in men than in women. Irrespective of the area and person's sex, barium concentration was detected higher in feces than in urine. In addition, in both areas and in both sexes, the concentrations of strontium, copper, lead, zinc, manganese, chromium, and cadmium were higher in feces than in urine (Table 1). It is interesting to note that heavy metals, namely copper, lead, zinc, manganese, and strontium in feces and lead and

manganese in urine were higher in Tirupati men than in Mangampeta men. This could be attributed to the food intake of the subjects being from different sources. Soetan and co-authors (2010) stated that cobalt is readily absorbed into the blood stream and excreted primarily in the urine, whereas the urinary excretion of zinc is low and would not vary markedly with the dietary supply. A statistical parameter to analyze variance, ANOVA, was applied to the data; no significant difference was found between Mangampeta and Tirupati areas, male and female samples, and urine and feces.

Water in the Mangampeta barite mine pit, which is used for irrigation of coconut plantations as well as other agricultural purposes, showed higher concentration of barium (133 ppm), strontium (1,835 ppm), and chromium (19 ppm) on ash weight basis than those elements in coconut water (Prasad & Raghu, 1994). The concentration of barium in soils of Mangampeta ranges from 110 ppm to 579 ppm, while strontium ranges from 14 ppm to 31 ppm (Raghu, 2001).

The greatest environmental health hazard to workers in barite mining areas is inhaling the microscopic-sized dust particles created from the blasting and mining. Excessive inhalation of barite causes baritosis, which is one form of pneumoconiosis, a diagnosable disease of the lungs wherein the tissues of the lungs react to the accumulation of dust in them, resulting in impaired lung function. The size composition, duration of

exposure, and concentration of the fine dust are critical in determining the onset of baritosis. The presence of metals in the barite are more of a health concern than the barite itself, as it is quite harmless and causes no other acute health problem other than choking, unless inhaled in very large amounts. In particular, it is the mineral quartz, ores of copper, and lead associated with barite as impurities that are more hazardous to health. The inhalation of such types of dust causes massive fibrosis. If long-term exposure to barite exists, enough to cause pulmonary disease and the person also has rheumatoid arthritis, there exists a potential for bronchogenic cancer. The total composition of the ore, including the "gangue" minerals (commercially worthless, nonmetallic minerals) cannot be neglected in ascertaining the cause of pneumoconiosis.

An excess, deficiency, or imbalance of inorganic elements originating from geological sources can affect human and animal well-being either directly or indirectly. It is an established fact that through food chain ingestion and inhalation of atmospheric dusts and gases, human health is directly linked to our geology. In the present study, the ore element barium is entering the human body through water, food, and inhaled particulates and is excreted in human feces and urine. As a result, the feces and urine of male laborers working at Mangampeta barite mining area showed a higher concentration of barium than men in the nonmineralized Tirupati

area. There is little comprehensive information on correlations of trace elements between dietary intake and the three biological media (blood, urine, and feces) and interelement interactions within blood, urine, and feces in healthy people (Wang et al., 2012).

Pollution in the environment and human exposure to various metallic and nonmetallic elements occurs in natural activities, but more particularly to mining and industrial workers. Oxman and co-authors (1993) stated that "occupational dust is an important cause of chronic obstructive pulmonary disease, and the risk appears to be greater for gold miners than for coal miners and one possible explanation of the greater risk among gold miners is the higher silica content in gold mine dust." The concentration of fluoride in dung, urine, and milk of certain grazing animals was studied in two places within the Indian state of Andhra Pradesh: Podili, an endemic fluorosis area, and Tirupati, a nonfluorosis area. The study showed the fluoride content of urine in animals is suitable for preparation of biogeochemical atlases to study the environmental effect in relation to human health (Reddy, Prasad, & Raju, 1999). A significant correlation between nickel in workers' urine and airborne nickel ( $r = .96$ ) was detected and a considerable difference was observed in the concentration of nickel in workers' urine between pre- and post-shift samples. The researchers concluded that urinary nickel can be used as a reliable internal dose bioindicator in biological monitoring of workers exposed to nickel sulfate in galvanizing plants regardless of the day of the workweek on which the samples are collected (Oliveira, de Siqueira, & da Silva, 2000).

Quinlan and co-authors (2001) stated that further research is needed to more clearly link health effects to particular business practices and neoliberal policies and to explore the regulatory implications of the growth of precarious employment, and then suggested ways to conceptualize the association between precarious employment and occupational health. Donoghue (2004) outlined the physical, chemical, biological, ergonomic, and psychosocial occupational health hazards of mining and associated metallurgical processes and stated that vigilance is required to ensure exposures to coal dust and crystalline silica remain effectively controlled.

Serum hepatic inflammatory functions were significantly altered in workers exposed to high nickel levels, as compared to moderate exposure and control group. The results of the study indicated that exposure to soluble nickel compounds had consistent effect on hepatic inflammatory function in nickel-exposed workers (Ravibabu, Rajmohan, & Rajan, 2006).

Changes in catecholamines in the urine of workers exposed to noise was evaluated at a copper industry; it was observed that noise reduction by ear plugs led to almost significant reductions in urinary epinephrine and a considerable decrease in norepinephrine. These results showed that with noise reduction, the urinary excretion of stress hormones, especially norepinephrine, significantly decreased and thus workers probably were less prone to stress-related disorders (Ghotbi et al., 2013).

Human exposure to arsenic and mercury was assessed in the urine of artisanal miners and it was estimated that the levels of both arsenic and mercury were relatively high compared to other studies because none of the artisanal gold miners used any personal protective equipment in the course of their work. This was coupled with poor hygienic practices (Dartey, Sarpong, Darko, & Acheampong-Marfo, 2013).

There is not much literature on using feces and urine as indicators in biogeoscience and mineral exploration. Based on the available literature, however, it seems that urine is a more sensitive marker of occupational health hazards than feces. In the present work, though, we used both urine and feces as bioindicators in our biogeochemical surveys.

Webb (1964) stated that:

The link between human health and geology is even more complex, since the food we eat varies widely both in composition and place of origin. Our water and milk may come from distant places. Human beings too move about from one geological environment to another. Processing, both in the factory and at home, can materially affect the content and availability of the mineral constituents of food and beverages. Atmospheric pollution particularly in the urban areas is widespread.

Underwood (1980) stated that:

Trace element deficiencies and toxicities in man are more difficult to relate to the geochemical environment than in grazing animals because

- 1) the geographical and hence the geochemical sources of human foods and beverages are continually widening, so that the overall diet usually contains materials grown or produced on a range of soil types;
- 2) modern dietaries, especially in the Western world, contain a wide variety of types of food so that trace element abnormalities that may be present in one type may be offset or counteracted by the consumption of other food items with no such abnormalities; and
- 3) technological developments in agriculture, i.e., food production, and in food processing, result in gains and losses of trace elements from foods, which can erode the directness of the relation between man and his natural geochemical environment.

Geoscientists and medical researchers bring to medical geology an arsenal of valuable techniques and tools that can be applied to health problems caused by geologic materials and processes. Although some of these tools may be common to both disciplines, practitioners of these disciplines commonly apply them in novel ways or with unique perspectives. In this context, unlike in the Western world, people in rural areas of India derive their dietary materials from their surrounding habitat. Thus, fecal material and urine output from human beings can be used as tools in biogeochemical orientation surveys.

## Conclusion

Different sampling media, such as soils, stream and lake sediments, waters, and vegetation have been utilized for establishing multi-element atlases for effective study of environmental geochemistry (Howarth & Thornton, 1983). For such a purpose, human feces and urine also serve as a significant sampling media. Human feces and urine can be utilized as tools in biogeochemical orien-

tation surveys as there exists a direct relationship between humans and their surrounding natural geochemical environment in the rural areas of India.

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