JOURNAL OF

# Environmental Health

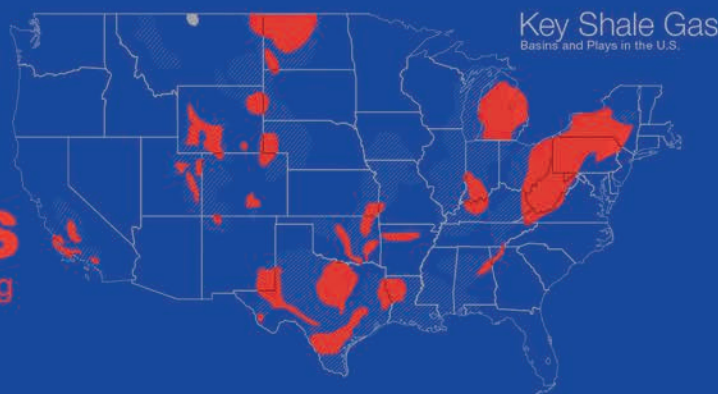
twelve dollars

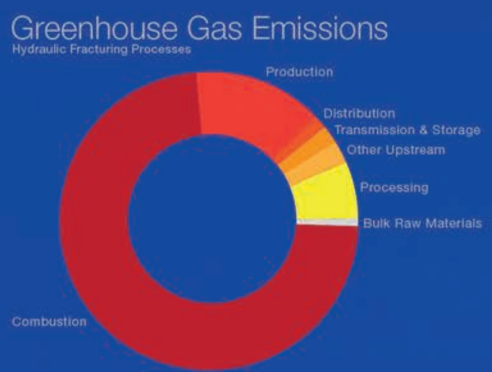
Dedicated to the advancement of the environmental health professional

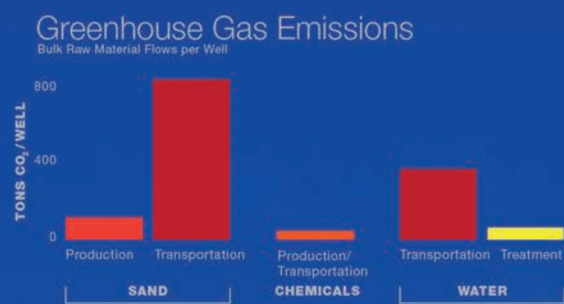
Volume 79, No. 4 November 2016

## LIFE CYCLE GREENHOUSE GAS EMISSIONS

Associated With Hydraulic Fracturing




Published by the National Environmental Health Association

www.neha.org

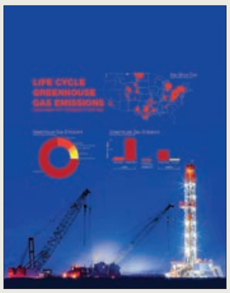
JOURNAL OF

# Environmental Health

Dedicated to the advancement of the environmental health professional

Volume 79, No. 4 November 2016

## ABOUT THE COVER



The November cover article, "An Assessment of Life Cycle Greenhouse Gas Emissions Associated With the Use of Water, Sand, and Chemicals in Shale Gas Production of Pennsylvania Marcellus Shale," focuses on upstream impacts of hydraulic fracturing for natural gas. The authors used real-world field data to assess life cycle greenhouse gas emissions associated with the production and transportation of chemicals and sand mining used in the process. The findings focus attention on large greenhouse gas emission sources that historically have had a high degree of uncertainty.

See page 8.

*Cover illustration © iStock.com/Ramon Perez*

## ADVERTISERS INDEX



## ADVANCEMENT OF THE SCIENCE



## ADVANCEMENT OF THE PRACTICE



## ADVANCEMENT OF THE PRACTITIONER



## YOUR ASSOCIATION



## E-*JOURNAL* BONUS ARTICLE

# don't miss
## in the next *Journal of Environmental Health*

- A Community-Based Participatory Research Approach to Identifying Environmental Concerns
- Interpersonal Skills in the Practice of Food Safety Inspections
- Use of the VectorTest for Advanced Warning of West Nile Virus Cases
- E-*Journal* Bonus Article: Atrazine in Kentucky Drinking Water


**Official Publication**

National Environmental Health Association

**Journal of Environmental Health**
(ISSN 0022-0892)

**Kristen Ruby-Cisneros,** Managing Editor
**Ellen Kuwana, MS,** Copy Editor
**Hughes design|communications,** Design/Production
**Cognition Studio,** Cover Artwork
**Soni Fink,** Advertising
For advertising call 303.756.9090, ext. 314

**Technical Editors**

**William A. Adler, MPH, RS**
Retired (Minnesota Department of Health), Rochester, MN

**Gary Erbeck, MPH**
Retired (County of San Diego Department of Environmental Health), San Diego, CA

**Carolyn Hester Harvey, PhD, CIH, RS, DAAS, CHMM**
Eastern Kentucky University, Richmond, KY

**Thomas H. Hatfield, DrPH, REHS, DAAS**
California State University, Northridge, CA

**Dhitinut Ratnapradipa, PhD, MCHES**
Sam Huston State University, Huntsville, TX

Published monthly (except bimonthly in January/February and July/August) by the National Environmental Health Association, 720 S. Colorado Blvd., Suite 1000-N, Denver, CO 80246-1926. Phone: (303) 756-9090; Fax: (303) 691-9490; Internet: www.neha.org. E-mail: kruby@neha.org. Volume 79, Number 4. Subscription rates in U.S.: $135 per year and $250 for two years. International subscription rates: $160 per year and $300 for two years (airmail postage included). Single copies: $12, if available. Reprint and advertising rates available at www.neha.org/JEH. CPM Sales Agreement Number 40045946.





Full text of this journal is available from ProQuest Information and Learning, (800) 521-0600, ext. 3781; (734) 973-7007; or www.proquest.com. The *Journal of Environmental Health* is indexed by Current Awareness in Biological Sciences, EBSCO, and Applied Science & Technology Index. It is abstracted by Wilson Applied Science & Technology Abstracts and EMBASE/Excerpta Medica.

All technical manuscripts submitted for publication are subject to peer review. Contact the managing editor for Instructions for Authors, or visit www.neha.org/JEH.

To submit a manuscript, visit http://jeh.msubmit.net. Direct all questions to Kristen Ruby-Cisneros, managing editor, kruby@neha.org.

Periodicals postage paid at Denver, Colorado, and additional mailing offices. POSTMASTER: Send address changes to *Journal of Environmental Health*, 720 S. Colorado Blvd., Suite 1000-N, Denver, CO 80246-1926.

Printed on recycled paper.

PRINTED WITH SOY INK

PRESIDENT'S MESSAGE

David E. Riggs,
MS, REHS/RS

# Water and Environmental Equity

The U.S. has remarkable water systems—designed, built, and operated over nearly two centuries of technical, social, and economic advances. The infrastructures of these systems, however, are aging and deteriorating. Many urban distribution systems were designed and built in the first half of the last century with materials, such as lead, that either are now consider toxic or that threaten the quality of the drinking water that is delivered. In rural areas, small community drinking water systems were often built in a piecemeal fashion, growing sequentially without overall design or measure of potential capacity. Now those systems have undersized water sources, inadequate water treatment, and in many cases, insufficiently trained system operators.

The provision of safe drinking water to our communities, urban or rural, is the obligation of environmental health professionals. As practitioners, our profession provides the expertise to find and develop adequate water sources, investigate and upgrade aging or poorly designed distribution systems, and mitigate the effects of unacceptable materials.

In general and historically, environmental health practitioners have done a good job in protecting our communities by providing an adequate quantity and quality of drinking water. We, as professional practitioners, and NEHA, as our premier professional organization, however, must examine and take leadership in identifying and solving two undeniable problems in providing sufficient amounts of safe drinking water.

The problems associated with not having acceptable drinking water have a domino effect in many environmental health areas. The negative effect of poor drinking water quality affects many of our other environmental practices in food safety, the built environment, and sewage transport and disposal. The first major problem our profession must target is the identification and remediation of decaying distribution systems, inadequate sources, and contamination by construction materials. Although this problem is large and complicated, it can be solved by straight forward identification and application of environmental health principles.

> *The provision of safe drinking water to our communities is the obligation of environmental health professionals.*

The second major problems that environmental health practitioners are best equipped to address and solve is water equity. Around the country, water equity is a term that has been used to define the interrelationship between local populations (e.g., rural, low income, city center) and the drinking water supplies that influence their health and community sustainability. Water equity is defined as the proportional and equitable distribution of water related to environmental benefits and risks among diverse economic and cultural communities. Water equity ensures that policies, activities, and government responses do not differentially impact diverse social, cultural, and economic groups. Water equity promotes the provision of safe drinking water for all people.

Flint, Michigan, is an example of the failure to apply water equity principles. A low socioeconomic community was, according to media reports, the most affected population in Flint. Among the adverse consequences of the entire incident was an abiding mistrust of government agencies and expertise. A positive outcome is that public and political focus has been put on water infrastructure and the frailty of existing systems. Water inequities, however, exist not only in urban inner city areas, but now appear to be equally prevalent in small rural communities. These rural communities do not have the population or revenue to maintain and properly operate their water supply systems. Nor do these rural water systems have the financial ability to newly develop or upgrade existing water sources.

Environmental health professionals are—by education, experience, and training—best suited to identify the physical factors leading to inadequate drinking water, as well as the socioeconomic characteristics of urban and rural low-income communities. Water equity, as part of the larger environmental equity concern, is an emerging environmental practice within our profession.

The problems extending to water include

- instances where urban and rural low-income communities are disproportionately burdened with drinking water hazards ranging from contamination and deteriorating distribution systems to inadequate water sources;
- land use planning and housing that perpetuate exposure to contaminates such as lead;
- failure to enforce water policies and regulations due to inadequate funding or lack of personnel;
- failure of policies, laws, and regulations to keep pace with science-based parameters for drinking water; and
- failure to study cumulative risks and impacts from the consumption and use of poor quality drinking water.

Regional studies and stories from across the country illustrate the water struggles of low-income urban centers and rural communities. Accurate, uniform data on water quality, quantity, and use do not exist in many places and are not collected and analyzed nationwide. There is also a lack of data analysis by demographics and socioeconomic factors.

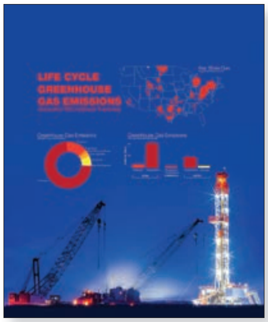
The environmental health profession is uniquely qualified to address the problem of providing safe drinking water. Our profession must identify the physical conditions that might result in water quality hazards. It is our obligation to promote scientific laws and regulations that assure safe drinking water. It is also our responsibility to ensure that activities that reduce water quality hazards are provided to all communities, regardless of economic or cultural factors.

The environmental health profession and NEHA need to be major influencers in the assurance of water equity in all our communities.

*David E. Riggs*
davideriggs@comcast.com

## Did You Know?

Water quality is a major area of focus for NEHA. Our water quality page is always being updated with new e-learning opportunities, relevant credentials, and upcoming events and webinars. Check it out today and learn more at www.neha.org/eh-topics/water-quality-0.



# An Assessment of Life Cycle Greenhouse Gas Emissions Associated With the Use of Water, Sand, and Chemicals in Shale Gas Production of the Pennsylvania Marcellus Shale

*Editor's Note: Two supplemental documents that were submitted along with this peer-reviewed article have been posted online due to publication space limitations. These documents were not peer reviewed or copy edited by the* Journal. *They are provided as extra resources should the reader want more information. The supplemental text and table can be accessed at www.neha.org/jeh/supplemental.*

Christopher Sibrizzi, MPH
Peter LaPuma, PhD, PE, CIH
*The George Washington University*
*Milken Institute School of Public Health*
*Department of Environmental and Occupational Health*

**Abstract** **The widespread use of hydraulic fracturing (HF) has enabled a dramatic expansion of unconventional natural gas extraction in the U.S. While life cycle greenhouse gas (LC-GHG) emissions associated with HF have gained attention in recent years, little focus has been devoted to upstream LC-GHG impacts of HF natural gas (Clark, Burnham, Harto, & Horner, 2013; Verrastro, 2012). Focusing on 1,921 wells in Pennsylvania from 2012 to 2013, we used the Economic Input-Output Life Cycle Assessment model to assess LC-GHG emissions associated with production and transportation of chemicals and sand mining. Ton-miles from the transportation of sand and water were assessed with life cycle transportation emissions factors to generate LC-GHG emissions. LC-GHG emissions from upstream inputs assessed in this study equaled 1,374 tons of $CO_2$e per well, but account for only 0.63% of the total LC-GHG emissions of HF natural gas. LC-GHG emissions from sand, water, and chemicals are quite small when compared with gas combustion, methane leakage, venting, and flaring from the other phases of the HF process.**

## Introduction

In recent years, the widespread use of hydraulic fracturing (HF) has enabled the rapid expansion of unconventional natural gas, tight gas, and tight oil production in the U.S. (Clark et al., 2013; Verrastro, 2012). As a result, the U.S. has been the world's leading natural gas and oil producer since 2010 and 2013, respectively (Smith, 2014; U.S. Energy Information Administration [U.S. EIA], 2015a; International Energy Agency, 2014). In 2012, over 60% of the natural gas produced in the U.S. came from unconventional sources; this number is projected to increase to 75% by 2040 (U.S. EIA, 2014). By 2040, it is projected that natural gas and coal will account for 31% and 34%, respectively, of U.S. electricity generation (U.S. EIA, 2015b).

In 2013, electricity production generated the largest share (31%) of U.S. greenhouse gas (GHG) emissions (U.S. Environmental Protection Agency [U.S. EPA], 2015). A reduction in GHG emissions over the next few decades can reduce risks to environmental and human health due to increasingly frequent, intense, and longer-lasting extreme heat; worsening droughts, wildfires, and air pollution risks; increasingly frequent extreme precipitation, intense storms, and changes in precipitation patterns that lead to drought and ecosystem changes; and rising sea levels that intensify coastal flooding and storm surge (Intergovernmental Panel on Climate Change, 2014; Luber et al., 2014).

The growth of U.S. shale gas production is said to be a pathway to a more energy-sustainable future; however, questions remain concerning its life cycle impacts on climate change. There have been numerous life cycle assessments (LCAs) that evaluate the life cycle greenhouse gas (LC-GHG) emissions of shale gas compared with conventional gas and/or coal. The primary focus of most studies is on the release of methane into the atmosphere during production, processing, transmission, storage, and distribution of natural gas (Burnham et al., 2012; Cathles, Brown, Taam, & Hunter, 2012; Clark, Han, Burnham, Dunn, & Wang, 2011; Fulton, Mellquist, Kitasei, & Bluestein, 2011; Howarth, Santoro, & Ingraffea, 2011; Howarth, Santoro, & Ingraffea, 2012; Hultman, Rebois, Scholten, & Ramig, 2011; Jiang et al., 2011; Skone, Littlefield, & Marriott, 2011).

Although recent LCAs have captured many stages of shale gas production, most studies have not considered the GHG emissions associated with the production and transportation of silica sand or chemical additives

TABLE 1

**Summary Information for Dataset**

| Data Summary Information | Quantity | Unit |
|---|---|---|
| Number of wells | 1,921 | wells |
| Fracture date (before 4/14/2012) | 1,495 | wells |
| Fracture date (on or after 4/14/2012) | 426 | wells |
| Mean well vertical depth | 6,942 | feet (1.3 miles) |
| Mean water quantity per well | 4.27 | million gallons |
| Mean quantity silica sand per well | 4.89 | million pounds |
| Mean quantity chemicals per well | 18,958 | gallons |
| Mean number of chemicals used per well | 16 | chemicals |
| Chemicals in dataset with CAS numbers | 181 | chemicals |

mixed in the HF fluid, nor the transportation of water to and from well sites. For example, Jiang and co-authors' study (2011) was among the most complete LCAs of HF, but broad approximations of sand, water, and chemical quantities used in HF and broad transportation assumptions for flowback water were used.

Our study complements Jiang and co-authors' work (2011) by using real-world field data of injected fluid to estimate sand, water, and chemical quantities used in HF wells. Our study also uses real-world field data of waste fluid to more accurately estimate transportation relevant to the various fates of flowback water. Using real-world quantities of sand, water, and chemicals in the HF fluid would allow for more accurate health and climate assessments as they relate to the life cycle production, transportation, and disposal of these materials. In addition, computing GHG emissions from real-world data will supplement the existing LCAs that either do not include chemicals, sand, or water, or rely on broad assumptions with respect to their usage.

## Methods

### Chemical Inventory

The chemical inventory for this study was created from real-world, well-specific chemical data from FracFocus Hydraulic Fracturing Fluid Product Component Information Disclosure Forms for Pennsylvania wells, which were extracted and compiled into a dataset by SkyTruth. A quality assurance analysis was conducted to assess both the accuracy of the SkyTruth data extraction from the FracFocus disclosure forms and the validity of the FracFocus data. The dataset was screened for duplicate, missing, or erroneous data, as well as extreme outliers. To assess suspected duplicate or erroneous data, disclosure forms from fracfocusdata.org were downloaded and compared with the SkyTruth extracted dataset.

After the removal of duplicate wells ($n$ = 16), wells with insufficient information ($n$ = 5), and wells with suspected erroneous data ($n$ = 3), the dataset included 1,921 HF wells with fracture dates from January 1, 2011, to August 31, 2012. The usage of sand, water, and chemicals detailed in the dataset pertains to these 1,921 wells.

The dataset included 181 chemicals with Chemical Abstracts Services (CAS) numbers for which frequency of use was computed. Of the 181 chemicals with CAS numbers, some lack any type of chemical quantity used ($n$ = 18), so only the remaining 163 chemicals were included in calculating the chemical usage statistics. Frequency of use and chemical usage statistics were only computed for chemicals with CAS numbers and can be found in the chemical inventory (see supplemental table).

Approximately 150 additional chemicals without CAS numbers appeared in the dataset listed as proprietary or under a generic name (e.g., surfactants). These 150 chemical names do not appear in the chemical inventory. Of the 150 chemicals without CAS numbers, 17 lacked any type of chemical quantity. The chemical quantities of the remaining 133 chemicals without CAS numbers were included in our GHG assessment of chemical production and transportation, but are not listed in the chemical inventory.

Concentration values were reported in FracFocus as a percent by mass, which were converted to volumes using chemical density (see supplemental text for calculation details and concentration values). Table 1 provides summary information for the sample of Pennsylvania wells. Figure 1 shows the frequency and quantities for all chemicals used in at least 10% of the wells (see supplemental table for the full chemical inventory).

### Assessment of Greenhouse Gas Emissions

*Production and Transportation of Chemicals*

The Economic Input-Output Life Cycle Assessment (EIO-LCA), developed by the Green Design Institute of Carnegie Mellon University, is an online tool we used to calculate the LC-GHG emissions associated with the production and transportation of chemicals used per well. The EIO-LCA U.S. National 2002 Purchaser Price Model was the most recent model published, which incorporates GHG emissions associated with all direct and indirect activities involved with the production of a product from the extraction of raw materials to the transportation to the final consumer (i.e., a cradle to consumer model). The estimation of GHG emissions from the production and transportation of HF chemicals was based on the average chemical quantities used per well from the dataset and the price to purchase the chemicals (see supplemental text for details).

*Production of Sand*

The EIO-LCA U.S. National 2002 Producer Price Model, which incorporates GHG emissions associated with all direct and indirect activities considered in the Purchaser Price Model minus transportation to the final consumer (i.e., a cradle to gate of factory model), was used to calculate the LC-GHG emissions associated with the production of sand used in the HF fluid per well. The estimation of GHG emissions from the production of HF sand was based on the quantity of sand per well from the dataset and the price to purchase sand (see supplemental text).

*Transportation of Sand and Water*

In order to assess GHG emissions associated with the transportation of sand and water used in HF, the number of ton-miles were calculated for a base case scenario using quantities of sand and water per well from the well dataset, and estimated distances traveled relative to the Pennsylvania Marcellus Shale gas development. The following transportation sections detail the methodology used to estimate average distances traveled for sand and water.

A) Transportation of Sand

In the base case scenario, sand is trucked from the mine to a processing plant (both in Wisconsin, mean distance 18.8 miles). Then the sand travels by rail to a transload station in Pennsylvania (mean distance 929 miles), and finally trucked to the HF well site (mean distance 32 miles) (see supplemental text for details on sand transport assumptions).

Two different rail routes from Wisconsin to Pennsylvania were assessed (supplemental text, figure 3). According to Google Maps, the rail route through parts of Canada is 1,027 miles and the entirely U.S. route is 830. The average of the two routes (929 miles) was used as the average rail distance traveled.

B) Transportation of Water: Freshwater to HF Well

In the Marcellus Shale, approximately two thirds of freshwater injected into a new hydraulically fractured well comes from surface water withdrawal sources (e.g., rivers, ponds, lakes, etc.) (Paugh, 2008; Penn State Cooperative Extension, 2011; Penn State Public Broadcasting, 2011; Seydor, Clements, Pantelemonitis, & Deshpande, 2012; Yoxtheimer, 2011). The geographic locations of 354 water withdrawal sources registered with the Pennsylvania Department of Environmental Protection (PA DEP) from January 2007 through October 2013 were compared with the geographic locations of registered HF wells in Pennsylvania using FracFocus maps in order to estimate the average distance water travels by truck from withdrawal source to HF well (estimated average distance: 8 miles) (see supplemental text, figure 6, for further information supporting water assumptions).

FIGURE **1**

**Quantities and Frequencies of Use for Most Frequently Used 31 Chemicals in Hydraulic Fracturing Fluid**

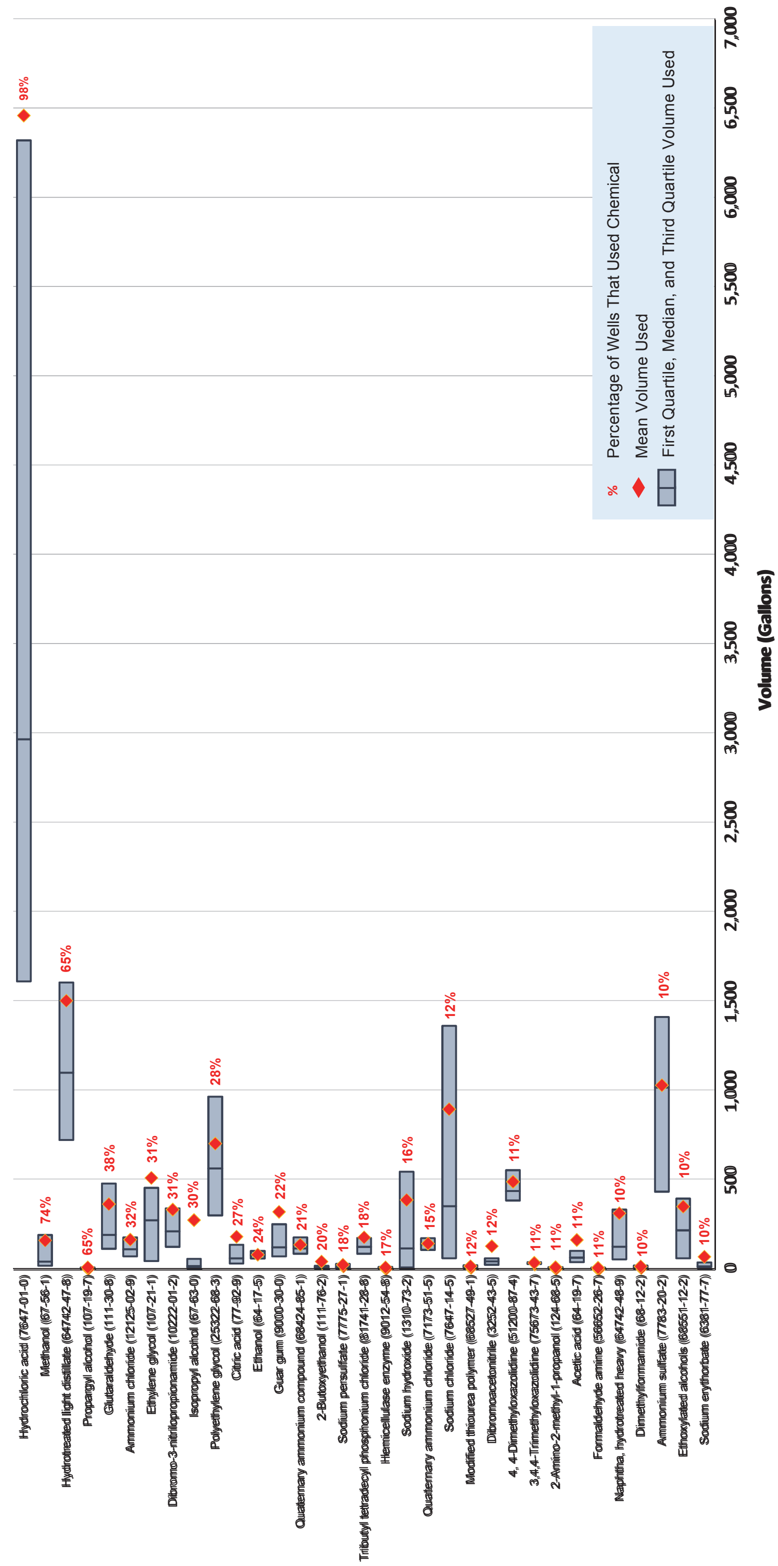
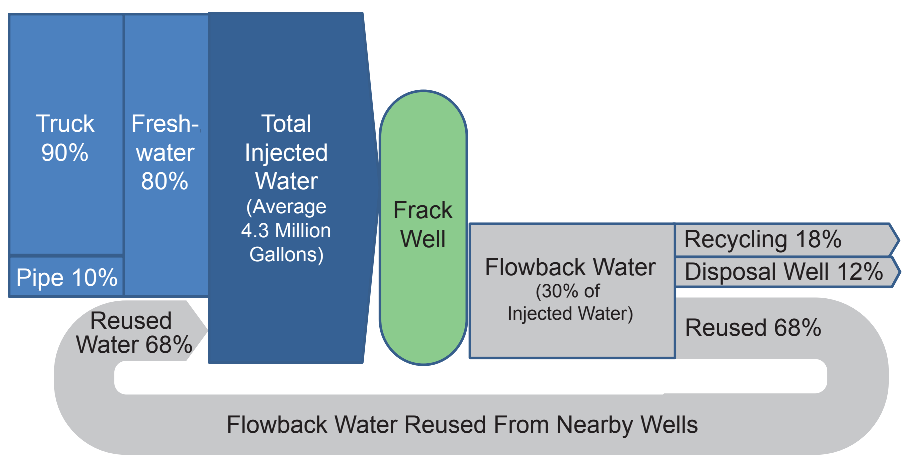


FIGURE **2**

**Assumptions Regarding Water Cycle per Well in Marcellus Shale**




C) Transportation of Water: Flowback Water

Approximately 35% to 40% of the injected water in Marcellus Shale wells returns to the surface as flowback water over the lifetime of the well (Jiang et al., 2011; Johnson, 2013; National Association of Development Organizations Research Foundation, 2010; Olawoyin et al., 2011; Paugh, 2008). Depending on the fate of flowback water, the distance traveled can vary greatly. According to PA DEP, of the waste fluid data from July 2012 through June 2013, 68.7% of HF fluid waste was reused without being brought to a recycling facility, 18.0% was reused after being brought to a centralized treatment plant for recycling, and 12.4% was brought to an injection disposal well. Travel associated with the disposal methods for the less than 1% of remaining waste fluid (e.g., brought to a landfill, used for road spreading, or brought to a centralized treatment plant and discharged) was not assessed in this study.

The July 2012 through June 2013 PA DEP fluid waste data were used to estimate the average distance waste fluid travels to centralized treatment plants for recycling and injection disposal wells. Google Maps driving routes were used to calculate the driving distance between the GPS coordinates of the HF wells and the addresses of the respective disposal facilities for a 5% random sample of reports of waste fluid to recycling facilities ($n$ = 390) and reports of waste fluid to injection disposal wells ($n$ = 411). The average distance waste fluid traveled to a recycling facility was 55 miles, and because recycling is typically round trip, 110 miles was used in this analysis. The average one-way distance traveled to an injection disposal well was 162 miles. This was not assumed to be round trip, and therefore 162 miles was assumed for injection well disposal.

Travel associated with water that was reused without being brought to a recycling facility was also considered in this study. We assumed that 15% of reused water is reused at the same well pad, and 85% is trucked to a different well 1.5 miles away (see supplemental text for details).

*Quantities of Water Traveled*

The quantities of water traveled that were used in the base case calculation were based on a range of assumptions and scenarios regarding water used in HF, as well as the dataset mean quantity of water injected per well (4.3 million gallons). Based on our literature review (supplemental text, figure 6), we assumed in the base case scenario that 80% of the 4.3 million gallons injected per well came from a freshwater source and 20% was reused from a previous well. A 70/30% and 90/10% split was used in the low-end and high-end scenarios, respectively. Of the water withdrawn from a freshwater source, it was assumed that 90% traveled to HF wells by truck (average estimate: 3.1 million gallons) and 10% traveled by temporary pipeline (Figure 2).

The quantities of initially injected water that return to the surface as flowback water were based on the dataset mean total HF fluid per well (4.3 million gallons of water and 18,958 gallons of chemicals). Three scenarios regarding the percentage of initially injected water that returns to the surface as flowback water were analyzed (10%, 30%, and 50%). According to our literature review (supplemental text, figure 6) and our assessment of PA DEP waste fluid data, 30% (1.3 million gallons) was used in the average estimate calculation. From the PA DEP waste fluid data, 12.4% (average estimate: 160,000 gallons) of flowback water was brought to an injection disposal well, 18.0% (average estimate: 232,000 gallons) was reused after being brought to a centralized treatment plant for recycling, and 68.7% (average estimate: 885,000 gallons) was reused without being brought to a recycling facility. Of the water reused without being brought to a recycling facility, it was assumed that 85% (average estimate: 752,000 gallons) traveled to a different well pad.

*Vehicle Carrying-Capacity Assumptions*

The calculation of truck-trips was based on quantities of sand and water used in the estimates, as well as various assumptions regarding train and truck carrying capacities (see supplemental text, table 7, for the carrying capacities used in the base case scenario, as well as the range of carrying capacities used in the low-end and high-end scenarios).

*Life Cycle Transportation GHG Emissions Factors*

Life cycle transportation GHG emission factors of 984 grams of $CO_2$ equivalence ($CO_2e$) per ton-mile for class 8b trucks and 269 grams of $CO_2e$ per ton-mile for intermodal rail were obtained from Facanha and Horvath (2007). The emission factors incorporate all life cycle phases of vehicles, transportation infrastructure, and fuels—including the production, use, maintenance, and end of life of vehicles and infrastructure—as well as the life cycle of diesel fuel (i.e., petroleum extraction and refining, fuel distribution) (Facanha & Horvath, 2007) (see supplemental text for a breakout of grams/ton-mile for $CO_2$ and NOx).

Final results of GHG emissions are presented in grams of $CO_2e$ per megajoule (MJ) of natural gas extracted from the well (i.e., in units of GHG emissions per natural gas energy). Consistent with Jiang and co-authors (2011), the conversion of tons (t) of $CO_2e$/well to grams $CO_2e$/MJ of natural gas is based on an assumed average natural gas production per well of 2.7 billion cubic feet or 2.89 x $10^9$ MJ.

*GHG Emissions From Deep Well Injection and Water Treatment*

GHG emissions associated with deep-well injection of waste fluid were assessed using the EIO-LCA tool. GHG emissions from treatment of fluid waste were based on an emission factor of 3.4 grams of $CO_2e$ emissions per gallon of water treated (Stokes & Horvath, 2006). This emissions factor was applied to the quantity of fluid waste brought to recycling facilities.

## Results

The transportation of sand, freshwater, and flowback water associated with HF results in 1,235 one-way truck-trips on average per well in the Marcellus Shale. The truck-trips do not include vehicle travel from drill pad workers; delivering equipment such as drill rig components, trailers, and forklifts; ancillary activities such as servicing portable restrooms; or transportation for chemical delivery.

The highest proportions of truck-trips are from the transportation of water from withdrawal sources to HF wells (56.0%; average = 692), the transportation of flowback water to another well pad to be reused (13.7%; average = 169), and the transportation of sand from transload facilities to HF wells (10.1%; average = 125).

The transportation of sand, freshwater, and flowback water associated with HF results in 2,718,089 ton-miles on average per HF well. The highest proportions of ton-miles are from the transportation of sand from Wisconsin to Pennsylvania via rail (83.6%; average = 2,272,789 ton-miles) (supplemental text, table 9).

Figure 3 shows GHG emissions per well calculated in this study. The ranges shown for sand transportation, water transportation, and water treatment represent low-end and high-end estimates based on varying assumptions. The ranges for sand transportation and water transportation pertain to the total column, not just the top section of the column. Of the GHG emissions per HF well assessed in this study (average: 1,374 t $CO_2e$), the production and transportation of sand account for the highest proportion (66.9%; average = 920 t $CO_2e$), followed by the transportation and treatment of water (29.7%; average = 408 t $CO_2e$), and the production and transportation of chemicals (3.4%; average = 46 t $CO_2e$).

FIGURE **3**

**Greenhouse Gas Emissions for Bulk Raw Material Flows per Well**

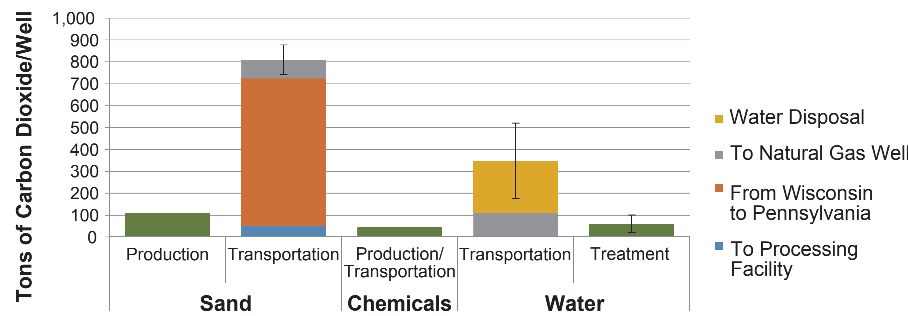
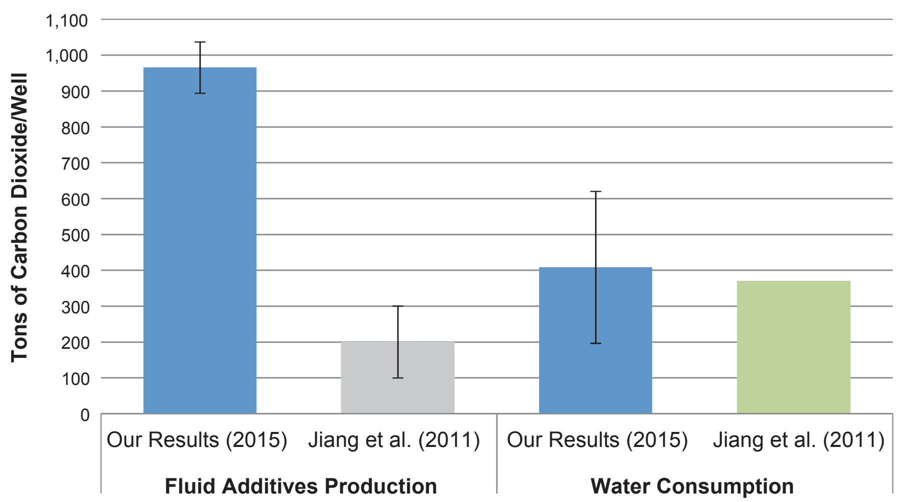



FIGURE **4**

**Comparison of Greenhouse Gas Emissions Results to Jiang et al. (2011)**



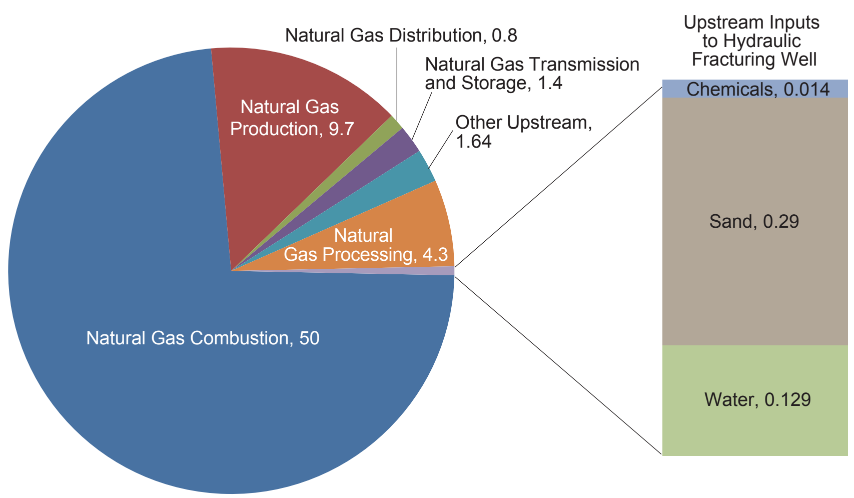

## Discussion

Using real-world data, the average GHG emission estimate for combined sand and chemicals in this study is 4.8 times higher than those estimated by Jiang and co-authors (2011). The average estimate for water consumption (including transportation and treatment) in this study is 10% higher than Jiang and co-authors with low- and high-end range estimates bracketing their average estimate (Figure 4). GHG emissions from sand, water, and chemicals estimated in this study, however, account for only 0.63% of all other upstream and downstream processes estimated by Jiang and co-authors (Figure 5).

The results for natural gas production, processing, transmission, and storage from Jiang and co-authors (2011) displayed in Figure 5 are based on estimates of methane leakage/venting. According to Howarth and co-authors (2012), unconventional gas upstream and downstream methane emis-

FIGURE **5**

**Greenhouse Gas Emissions Resulting From Upstream and Downstream Processes in Hydraulic Fracturing (in Grams of $CO_2$e/MJ of Natural Gas)**




sions used by Jiang and co-authors are roughly one half and one third of those from U.S. EPA (2011), respectively, and are lower than those from any other paper or report that has examined the GHG emissions of shale gas production (Howarth et al., 2012; U.S. EPA, 2011).

As methane leakage, venting, and flaring activities do not influence water consumption or sand and chemical production, if Jiang and co-authors' estimates of upstream and downstream GHG emissions are too low, then the proportion of total GHG emissions attributable to sand, water, and chemicals estimated in this study would be even lower.

### Strengths and Limitations

Certain limitations are associated with the FracFocus/SkyTruth data. Most of the Pennsylvania FracFocus data (78%) have been disclosed voluntarily (i.e., fracture date before April 14, 2012), and therefore might not be representative of all wells in Pennsylvania during this time. Duplicated data, missing information, and suspected erroneous entries were discovered, some of which were attributable to entry errors to FracFocus, and some issues were due to SkyTruth's data extraction. Several quality assurance steps were taken to correct misinformation such as duplications, typos, and erroneous data, but all types of errors might not have been corrected. Extreme outliers were also removed (see supplemental table).

The large sample size of 1,921 wells helps to minimize the impact of potential errors in the dataset. Ultimately the use of reported chemical data to assess GHG emissions allows for a more accurate assessment than previously reported.

The use of the EIO-LCA model has limitations due to the lack of specificity and relativity to Pennsylvania Marcellus Shale production. The use of real-world field data from over 1,900 HF and 30 natural gas operators to estimate sand, water, and chemical quantities per well, however, allowed for a more accurate estimation of GHG emissions than previous LCAs using the EIO-LCA model. Compared with Jiang and co-authors' assessment (2011), whose sand and chemical volumes were based on a fact sheet by one natural gas operator, Chesapeake Energy, our assessment assumed a 6.5 times higher mass of sand (2.2 million kg versus 0.34 million kg), twice the mass of acids (23,649 kg versus 12,000 kg), a third the mass of surfactants (1,015 kg versus 3,000 kg), and nearly twice the mass of chemicals overall (44,982 kg versus 24,930 kg).

The use of real-world, field waste fluid data to determine the proportions of flowback water associated with different disposal methods, and to determine the average distance traveled per disposal method, allowed for a more accurate assessment of the HF water cycle. For example, Jiang and co-authors (2011) used injection disposal well as the base case disposal method with a distance traveled of 80 miles. Twelve months of recent PA DEP waste fluid data show that only 12% of flowback water traveled to deep injection wells, with an average distance traveled of 162 miles.

## Conclusion

The truck-trips calculated in this study provide insight into the traffic-related impacts and the associated diesel emissions associated with HF in the Pennsylvania Marcellus Shale. To transport sand and water, the average estimate in this study results in 1,235 truck-trips per well and 7,410–9,880 truck-trips for a multiwell drill pad with six to eight wells, respectively. This does not include empty return truck-trips or the 150–200 rail cars of sand needed for six to eight wells on a pad, respectively.

The chemical inventory developed from FracFocus data provides more transparency to the HF process, especially regarding the quantities and frequencies of chemicals used. Of note, only 16 chemicals on average were used per well despite 181 chemicals identified across 1,921 wells. This suggests a high degree of variability with each company's choice in chemical usage. Other than hydrochloric acid (98% of wells; mean = 6,458 gallons), most other chemicals were used far less frequently and in lower volumes. With respect to local communities, this underscores the importance of knowing which HF chemicals are actually used in a localized geographical area when conducting an environmental assessment and considering risks to public health, as opposed to considering all HF chemicals that are known to be used in HF. This information can help narrow the scope of environmental health risk assessments and can offer opportunities to substitute less toxic or less volatile compounds where applicable.

The GHG emissions from the upstream processes assessed in this study (i.e., sand, water, and chemicals) are relatively small compared with natural gas combustion, methane leakage, venting, and flaring from the other downstream phases of the HF process. Comparing the upstream GHG emissions against the large magnitude of the downstream emissions suggests that long-term reliance on unconventional natural gas emits a substantial amount of overall GHG emissions, which will exacerbate climate change. These findings focus attention on large GHG emission sources that historically have had a high degree of uncertainty, such as the magnitude of methane leakage from unconventional natural gas extraction. Further study is needed to better understand the implications of LC-GHG emissions from shale gas production, especially with regards to methane emissions.

*Corresponding Author:* Christopher Sibrizzi, The George Washington University, Milken Institute School of Public Health, Department of Environmental and Occupational Health, 950 New Hampshire Avenue NW, 7th Floor, Washington, DC 20052.
E-mail: csibriz@gwu.edu.

## References

Burnham, A., Han, J., Clark, C.E., Wang, M., Dunn, J.B., & Palou-Rivera, I. (2012). Life-cycle greenhouse gas emissions of shale gas, natural gas, coal, and petroleum. *Environmental Science and Technology, 46*(2), 619–627.

Cathles, L.M., III, Brown, L., Taam, M., & Hunter, A. (2012). A commentary on “The greenhouse-gas footprint of natural gas in shale formations” by R.W. Howarth, R. Santoro, and A. Ingraffea. *Climatic Change*, *113*(2), 525–535.

Clark, C.E., Burnham, A., Harto, C., & Horner, R. (2013). *Hydraulic fracturing and shale gas production: Technology, impacts, and policy*. Chicago, IL: Argonne National Laboratory. Retrieved from http://www.afdc.energy.gov/uploads/publication/anl_hydraulic_fracturing.pdf

Clark, C.E., Han, J., Burnham, A., Dunn, J.B., & Wang, M.Q. (2011). *Life-cycle analysis of shale gas and natural gas* (No. ANL/ESD/11-11). Chicago, IL: Argonne National Laboratory, U.S. Department of Energy. Retrieved from https://greet.es.anl.gov/publication-shale_gas

Facanha, C., & Horvath, A. (2007). Evaluation of life-cycle air emission factors of freight transportation. *Environmental Science and Technology*, *41*(20), 7138–7144.

Fulton, M., Mellquist, N., Kitasei, S., & Bluestein, J. (2011). *Comparing greenhouse gas emissions from natural gas and coal*. Washington, DC: Worldwatch Institute/Deutsche Bank. Retrieved from http://www.worldwatch.org/system/files/pdf/Natural_Gas_LCA_Update_082511.pdf

Howarth, R.W., Santoro, R., & Ingraffea, A. (2011). Methane and the greenhouse-gas footprint of natural gas from shale formations. *Climatic Change*, *106*(4), 679–690.

Howarth, R.W., Santoro, R., & Ingraffea, A. (2012). Venting and leaking of methane from shale gas development: Response to Cathles et al. *Climatic Change*, *113*(2), 537–549.

Hultman, N., Rebois, D., Scholten, M., & Ramig, C. (2011). The greenhouse impact of unconventional gas for electricity generation. *Environmental Research Letters*, 6(4).

Intergovernmental Panel on Climate Change (2014). *Climate change 2014: Synthesis report.* Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

International Energy Agency. (2014). *Key world energy statistics*. Paris, France: International Energy Agency Publications.

Jiang, M., Griffin, W.M., Hendrickson, C., Jaramillo, P., VanBriesen, J., & Venkatesh, A. (2011). Life cycle greenhouse gas emissions of Marcellus shale gas. *Environmental Research Letters*, 6(3).

Johnson, K. (2013, May). Operators turn to reuse, recycling. *The American Oil & Gas Reporter*. Retrieved from http://www.aogr.com/magazine/editors-choice/operators-turn-to-reuse-recycling

Luber, G., Knowlton, K., Balbus, J., Frumkin, H., Hayden, M., Hess, J., . . . Ziska, L. (2014). Human health. In J.M. Melillo, T.C. Richmond, & G.W. Yohe (Eds.), *Climate change impacts in the United States: The third national climate assessment* (pp. 220–256). Washington, DC: U.S. Global Change Research Program. Retrieved from http://www.globalchange.gov/browse/reports/climate-change-impacts-united-states-third-national-climate-assessment-0

National Association of Development Organizations Research Foundation. (2010). *Natural gas drilling in the Marcellus shale: Regional economic opportunities and infrastructure challenges*. Washington, DC: Author.

Olawoyin, R., York, J., Madu, C., Li, H., Ahn, C.H., & Enab, K. (2011). *Optimization of well stimulation fluids in the Marcellus shale gas development using integrated technologies*. Pennsylvania State University.

Paugh, L.O. (2008, January). *Marcellus shale water management challenges in Pennsylvania* (No. SPE 119898). Society of Petroleum Engineers Shale Gas Production Conference, Ft. Worth, TX. Retrieved from https://www.onepetro.org/conference-paper/SPE-119898-MS

Penn State Cooperative Extension. (2011). *Water's journey through the shale gas drilling and production processes in the mid-Atlantic region*. University Park, PA: Pennsylvania State University. Retrieved from http://extension.psu.edu/natural-resources/water/marcellus-shale/regulations/waters-journey-through-the-shale-gas-drilling-and-production-processes-in-the-mid-atlantic-region

Penn State Public Broadcasting. (2011). *Explore shale: An exploration of natural gas drilling and development in the Marcellus shale*. Retrieved from http://exploreshale.org

Seydor, S.M., Clements, E., Pantelemonitis, S., & Deshpande, V. (2012). *Understanding the Marcellus shale supply chain working*

## References

*paper*. Pittsburgh, PA: University of Pittsburgh Katz Graduate School of Business.

Skone, T.J., Littlefield, J., & Marriott, J. (2011). *Life cycle greenhouse gas inventory of natural gas extraction, delivery and electricity production* (No. NETL/DOE-2011/1522). U.S. Department of Energy, National Energy Technology Laboratory.

Smith, G. (2014, July 4). U.S. seen as biggest oil producer after overtaking Saudi Arabia. *Bloomberg*. Retrieved from http://www.bloomberg.com/news/articles/2014-07-04/u-s-seen-as-biggest-oil-producer-after-overtaking-saudi

Stokes, J., & Horvath, A. (2006). Life cycle energy assessment of alternative water supply systems. *International Journal of Life Cycle Assessment*, *11*(5), 335–343.

U.S. Energy Information Administration. (2014). *Annual energy outlook 2014 with projections to 2040* (No. DOE/EIA-0383(2014). Washington, DC: Author. Retrieved from http://www.eia.gov/forecasts/archive/aeo14/

U.S. Energy Information Administration. (2015a). *International energy statistics*. Retrieved from http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=5&pid=53&aid=1

U.S. Energy Information Administration. (2015b). *Annual energy outlook 2015 with projections to 2040* (No. DOE/EIA-0383(2015). Washington, DC: Author. Retrieved from www.eia.gov/forecasts/aeo/pdf/0383%282015%29.pdf

U.S. Environmental Protection Agency. (2011). *Inventory of U.S. greenhouse gas emissions and sinks: 1990–2009* (No. EPA 430-R-11-005). Washington, DC: Author. Retrieved from https://www.epa.gov/ghgemissions/us-greenhouse-gas-inventory-report-archive

U.S. Environmental Protection Agency. (2015). *Inventory of U.S. greenhouse gas emissions and sinks: 1990–2013* (No. EPA 430-R-15-004). Washington, DC: Author. Retrieved from https://www.epa.gov/ghgemissions/us-greenhouse-gas-inventory-report-archive

Verrastro, F.A. (2012). *The role of unconventional oil and gas: A new paradigm for energy*. Washington, DC: Center for Strategic and International Studies. Retrieved from https://www.csis.org/analysis/role-unconventional-oil-and-gas-new-paradigm-energy

Yoxtheimer, D. (2011). *Water management options for Marcellus natural gas development*. Penn State Cooperative Extension.

# Assessed Food Safety Risks Associated With Grocery Stores

Robert Newsad, MPH
*Tennessee Department of Health*

Danny Ripley
*Metro Public Health Department*

Craig A. Shepherd, MPH, REHS, DAAS
*Tennessee Department of Health*

Abstract **The growing grocery market industry is under increasing pressure to improve profit margins to maintain profitability. With the offerings at grocery stores continually evolving toward more profitable niches, food safety risks can be introduced or elevated as operations are added or modified. This study surveyed 132 private and corporate-owned grocery stores to assess food safety risk. A 2009 Food and Drug Administration *Food Code* risk category assessment score was assigned to each of the departments at these stores for comparison of risks associated with their processes and policies. Private stores had slightly more risk when compared with corporate-owned stores. High-risk processes, including reduced oxygen packaging and smoking and curing operations, existed in 13% of the grocery stores. Bakeries, delicatessens, and/or meat departments sharing the same operating space also increased the risk scoring.**

## Introduction

In 2015, there were over 38,000 grocery stores or supermarkets in the U.S. In 2012 in the U.S., grocery stores employed approximately 3.4 million workers. Grocery store revenue grew 14% from $568 billion in 2007 to $649 billion in 2015 (Food Marketing Institute, 2016). Nearly all of this growth has been attributed to adapting new marketing strategies and offerings to consumers in areas that were not widely offered over the last several decades (Rogers, 2012).

The grocery industry operates with a very low profit margin of approximately 1.5% (Food Marketing Institute, 2012). Emerging trends such as increasing demand from consumers for quick, convenient meals and organic foods have produced opportunities for grocers to increase their profit margins by meeting these needs (Binkley & Ghiselli, 2005). The vast majority of grocery stores now offer prepared foods for meals to eat in the store or for take-out (U.S. Department of the Treasury, 2011).

Grocery stores have acquired equipment and implemented food preparation procedures to capitalize on these trends. Included in these changes have been the addition of large, fully operating kitchens to prepare foods in ways more traditionally found in restaurants.

Foods from around the world are more commonly available because of increased importing; however, the Food and Drug Administration (FDA) samples only 2.3% of the food lots imported into the U.S. (FDA, 2014). Large stores frequently include special areas to market diverse foods from around the globe. Food safety standards, however, vary greatly around the world and using imported foods to prepare new products has introduced additional risk that would not be present with foods produced in the U.S. (McLean, Dunn, & Palombo, 2010).

FDA estimates that there are more than 3,000 different federal, state, local, and tribal agencies that regulate the safety for food distributed and sold in the U.S. (FDA, 2013). In Tennessee, food safety inspections of grocery stores are conducted using the state's Department of Agriculture regulations and inspectors. Agricultural inspections and regulations may have gaps, however, in completely addressing evolving food safety aspects in grocery stores.

During July 2010, the Centers for Disease Control and Prevention (CDC) and Environmental Health Specialists Network (EHS-Net) (www.cdc.gov/nceh/ehs/ehsnet), in conjunction with the U.S. Public Health Service (USPHS) (www.usphs.gov), completed a grocery store risk assessment survey in Davidson County, Tennessee. EHS-Net is a network of environmental health specialists and epidemiologists focused on investigating environmental factors that contribute to foodborne illness. EHS-Net is a collaborative project of CDC, FDA, U.S. Department of Agriculture (USDA), and state and local health departments. There were three goals for this study: identify high risk processes in grocery stores, provide data for development/improvement of risk-based inspection protocols, and collect baseline data for the Nashville-Davidson County Metropolitan Health Department.

## Methods

The study population included 171 retail grocery stores with groceries being the primary business.

The survey used to collect data consisted of 37 questions. The survey can be found at www.nashville.gov/Portals/0/SiteContent/Health/PDFs/FoodProtection/GrocerySurvey.pdf. The survey was developed by senior environmental health specialists and

TABLE **1**

**2009 Food and Drug Administration *Food Code* Risk Categories**

| Risk Category | Description |
|---|---|
| 1 | Examples include most convenience store operations, hot dog carts, and coffee shops. Examples also include establishments that • serve or sell only prepackaged, nonpotentially hazardous foods (nontime/temperature control for safety [TCS] foods). • prepare only nonpotentially hazardous foods (non-TCS foods). • heat only commercially processed, potentially hazardous foods (TCS foods) for hot holding. • do not cool potentially hazardous foods (TCS foods). • would otherwise be grouped in Category 2 but have shown through historical documentation to have achieved active managerial control of foodborne illness risk factors. |
| 2 | Examples include retail food store operations, schools not serving a highly susceptible population, and quick service operations. Examples also include establishments that • have a limited menu. • have products that are mostly prepared or cooked and served immediately. • might involve hot/cold holding of potentially hazardous foods (TCS foods) after preparation or cooking. • perform complex preparation of potentially hazardous foods (TCS foods) requiring cooking, cooling, and reheating for hot holding that is limited to only a few potentially hazardous foods (TCS foods). • would otherwise be grouped in Category 3 but have shown through historical documentation to have achieved active managerial control of foodborne illness risk factors. • are newly permitted establishments that would otherwise be grouped in Category 1 until history of active managerial control of foodborne illness risk factors is achieved and documented. |
| 3 | An example is a full service restaurant. Examples also include establishments that • have an extensive menu and handle of raw ingredients. • perform complex preparation including cooking, cooling, and reheating for hot holding involving many potentially hazardous foods (TCS foods). • have a variety of processes that require hot and cold holding of potentially hazardous foods (TCS food). • would otherwise be grouped in Category 4 but have shown through historical documentation to have achieved active managerial control of foodborne illness risk factors. • are newly permitted establishments that would otherwise be grouped in Category 2 until history of active managerial control of foodborne illness risk factors is achieved and documented. |
| 4 | Examples include preschools, hospitals, nursing homes, establishments conducting processing at retail, and establishments serving a highly susceptible population or that conduct specialized processes (e.g., smoking and curing, reduced oxygen packaging for extended shelf-life). |

included an FDA food inspector (www.fda.gov/Food/GuidanceRegulation/RetailFoodProtection/Standardization/default.htm) and an EHS-Net specialist. The survey questions focused on policies, equipment, processes, and training. Policy and training data were obtained through interviews, while equipment and process data were obtained through both observation and interviews. Qualifying formal manager food safety certification was through ServSafe, National Registry of Food Safety Professionals, Prometric, or the local health department. The approximate size of each facility in terms of square footage was determined through manager interviews.

The survey instrument was administered by four teams with two USPHS officers each. Each USPHS team had at least one registered environmental health specialist (REHS). The Davidson County EHS-Net specialist conducted standardization training with all survey teams. This training included pilot testing the instrument and developing a standardized administration and interpretation of the survey.

The criteria for assessing risk were based on the 2009 FDA *Food Code* guidelines. Departments included in the survey were bakeries, combination deli/bakeries, delis, meat and seafood, and produce. Combination deli/bakeries were defined as departments having both deli and bakery operations within the same physical space. Equipment such as dish washing, food preparation, and food storage may have been shared. Meat and seafood departments may have included meat department only, seafood department only, or a combination of meat and seafood. Risk categories listed in Table 1, as defined by Annex 5 of the 2009 FDA *Food Code,* are presented here from highest to lowest risk.

- Risk Category 4: Smoking, curing, and increased shelf-life with use of reduced oxygen packaging (ROP).
- Risk Category 3: Extensive handling of raw ingredients, complex preparation, and hot or cold holding of foods needing temperature control.
- Risk Category 2: Serving foods that are prepared but most are served immediately, with limited holding of foods needing temperature control.
- Risk Category 1: Serving mostly prepackaged foods that are commercially processed.

Based on the survey findings, the team assigned one of these risk categories to each department. Additional information was collected, including number of employees and the type of training they received. Grocery stores were classified as corporate or private based on ownership. Overall risk scores were determined by the highest individual department within each store.

## Results

A total of 171 stores were visited. Of these, 7 were closed, 10 refused to be surveyed, and 22 were considered ineligible due to very limited food handling and preparation activities. Surveys were completed at 132 stores. Of the stores surveyed, 69 (52%) were corporate owned and 63 (48%) were privately owned.

Table 2 shows a comparison between corporate and private stores in terms of store size, number of employees, managers with formal food safety certification, no bare hand contact policy, and 41 °F refrigeration policy. Corporate-owned stores generally were larger, with more employees and stricter policies.

There were a total of 339 different departments in the 132 stores surveyed. Of these 132 stores, 31 (24%) had a bakery, 34 (26%) had a combination deli/bakery, 47 (36%) had a deli, 115 (87%) had a meat and/or seafood department, and 111 (84%) had a produce department.

Table 3 contains the results by department for the practices assessed during the survey. A risk factor noted from the survey not listed in the table was that six meat and seafood departments (5%) did not have separate hand washing sinks present. In addition, fresh produce was observed in 43 (37%) of the meat and seafood departments and raw shellfish was observed in two (2%) of the produce departments.

Complex processes involving the cooking of raw animal product and its subsequent cooling were noted in 43 (62%) of the corporate-owned stores as compared with 18 (29%) of the privately owned stores surveyed. Figure 1 shows the risk scores assigned and averaged for the five types of grocery departments surveyed.

TABLE **2**

**Comparison of Selected Results for Private Versus Corporate-Owned Grocery Stores**

| | Corporate (*n* = 69) | Private (*n* = 63) |
|---|---|---|
| Average size of grocery store | 56,000 ft$^2$ | 2,000 ft$^2$ |
| Average number of employees per grocery store | 110 | 8 |
| Managers with formal food safety certification | 30 (43%) | 11 (17%) |
| No bare hand contact policy for ready-to-eat foods | 61 (88%) | 41 (65%) |
| 41 °F refrigeration policy | 60 (87%) | 36 (57%) |

TABLE **3**

**Selected Results for Various Practices by Grocery Store Department**

| Practice | Department Type | | | | |
|---|---|---|---|---|---|
| | Bakery (*n* = 31) | Combination Deli/Bakery (*n* = 34) | Deli (*n* = 47) | Meat and Seafood (*n* = 115) | Produce (*n* = 111) |
| Reheating/cooking | 22 (71%) | 34 (100%) | 41 (87%) | N/A | N/A |
| Cooling | 20 (65%) | 33 (97%) | 28 (60%) | N/A | N/A |
| Hot/cold holding | N/A | 34 (100%) | 43 (91%) | N/A | N/A |
| Raw meat processing | N/A | N/A | N/A | 115 (100%) | 8 (7%) |
| Raw shellfish processing | N/A | N/A | N/A | 43 (37%) | 2 (2%) |
| Smoking or curing | N/A | N/A | N/A | 10 (9%) | N/A |
| Grinding | N/A | N/A | N/A | 94 (82%) | N/A |
| Tenderizing | N/A | N/A | N/A | 61 (53%) | N/A |
| Slicing/chopping/washing | N/A | N/A | N/A | N/A | 70 (63%) |
| Salad bar | N/A | N/A | N/A | N/A | 6 (5%) |
| Reduced oxygen packaging | N/A | 4 (11%) | N/A | 4 (3%) | N/A |

N/A = not applicable.

## Discussion

By conducting risk-based surveys, our team was able to inventory and assign risk categories to store departments. This information has provided insight into the current state of risk distribution among Davidson County grocery stores. Based on the findings in this survey, when comparing the relationship of risk between private and corporate-owned stores, the overall risk scoring was slightly higher for private stores (Figure 2). There may be a variety of factors that contribute to differences in risk scores between private and corporate-owned stores.

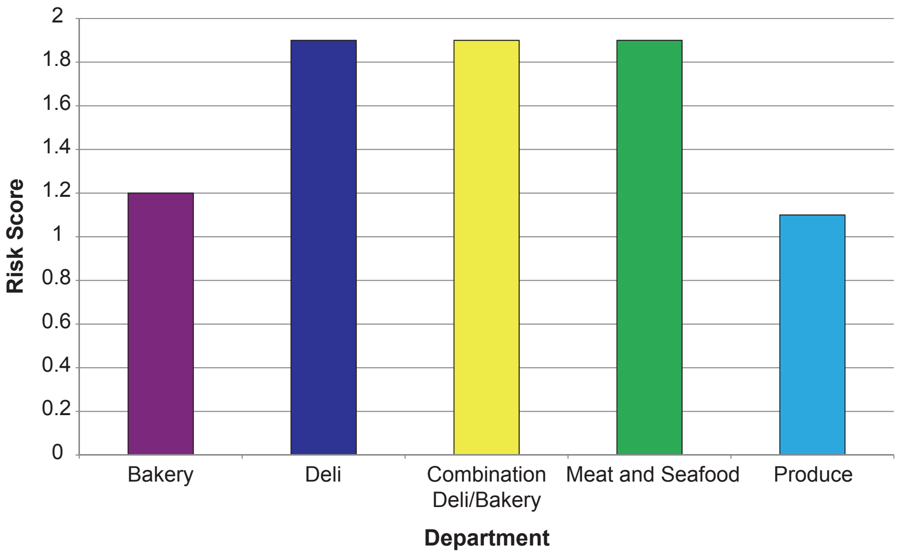
Our study found that both store size and number of employees were considerably larger for corporate-owned stores as compared with privately owned stores, which could increase risk. Employees are significant sources for contamination of food, which can result in foodborne outbreaks (Hedican et al., 2010); therefore, a lower number of employees might reduce food safety risk. Employees well trained in food safety practices, however, may offset this concern. Further, having fewer employees might discourage ill-worker exclusion due to unavailable employee replacements, which could increase risk.

The presence of a certified food manager has been found to reduce risk for foodborne outbreaks (Hedberg et al., 2006). Formal food safety certification as recognized by the FDA was reported to be higher at corporate-owned stores (43%) versus privately owned stores (17%). Additional requirements and resources through the corporate-owned store structures were likely to influence the higher level of certification for corporate store employees.

Increased inspections of groceries alone are not likely to reduce food safety risk in this evolving industry (Jones, Pavlin, LaFleur, Ingram, & Schaffner, 2004). Instead, the implementation of applicable food safety systems and policies, along with training for specific food handling practices, are key to controlling food safety risk.

FIGURE **1**

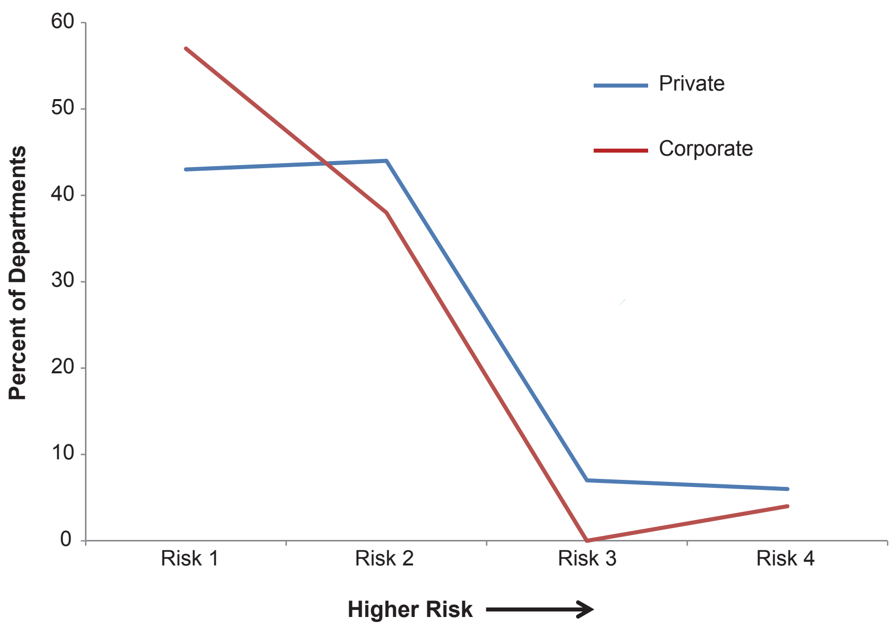
**Average Risk Score by Grocery Store Department Type (*N* = 339)**




Based on 2009 Food and Drug Administration risk assessment criteria.

FIGURE **2**

**Distribution of Risk Scores for Private Versus Corporate-Owned Grocery Stores (*N* = 132)**




The number and type of food processes within a store department may relate to food safety risk. Grocery stores that serve only ready-to-eat foods with limited preparation prior to service are likely to pose less risk than departments that conduct complex food handling processes such as preparing and cooking raw animal products, cooling, and hot/cold holding temperature control for safety (TCS) foods. In addition, special food preparation processes such as smoking, curing, and ROP increase food safety risk if critical limits are not maintained during the production process (FDA, 2009). Several of the stores surveyed were repackaging food with the use of ROP, which confers many benefits including extended shelf life, enhanced quality, increased profit margins, and reduced waste (Herald, 2014). Strict controls that may be unfamiliar to both customers and food service workers, however, are necessary to ensure ROP products remain safe during preparation, storage, display, and service. As a result, federal guidelines suggest implementation of a hazard analysis critical control points (HACCP) program for special food preparation processes.

Raw animal products can contain pathogenic bacteria. Data from 2002 to 2011 from the Retail Meat Annual Report published by the FDA reported retail chicken sampled from participating states had high levels of bacterium (FDA, 2012). As seen in Figure 1, departments where raw animal products and ready-to-eat products are prepared in the same environment may increase the risk of cross-contamination, especially if common equipment is used for both product types. This survey found that all combination deli/bakery departments were processing raw animal products and ready-to-eat products in the same environment.

For the meat departments surveyed, grinding was found at 82% and tenderizing at 53%. Mechanical tenderizing of meats by grocery stores is a value-added procedure that can also increase profit margins. Mechanical tenderizing is, however, likely to spread surface contamination into deep tissue of meats such as steaks. Safe cooking practices for intact meat cuts can be achieved with lower temperatures than for commutated meat such as hamburger. The degree of elevated risk for mechanically tenderized meat is not well defined, but it is generally accepted (Gill & McGinnis, 2004).

At the time of this study, the minimum temperature requirement for refrigerated TCS foods was 45 °F in the state of Tennessee. However, federal guidelines suggest 41 °F or below for refrigeration storage or holding of

TCS foods. Stores under corporate ownership were significantly higher in compliance with the 41 °F refrigeration federal guideline (60, 87%) compared with privately owned grocery stores (36, 57%), even though the lower temperature was not locally mandated.

In addition, a no bare hand policy such as glove use while handling ready-to-eat foods was not required at the time of the survey. Bare hand contact of ready-to-eat foods increases risk. It has been demonstrated that many pathogens can survive on the hands for extended periods of time. *Salmonella* was found to survive for at least 3 hours in normal working conditions after an inocula of <100 organisms per fingertip (Hedberg et al., 1991). Although not mandated by Tennessee food regulations, management reported 102 (77%) of the grocery stores had a no bare hand contact policy for ready-to-eat foods. This high rate of voluntary compliance may be attributed to multistate corporate policies and customer expectations where food processing and preparation are highly visible.

Produce was washed considerably more in corporate-owned stores (49, 71%) than in privately owned stores (14, 22%). This finding likely indicates more ready-to-eat foods were being created from produce in corporate stores. Significant food safety risk may occur when ready-to-eat foods are contaminated without a temperature "kill step" to inactivate pathogens before the food is consumed (Podolak, Enache, Stone, Black, & Elliot, 2010).

Cross-contamination prevention during produce handling is imperative to food safety. Cross-contamination was reportedly involved in 57% of known causes for foodborne outbreaks in the United Kingdom (Podolak et al., 2010). Norovirus is the leading cause of foodborne outbreaks in the U.S. and has been found to easily spread through cross-contamination (Hall, 2012). Washing produce may create opportunities for cross-contamination if all food contact surfaces involved are not properly cleaned and sanitized. Cross-contamination prevention should be promoted through employee training, as well as active managerial control.

Some pathogenic organisms can survive in harsh and unlikely environments. For example, *Salmonella* grows in a wide range of temperature and pH, and it has been found to have greater heat resistance in low-moisture foods (Podolak et al., 2010). Procedures and products must be continually evaluated as marketing approaches change so that employees can be adequately trained and systems can be modified to prevent growth or survival of pathogens to reduce risk.

Additional food safety risks may be introduced as stores add new marketing, display, and self-service venues. For example, self-service food bins and salad bars without adequate dispensing utensils, practices, and sneeze guards may increase risk from both employee and customer contamination. Further, inadequate barriers between raw and ready-to-eat foods may occur with temporary promotional food displays.

Health trends in customer preferences have encouraged shifts toward more preservative-free, low-fat, gluten-free products with reduced calories (Smith, Daifas, El-Khoury, Koukoutsis, & El-Khoury, 2004). Modifications of traditional products and packaging may also greatly influence risk factors that would promote growth of emerging pathogens. Home meal replacement (HMR) prepared at stores is a current trend that is likely to continue. HMR food out of appropriate temperature range while in transit or awaiting to be consumed provides time for pathogens to multiply. Results from this survey, however, indicate that the grocery industry is implementing many measures to reduce the food safety risks for these trends. Another study looking more specifically at HMR operations found that only 10% of workers reported that they did not receive food safety training (Binkley & Ghiselli, 2005). Current trends and widening landscapes for store formats often require additional food safety risk considerations that go far beyond those of previous generations.

There were several limitations identified with this study. The survey area was limited to Davidson County, Tennessee, with a total of 132 stores included. Although every effort was made to collect factual data, much of the information in this study was collected through interviews with managers. In addition, self-reported behaviors and policies inevitably include bias. Inquiries to ascertain employee health programs could have yielded additional useful data with ill-employee exclusions and restrictions being an important part of any retail food safety program.

## Conclusion

Findings from this study could be used to prioritize and justify resources necessary to achieve recommended inspection frequency within high-risk stores. Locations with increased risk often place additional burden on regulatory agencies related to inspection frequency and administrative activities. Recommendations from the FDA *Food Code* suggest increased inspection frequency for establishments with higher risks. Other jurisdictions may find these data useful for comparisons or to facilitate additional resource justification.

*Acknowledgements:* We thank Drs. Timothy F. Jones and Laura G. Brown for insight and direction and the USPHS Applied Public Health Team #2 for their excellent work in performing the assessments.

*Corresponding Author:* Robert Newsad, Emergency Preparedness, Tennessee Department of Health, 3rd Floor Andrew Johnson Tower, 710 James Robertson Parkway, Nashville, TN 37243. E-mail: robert.newsad@tn.gov.

## References

Binkley, M., & Ghiselli, R. (2005). Food safety issues and training methods for ready-to-eat foods in the grocery industry. *Journal of Environmental Health*, *68*(3), 27–31.

Food and Drug Administration. (2009). *FDA report on the occurrence of foodborne risk factors in selected institutional foodservice, restaurant, and retail food store facility types*. Washington, DC: Author. Retrieved from http://www.fda.gov/food/guidanceregu

## References


lation/retailfoodprotection/foodborneillnessriskfactorreduction/ucm224321.htm

Food and Drug Administration. (2012). *2011 retail meat annual report, national antimicrobial resistance monitoring system*. Washington, DC: Author. Retrieved from http://www.fda.gov/downloads/AnimalVeterinary/SafetyHealth/AntimicrobialResistance/NationalAntimicrobialResistanceMonitoringSystem/UCM334834.pdf

Food and Drug Administration. (2013). *Retail food protection*. Retrieved from http://www.fda.gov/Food/GuidanceRegulation/RetailFoodProtection/default.htm

Food and Drug Administration. (2014). *2012 annual report on food facilities, food imports, and FDA foreign offices*. Washington, DC: Author. Retrieved from http://www.fda.gov/food/guidanceregulation/fsma/ucm315486.htm#food_imports

Food Marketing Institute. (2016). *Supermarket facts*. Retrieved from http://www.fmi.org/research-resources/supermarket-facts

Gill, C.O., & McGinnis, J.C. (2004). Microbiological conditions of mechanically tenderized beef cuts prepared at four retail stores. *International Journal of Food Microbiology, 95*(1), 95–102.

Hall, A.J. (2012). Noroviruses: The perfect human pathogens? *The Journal of Infectious Diseases, 205*(11), 1622–1624.

Hedberg, C.W., Smith, S.J., Kirkland, E., Radke, V., Jones, T.F., Selman, C.A., and The EHS-Net Working Group. (2006). Systematic environmental evaluations to identify food safety differences between outbreak and nonoutbreak restaurants. *Journal of Food Protection, 69*(11), 2697–2702.

Hedberg, C.W., White, K.E., Johnson, J.A., Edmonson, L.M., Soler, J.T., Korlath, J.A., . . . Osterholm, M.T. (1991). An outbreak of *Salmonella enteritidis* infection at a fast-food restaurant: Implications for foodhandler-associated transmission. *The Journal of Infectious Diseases, 164*(6), 1135–1140.

Hedican, E., Miller, B., Ziemer, B., LeMaster, P., Jawahir, S., Leano, F., & Smith, K. (2010). Salmonellosis outbreak due to chicken contact leading to a foodborne outbreak associated with infected delicatessen workers. *Foodborne Pathogens and Disease*, *7*(8), 995–997.

Herald, P. (2014). *White paper: Reduced oxygen packaging in foodservice environments*. Charlotte, NC: The Steritech Group, Inc.

Jones, T.F., Pavlin, B.I., LaFleur, B.J., Ingram, L.A., & Schaffner, W. (2004). Restaurant inspection scores and foodborne disease. *Emerging Infectious Diseases, 10*(4), 688–692.

McLean, S.K., Dunn, L.A., & Palombo, E.A. (2010). A pilot study of the microbiological quality of culturally diverse, ready-to-eat foods from selected retail establishments in Melbourne, Australia. *Foodborne Pathogens and Disease, 7*(5), 585–588.

Podolak, R., Enache, E., Stone, W., Black, D.G., & Elliot, P.H. (2010). Sources and risk factors for contamination, survival, persistence, and heat resistance of *Salmonella* in low-moisture foods. *Journal of Food Protection, 73*(10), 1919–1936.

Rogers, D. (2012). Current U.S. grocery retailing trends. *Progressive Grocer.* Retrieved from http://www.progressivegrocer.com/industry-news-trends/national-supermarket-chains/current-us-grocery-retailing-trends

Smith, J.P., Daifas, D.P., El-Khoury, W., Koukoutsis, J., & El-Khoury, A. (2004). Shelf life and safety concerns of bakery products—A review. *Critical Reviews in Food Science and Nutrition, 44*(1), 19–55.

U.S. Department of the Treasury, Community Development Financial Institutions Fund. (2011). *Understanding the grocery industry*. Washington, DC: The Reinvestment Fund. Retrieved from https://www.cdfifund.gov/Documents/Understanding%20Grocery%20Industry_for%20fund_102411.pdf




# Noise Exposure and Temporary Hearing Loss of Indoor Hockey Officials: A Pilot Study

Karin L. Adams, PhD
Ammon Langley, MS
William Brazile, PhD, CIH
*Department of Environmental & Radiological Health Sciences*
*Colorado State University*

**Abstract** **Indoor hockey officials might be at high risk of hearing loss at an earlier age because their noise exposures have not been evaluated and officiating can begin as early as 10 years of age. Officials of junior and collegiate hockey leagues in northern Colorado participated in noise dosimetry and pre and postgame pure-tone audiometry to determine if a ≥10 decibels (dB) decrease in hearing sensitivity resulted from noise exposures during the game. All of the officials (*N* = 23) were exposed to equivalent sound pressure levels ≥85 A-weighted decibels (dBA) and 65% were overexposed based on noise criteria set by the American Conference of Governmental Industrial Hygienists. Of the sampled officials, 10 of 18 demonstrated a ≥10 dB increase in hearing threshold, seven of whom included shifts in more than one ear and/or frequency and two of whom demonstrated a 15 dB shift. The results of this study suggest exposure to hazardous levels of noise and a possible increased risk for hearing loss among hockey officials.**

## Introduction

Exposure to hazardous levels of noise might cause hearing damage and affect one's health, communication, and quality of life. Prolonged exposures to sounds of less than 75 decibels (dB) are not likely to cause hearing loss, yet repetitive exposures to sounds at or above 85 dB are hazardous, increase risk of hearing loss, and may cause permanent hearing loss (American Speech-Language-Hearing Association, 2016; National Institute on Deafness and Other Communication Disorders, 2014). Researchers have found that repeated exposure to hazardous noise levels might eventually result in a temporary threshold shift (TTS) in hearing such as tinnitus and "fullness in head" (Ward, 1970), and repeated TTSs may cause permanent shifts (Kirchner et al., 2012).

Damage-risk criteria provide the basis for recommending occupational noise exposure limits based on noise level and exposure duration, assuming nonoccupational noise levels are low enough to allow the ear to recover. The Occupational Safety and Health Administration (OSHA) permits an 8-hour time-weighted average (TWA) sound level of 90 A-weighted decibels (dBA) with a 5 dB exchange rate (U.S. Department of Labor, 2016), whereas the American Conference of Governmental Industrial Hygienists (ACGIH) recommends an 8-hour TWA sound level of 85 dBA with a 3 dB exchange rate (ACGIH, 2014).

Various noise exposure studies have been conducted on spectators and employees at sporting events (Cranston, Brazile, Sandfort, & Gotshall, 2013; Engard, Sandfort, Gotshall, & Brazile, 2010). Researchers studying noise exposures of fans and ushers at two indoor hockey arenas found that fans and ushers at collegiate and semiprofessional hockey games exceeded ACGIH noise exposure criteria (Cranston et al., 2013). Investigators who assessed the noise exposures of fans and workers at various-sized football stadiums found that 96% of workers and 96% of fans were considered overexposed according to ACGIH recommendations (Engard et al., 2010).

There have been a limited number of TTS studies for sports venues. Researchers performed a pure-tone audiometry study during the 2006 Stanley Cup and found the average noise exposure levels for each game were above 101 dB and hearing thresholds of two subjects deteriorated by 5 to 10 dB for most frequencies (Hodgetts & Liu, 2006). Recently, researchers studied the intensity of noise exposure and hearing thresholds of attendees during basketball games at Utah State University and found that the hearing thresholds of the attendees deteriorated by 4.43 dB (England & Larsen, 2014).

Although spectators of various sports have been evaluated for noise exposure and TTSs, sports officials have not been assessed, possibly to the detriment of their hearing. A literature review revealed that indoor hockey officials' noise exposure levels and temporary hearing losses have not been studied previously. This population of over 23,000 registered hockey officials, not including nonregistered officials, is unique for various reasons: officiating can begin as early as 10 years of age (USA Hockey, 2014), noise exposures include sources on and off the ice (e.g., whistles, crowd noise), and the hockey game noise exposure is supplemental to any noise exposure experienced during the official's normal workday. The purpose of this pilot study was to determine if indoor hockey officials are exposed to hazardous levels of noise and whether or not they experienced a temporary hearing loss.

The pilot study was conducted at two small indoor hockey arenas in northern Colorado with fewer than 200 spectators in attendance. Investigators monitored the noise exposures of indoor hockey officials of the American Collegiate Hockey Association (ACHA) and the Western States Hockey League (WSHL) who officiated collegiate and junior league hockey games. Pre and postgame audiometric tests were administered in areas adjacent to the ice arena. The results of this study might identify a population that might be at an increased risk of noise-induced hearing loss (NIHL) at an early age and might reduce future cases of NIHL in hockey officials and officials of other sporting events.

## Methods

Study participants included indoor hockey officials of WSHL and ACHA who officiated junior and collegiate hockey games in two northern Colorado ice arenas during the 2013–2014 hockey season. All study participants were male and 21 years of age or older. All aspects of this study were conducted in compliance with a human subjects study protocol approved by Colorado State University's Institutional Review Board.

### Audiometry

Audiometric tests were conducted on 18 offiicials from November 2013 through January 2014. All officials completed a hearing history questionnaire and received an ear examination with an otoscope prior to each pregame hearing test. The questionnaire was used to determine the length of time since the last excessive noise exposure and nonoccupational noise exposures (e.g., music, firearms). The otoscopic examination was conducted to identify conditions that could exclude the official from participation in the study (e.g., excessive ear wax, ruptured tympanic membrane).

Areas used for audiometric testing were selected to best achieve acceptable background noise levels, as per Table D-1 of OSHA 1910.95 Appendix D (U.S. Department of Labor, 2016). An exercise room adjacent to the ice in arena I and the stairwell closest to the officials' locker room in arena II were used for administering hearing tests. The background octave band sound pressure levels (SPLs) were measured at 500, 1,000, 2,000, 4,000, and 8,000 Hz before and after the pre and postgame hearing tests. Background ambient noise levels were measured using a CEL 383 sound level meter/ octave band analyzer, which was pre and post-calibrated with the CEL 282 calibrator at 114 dB to assure calibration was maintained.

Audiometric tests were performed by a certified researcher from the Council of Accreditation in Occupational Hearing Conservation using an Earscan 3 ES3S pure-tone audiometer. A functional, "look and listen" calibration of the audiometer was performed prior to the first hearing test of each sampling day. The modified Hughson-Westlake technique was used to manually test the threshold for each ear at 500, 1,000, 2,000, 3,000, 4,000, 6,000, and 8,000 Hz. The descending (10 dB) and ascending (5 dB) process was repeated until the official responded at a specific intensity at least 50% of the time at each of the frequencies. Postgame audiometry was conducted after the official's departure from the ice.

### Noise Dosimetry

Personal noise dosimetry was conducted on 23 officials in January and February 2014. Each official was fitted with a Larson Davis Model 706 RC noise dosimeter. The dosimeters were calibrated before and after sampling using a Larson Davis CAL 150 at 94 dB and 114 dB, and collected data were downloaded with the Larson Davis Blaze software package. Noise sampling was performed in accordance with the OSHA Technical Manual, Section III, Chapter 5. The dosimeter was secured to each official before the start of the game. The microphone (including windscreen) was attached to the official's shoulder or lapel on the dominant side (opposite the whistle hand). The microphone and cable were secured with adhesive tape in order to keep the microphone upright and the cable from snagging on players' hockey sticks. Each official was instructed to not remove, tap, or yell into the microphone and operating conditions of the dosimeter and microphone were confirmed and adjusted, if necessary, at each of the intermissions. The dosimeter was stopped and removed after the official exited the ice at the end of the game.

### Analysis

SAS version 6.1 was used to perform statistical analysis. Descriptive statistics were used to express the proportion of officials exceeding the 85 dB equivalent sound pressure level ($L_{eq}$) and the noise regulations/recommendations, and the proportion of officials who experienced a 10 dB or greater decrease in hearing sensitivity.

## Results

### Audiometry

A total of 18 questionnaires were completed by the officials about their hearing history prior to the pregame hearing test. The study participants were male and ranged from 21 to 65 years of age, with an average officiating experience of 12.9 years (range 4–37 years). When asked to report the source of their most recent noise exposure, 27.8% (5/18) reported hockey, 11.1% (2/18) reported music, and 61.1% (11/18) reported no recent noise exposure.

Audiometric tests were conducted in the most feasible space adjacent to the ice rink in each arena. The background SPLs for each testing area were under the maximum allowable SPLs for audiometric test rooms for 2,000, 4,000, and 8,000 Hz, but exceeded the allowable limit at 500 and 1,000 Hz.

We conducted 18 pre and postgame hearing tests on 15 different officials. One official was sampled three times and another was sampled twice. An increase in hearing threshold of 10 dB or greater was exhibited in more than half (55.6%) of the sampled officials.

Of those officials with the ≥10 dB decrease in hearing sensitivity, 70.0% experienced a threshold shift in more than one ear and/or at more than one frequency and 20% experienced a 15 dB threshold shift. The proportions of those officials with ≥10 dB deterioration of hearing thresholds in each ear at each of the tested frequencies are shown in Figure 1.

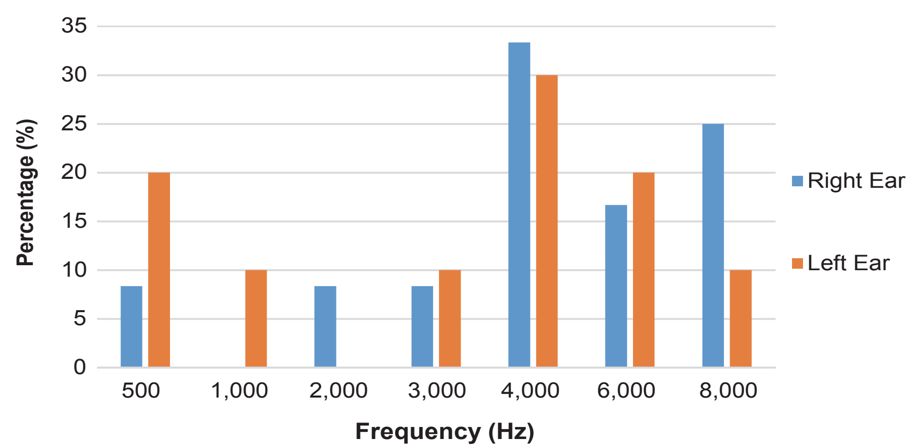
The Wilcoxon signed-rank test was performed on the paired audiometry data because it was not normally distributed. Based on the results of the Wilcoxon signed-rank test, there were significant differences between the pre and postgame hearing thresholds at 2,000 Hz for the left ear ($p = .012$) and at 4,000 Hz for the right and left ears ($p = .037$, $p = .017$, respectively). The differences at the other frequencies for both ears were not significant ($p > .05$).

### Noise Dosimetry

Noise dosimetry was conducted during four hockey games at arena I and two hockey games at arena II. A total of 23 personal noise dosimetry samples were collected over an average hockey game time of 2 hours and 42 minutes (Table 1). The mean peak sound pressure level ($L_{peak}$) and the mean $L_{eq}$ were 133 dB and 90 dBA, respectively. None of the officials was overexposed to noise based on OSHA noise criteria, yet 65% of hockey officials were overexposed to noise based on ACGIH recommendations.

FIGURE **1**

**Percentage of Hockey Officials With ≥10 dB Increase in Hearing Threshold by Frequency**




## Discussion

### Audiometry

The hearing history questionnaire was used to determine the length of time since the officials' last excessive noise exposure. Of the 18 officials queried, 11 (61%) reported no recent noise exposure, whereas 5 (28%) reported a previous hockey game as a noise exposure. In retrospect, it might have been more appropriate to ask the source and duration of the noise exposure within the last 48 hours, including sports officiating. Officiating more hockey games than documented or the increased background noise levels in the audiometric testing rooms might explain a higher pregame hearing threshold (≥25 dB) found in 10 (56%) of the officials. The questionnaire should have included a question regarding the presence of TTS symptoms before and after the hockey game, similar to that done by researchers investigating hearing loss associated with loud music exposure (Sadhra, Jackson, Ryder, & Brown, 2002). Although the noise exposures from the officials' nonoccupational and leisure noise exposures were not measured in this study, they likely are contributing to the officials' overall noise exposure and associated symptoms, as supported by Clark's literature review (1991) of noise exposures from leisure activities.

Pure-tone threshold shifts of 10 dB or greater were identified at all of the tested frequencies in one or both ears, with the largest percentage of shifts occurring at 4,000 Hz. These results are similar to those found by Hodgetts and Liu (2006) during a Stanley Cup game. The researchers found a pure-tone shift of 5–10 dB for most of the tested frequencies, with one subject experiencing a 20 dB shift in one ear. The audiometric testing, however, occurred on only two spectators in the Hodgetts and Liu study (2006), and therefore the results might not be representative. The current study results are consistent with those of several researchers who have used pure-tone audiometry to identify the presence of a TTS after exposure to loud music (Le Prell et al., 2012; Sadhra et al., 2002). In particular, the results and design of the study by Sadhra and co-authors (2002) are similar to the current study in that it measured the noise exposure and hearing thresholds of employees in a noisy environment, not just the spectators/attendees. Furthermore, they found that the correlation between TTS and personal exposure was higher at 4,000 Hz. Le Prell and co-authors (2012) found the 4,000 Hz "notch" that is typical of NIHL after noise exposure from digital music players.

The differences between pre and postgame hearing thresholds were significantly different at 4,000 Hz in both ears and at 2,000 Hz in the left ear. The Wilcoxon signed-rank test results were less powerful due to the small sample size and sampling officials multiple times occurred because only a small pool of 28 to 32 officials work the hockey games in northern Colorado. England and Larsen (2014) used *t*-tests with Bonferroni adjustments and found significant differences between pre and postgame pure-tone audiometry at basketball games at all tested frequencies in both ears, except for the left ear at 1,000 Hz and right ear at 6,000 Hz. The inconsistency in results with the current study might be explained by the unfavorable audiometric testing conditions in the current study.

Background noise levels of audiometric testing areas did not meet the acceptable levels for 500 and 1,000 Hz and the results at those frequencies might not be indicative of actual hearing thresholds, as 61% of officials had pregame hearing thresholds ≥25 dB at those frequencies. Limited funding, time, and instrumentation did not allow for optional testing environments or continual background noise measurements. The inconsistencies might also be because several of the postgame hearing tests were conducted more than 30 minutes after the game's end, therefore possibly underestimating the number of hearing threshold shifts. Ideally, the audiometric testing would occur in an audiometric testing booth that meets or exceeds the requirements outlined in OSHA's Appendix D and testing would be done quickly after the game, as the ear begins to heal from a TTS in as little as a few minutes after removal of the noise source (Melnick, 1991; Ward, 1980).

Previous researchers (England & Larsen, 2014; Le Prell et al., 2012; Sadhra et al., 2002) included a follow-up hearing test within 48 hours of the noise exposure and found that the TTS recovery was essentially

TABLE **1**

**Noise Dosimetry Results of Hockey Officials in Arenas I and II***

| Parameter | Criteria | | | |
|---|---|---|---|---|
| | OSHA Action Limit[a] | | ACGIH Threshold Limit Values[b] | |
| | Mean | *SD* | Mean | *SD* |
| Dose (%) | 19.2 | 5.63 | 119.9 | 96.3 |
| $L_{eq}$ (dBA) | 90 | 2.13 | 90 | 2.13 |
| TWA (dBA)[c] | 86 | 1.78 | 90 | 2.16 |
| $L_{max}$ (dBA) | 115 | 4.50 | 115 | 4.50 |
| $L_{peak}$ (dB) | 133 | 5.49 | 133 | 5.49 |

**N* = 23 officials.

[a]Dosimeter settings for Occupational Safety and Health Administration (OSHA) action limit criteria include: A-weighting, slow averaging, 85 criterion level, 8-hour criterion time, 80 threshold level, 5 dB exchange rate.

[b]Dosimeter settings for American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit values include: A-weighting, slow averaging, 85 criterion level, 8-hour criterion time, 80 threshold level, 3 dB exchange rate.

[c]Time-weighted average (TWA) for time sampled: Average of 2 hours, 42 minutes.

complete within the first 4 hours after exposure. Unlike previous studies, the researchers were unable to coordinate a follow-up hearing test and assumed that the threshold shifts were only temporary. The study participants were notified to contact a physician if symptoms persisted for more than 48 hours.

### Noise Dosimetry

All of the hockey officials who participated in this study were exposed to an $L_{eq}$ >85 dBA, with a mean $L_{eq}$ of 90 dBA. The mean $L_{eq}$ of 90 dBA in this study was similar to the mean $L_{eq}$ of 85 dBA found by England and Larsen (2014) in basketball arenas, and within the $L_{eq}$ range found by area monitoring at two indoor hockey venues by Cranston and co-authors (2013). During National Hockey League playoff games, researchers found $L_{eq}$ values in a range from 101–104 dBA (Hodgetts and Liu, 2006), which was greater than the $L_{eq}$ found in the current study. The previous study had more attendees, as would be expected for a Stanley Cup playoff, and crowd noise was most likely a contributing factor.

The researchers measured a mean $L_{peak}$ of 133 dB in the current study that is consistent with the $L_{peak}$ range (130–146 dB) found by Engard and co-authors (2010), yet higher than the area monitoring $L_{peak}$ range of 105–124 dB at venue 1 and the 110–117 dB at venue 2 found by Cranston and co-authors (2013). The variations between personal and area monitoring might explain the difference in results. Area sampling in the current study might have been beneficial in assessing the frequency spectra of the noise in various locations in the hockey arenas.

Our findings that 65% of officials exceeded ACGIH noise exposure criteria are consistent with the findings of Cranston and co-authors (2013). The researchers of the current and previous study concur that none of the study participants exceeded OSHA noise criteria. The Engard and co-authors' study results (2010) support the current study's findings based on ACGIH criteria, yet those researchers found that 20% of fans exceeded OSHA permissible exposure limit of 90 dBA. The differences might be the result of different arena/stadium acoustics, location of personal sampling, and number of people in attendance.

For example, the current study included fewer than 200 spectators, while the Engard and co-authors' study (2010) included a range of 19,721–75,703 spectators. The larger crowd likely produced more noise, which might account for increased noise exposure levels in the Engard study. It is also possible that the results from the smaller venue with fewer spectators underestimated the noise exposures of officials in larger arenas.

The hockey officials in this study often use officiating as supplementary income to their primary employment. Personal noise dosimetry data were only collected for the duration of the hockey game, but the occupational noise criteria are based on an 8-hour workday.

The researchers chose not to report results that compared to OSHA or ACGHI 8-hour TWA because the calculations would have assumed that the official's remaining noise exposure for the day was less than the threshold dB value, which is unlikely. For instance, other common noise sources integrated in a daily noise exposure may include noise from another job or occupation, music, hunting, power tools, and other sporting events, as is supported by Clark's literature review (1991) of noise exposures from leisure activities.

## Conclusions

This pilot study was the first step in evaluating the noise exposure and hearing loss of indoor hockey officials. Preliminary surveys indicate engineering controls are not feasible and officials do not wear hearing protection. Exposure to hazardous levels of noise increases the risk of repetitive TTSs, which may increase the risk of permanent hearing loss. Based on the results of this study, indoor hockey officials are exposed to levels of noise that may result in repetitive TTSs; further research is warranted.

Future research should include noise monitoring at a larger venue, audiometric testing in a room with allowable background noise levels, and postgame audiometry within minutes of the game's end. Further research has the potential to identify officials of other sporting events, regionally and nationally, who might be at an increased risk of NIHL. In an effort to reduce noise exposure, hockey officials should consider wearing hearing protection while officiating games.

*Acknowledgements:* The authors thank Dan Van Arsdall for his cooperation and supervision of the ACHA and WSHL officials who volunteered for the project. This research was partially funded by the Mountain & Plains Education and Research Center.

*Corresponding Author:* Karin L. Adams, School of Allied Sciences, Department of Community and Environmental Health, Boise State University, 1910 University Drive, Boise, ID 83725-1835. E-mail: karadams@gmail.com.

*References on page 26*

## References *continued from page 25*

American Conference of Governmental Industrial Hygienists. (2014). *Threshold limit values for chemical substances and physical agents* (pp. 130–133). Cincinnati, OH: Author.

American Speech-Language-Hearing Association. (2016). *Noise*. Retrieved from http://www.asha.org/public/hearing/Noise

Clark, W.W. (1991). Noise exposure from leisure activities: A review. *The Journal of the Acoustical Society of America, 90*(1), 175–181.

Cranston, C.J., Brazile, W.J., Sandfort, D.R., & Gotshall, R.W. (2013). Occupational and recreational noise exposure from indoor arena hockey games. *Journal of Occupational and Environmental Hygiene, 10*(1), 11–16.

Engard, D.J., Sandfort, D.R., Gotshall, R.W., & Brazile, W.J. (2010). Noise exposure, characterization, and comparison of three football stadiums. *Journal of Occupational and Environmental Hygiene, 7*(11), 616–621.

England, B., & Larsen, J.B. (2014). Noise levels among spectators at an intercollegiate sporting event. *Americal Journal of Audiology, 23*(1), 71–78.

Hodgetts, W.E., & Liu, R. (2006). Can hockey playoffs harm your hearing? *Canadian Medical Association Journal, 175*(12), 1541–1542.

Kirchner, D.B., Evenson, E., Dobie, R.A., Rabinowitz, P., Crawford, J., Kopke, R., & Hudson, T.W. (2012). Occupational noise-induced hearing loss: ACOEM task force on occupational hearing loss. *Journal of Occupational and Environmental Medicine*, *54*(1), 106–108.

Le Prell, C.G., Dell, S., Hensley, B., Hall, J.W., III, Campbell, K.C., Antonelli, P.J., . . . Guire, K. (2012). Digital music exposure reliably induces temporary threshold shift in normal-hearing human subjects. *Ear and Hearing, 33*(6), e44–58.

Melnick, W. (1991). Human temporary threshold shift (TTS) and damage risk. *The Journal of the Acoustical Society of America, 90*(1), 147–154.

National Institute on Deafness and Other Communication Disorders. (2014). *Noise-induced hearing loss*. Retrieved from http://www.nidcd.nih.gov/health/hearing/pages/noise.aspx#5

Sadhra, S., Jackson, C.A., Ryder, T., & Brown, M.J. (2002). Noise exposure and hearing loss among student employees working in university entertainment venues. *Annals of Occupational Hygiene, 46*(5), 455–463.

USA Hockey. (2014). *Membership statistics*. Retrieved from http://www.usahockey.com/page/show/839306-membership-statistics

U.S. Department of Labor, Occupational Safety and Health Administration. (2016). *Occupational noise exposure* (Standard 29 C.F.R. 1910.95). Retrieved from www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9735

Ward, W.D. (1970). Temporary threshold shift and damage-risk criteria for intermittent noise exposures. *The Journal of the Acoustical Society of America, 48*(2), 561–574.

Ward, W.D. (1980). Effects of impulse noise on hearing. Summary and overview. *Scandinavian Audiology. Supplementum,* (Suppl. 12), 339–348.

## Did You Know?

NEHA is in Washington, DC! Check out our Government Advocacy page to learn more about current events taking place in Washington, DC, at www.neha.org/about-neha/advocacy.

▸ SPECIAL REPORT

# The Permitting of Desalination Facilities: A Sustainability Perspective

Brett Koontz, DPA, REHS
Thomas Hatfield, DrPH, REHS, DAAS
*California State University, Northridge*

**Abstract** **Desalination provides a partial solution to water scarcity. While the desalination process provides much needed water to coastal areas, it also has various environmental impacts. Older operations entrain and impinge large and small organisms during the collection process, use significant amounts of energy, and produce substantial volumes of waste brine. These short- and long-term impacts warrant the involvement of environmental health practitioners.**

**Sustainable water supplies depend on more than just the weather. Accordingly, we start by analyzing the rising global demand for drinking water and the ongoing deterioration of the oceans. Next, we detail known impacts of desalination, and discuss alternatives for addressing water scarcity. We challenge environmental health practitioners to help meet current and future drinking water needs with respect to environmental sustainability. The ocean is finite. We should ask the right questions so as not to consume it at an untenable pace.**

## Introduction

In the midst of a drought, public opinion in California focuses yet again on a search for new supplies of drinking water. An option frequently mentioned in the popular media is the technology of desalination (Rogers, 2014). A common argument is that we have a virtually unlimited water supply from the ocean—the technology for desalination is available, the need is clear, and therefore we should proceed with building the treatment plants. Time and technology advance rapidly, and we can now deploy mobile desalination vehicles around the world for small-scale water emergencies (see photo on page 29).

Drought conditions extend well beyond the borders of California, creating environmental challenges in various parts of the globe. Many parts of the world struggle with water scarcity issues (Briffa, van der Schrier, & Jones, 2009), and these trends have emerged over extended periods of time (Rogers, 2014).

The World Health Organization (WHO) recognizes multiple impacts from desalination (WHO, 2007). Thoughtful decision makers must evaluate desalination against all available alternatives for drinking water, and the technology may be more applicable in some areas than others. Stakeholders must consider conservation measures and financial sustainability in addition to site-specific environmental issues.

The environmental health profession adapts as new conditions evolve. Historically, our role focused on short-term, human health concerns, especially from contamination by pathogens. With increasing knowledge of chemical toxicity, our role expanded to regional approaches that address contaminated aquifers. Today's issues of population growth, food supply, and energy production require attention to the physical availability of sustainable water sources. Many aspects of current drinking water regulations focus on short-term impacts, but future generations will depend on our decisions today for the sustainable use of common pool resources.

Environmental health practitioners face a number of issues associated with desalination. For example, a joint effort of the City of Santa Cruz Water Department and the Soquel Creek Water District reveals a complex system of public health concerns and related permits for the construction and operation of a single desalination plant (The City of Santa Cruz Water Department and Soquel Creek Water District, 2015). At the state level, policy makers in California are also addressing the issues of desalination and formulating new rules (California Environmental Protection Agency, 2015). The long-term viability of desalination decisions on both coasts requires an understanding of short- and long-term consequences.

We start by analyzing the rising global demand for drinking water and then examine the ongoing deterioration of the oceans. We detail the known impacts of desalination, and discuss a range of alternatives for drinking water supplies. With an understanding of the interconnectedness of desalination and environmental health, we argue that the profession has an obligation to be more involved in the decision-making process. With a better understanding of desalination operations and their impacts, our profession should ask

*Portable desalination vehicle. Reprinted with permission from G.A.L. Water Technologies Ltd.*

the necessary questions before consuming this finite resource.

## Rising Global Demand for Drinking Water

Water consumption data indicate that heavily populated countries consume great amounts of water. The three most populous countries—India, China, and the U.S.—are the world leaders in freshwater withdrawals (World Bank, 2015). Existing data also indicate that drinking water consumption per capita varies significantly across continents. For example, residential drinking water consumption in the water-strapped nation of Australia was as low as 42 gallons per person per day (Melbourne Water, 2014), while U.S. estimates were significantly greater at 80 to 100 gallons per person per day (U.S. Geological Survey, 2015). The numbers suggest that countries such as the U.S. should look at a combination of consumer behaviors and emerging technologies as ways of ensuring water security for future generations.

Worldwide droughts drive the need for new sources of drinking water. Data from Europe indicate a trend of increasing drought conditions over multiple years (Briffa et al., 2009). In the U.S., approximately 29 states maintain areas with drought conditions. The conditions are noticeably elevated in the western, southwestern, and southern coastal states (National Drought Mitigation Center, 2015). The growing influence of droughts requires adjustments to consumer behavior and drinking water infrastructure. Consumption habits, drought conditions, and growing populations accelerate water scarcity concerns. Ironically, many people in drought areas live next to large bodies of water.

Millions of people live, work, and recreate in coastal areas. In 2001, more than half of the world's population lived within 124 miles of a coastline (United Nations, 2016). Population values of U.S. cities along the coast indicate a similar trend. In the last decade, coastal areas included 5 of the 10 most populous cities and 7 of the 10 most populous counties (Wilson & Fischetti, 2010).

Historically, groundwater and surface water provided drinking water to large coastal populations even in the presence of access to seawater. As pressure on historic water resources increases, desalination becomes a more attractive option. Desalination, however, requires that we manage the oceans—the ultimate common pool resource—with respect to environmental values, commercial resources, and social benefits for future generations.

## Degradation of the Oceans

Stakeholders need to consider desalination in the context of other environmental impacts. The current and future consequences on ocean ecosystems occur in addition to existing impacts from other sources. The geospatial distribution of existing desalination plants can be useful in understanding site-specific effects and potential concerns (Dimitriou, Angeliki, Vasiliki, Maria, & Christina, 2014).

Environmental health practitioners recognize the variety of point and nonpoint discharges to oceans from stormwater flows, aquaculture, oil spills, and sewage outfalls (Sindermann, 1995). Regulators often respond to these issues as localized, independent events with short-term effects. These discharges can lead to beach closures or other short-term, visible impacts. One need only recall the recent BP oil spill in the Gulf of Mexico, however, to recognize the longer term consequences to wildlife and beach areas. Furthermore, research continues to assess the impact of plastic waste in coastal zones (Baztan et al., 2014).

The ocean acts as a global carbon dioxide sink. In this role, it is subject to acidification from increased atmospheric levels of carbon dioxide. Data indicate that despite the high alkalinity and tremendous mass of the ocean, the average pH of the ocean surface has dropped from 8.2 to 8.08 in the last 50 years (Schnoor, 2013). These observations refute the notion that the ocean is an infinite and resilient resource. Such a shift requires further attention. Meanwhile, research continues on the long-term combined impacts of acidification and changes in salinity (Durack, 2015). The combination of site-specific and global impacts from desalination underscores the importance of detailing a list of recognized impacts.

## Known Impacts From Desalination

Desalination presents negative impacts on ecological elements of ocean systems. Fortunately, the application of lessons learned from management of freshwater resources can mitigate some of these impacts. Currently, permitting processes in the U.S. address some concerns by requiring environmental impact assessments that identify and mitigate environmental health issues over time (WHO, 2007).

Specifically, desalination causes biological impacts in the form of entrainment and impingement (National Research Council, 2008). Entrainment occurs when intake pipes pull small aquatic organisms such as plankton, fish eggs, and larvae into a desalination plant. Organisms die off when subjected to high temperatures or high-pressure elements in the system. Impingement refers to trapping of fish or other larger organisms against water intake screens, which can cause injury and death. We can mitigate these impacts by installing underground collection pipes at the bottom of the ocean, which adds to the cost of installation and maintenance.

Furthermore, evidence from desalination activity in the Mediterranean region indicates negative impacts to sea grass in the presence of elevated salinity (Laspidou, Hadjibiros, & Gialis, 2010). Additional studies and monitoring may provide a deeper understanding of impacts from desalination. Agencies should provide coastal stakeholders with information on these various impacts in readily available, easy-to-read formats.

Desalination consumes significant amounts of energy, and older technologies are likely to use fossil fuels (Gude, Nirmalakhandan, & Deng, 2011), which can produce air pollution and negative health consequences. Flash processes rely on the heat of distillation to separate the salt and water, while membrane technologies require energy to move masses of water across a membrane. Ongoing research continues to evaluate the use of renewable energy sources such as solar, wind, and geothermal technology to support desalination (Ghaffour et al., 2014). An increased use of renewable power to support desalination can reduce air pollution and the associated health impacts.

Liquid discharges from desalination produce brine. Therefore, agencies must consider changes in salinity to receiving waters during plant permitting and operation. Historical work by the U.S. Department of the Interior's Office of Saline Water in the early 1970s identified and addressed concerns related to brine disposal (Rinne, 1971). Their work focused on brine discharge characteristics such as pH, metals, and chemical contaminants. The concluding recommendations suggested copious amounts of dilution and dispersion.

Increased salinity from desalination facilities may also contribute to hypoxia in the bottom layers of a bay (Hodges et al., 2011). In the current regulatory landscape, disposal regulations continue to incorporate dilution, dispersion, and mixing zones to reduce brine toxicity with respect to ecological sensitivity (Ahmad & Baddour, 2013). It is not entirely clear as to how long this strategy might be effective, nor is it entirely clear how ecological changes may have secondary impacts on environmental health.

Brine disposal continues to be problematic and costly for existing coastal or inland plants. Expenditures related to brine disposal can vary from 5% to 33% of total desalination costs (Abdul-Wahab & Jupp, 2009). The time and energy required to move brine off site drives disposal costs in an upward direction (Laspidou et al., 2010). Agriculture and aquaculture can provide some financial relief as limited alternatives for brine disposal. For example, brine solutions can irrigate almond, olive, and pistachio crops (Abdul-Wahab & Jupp, 2009). This could be significant in California, where almonds occupied 935,804 farming acres in 2012 (U.S. Department of Agriculture, 2012). Currently, the almond industry endures criticism for growing a product with a relatively high water footprint that equates to one gallon of water per almond (Mekonnen & Hoekstra, 2010). Further research will also increase our understanding of the impacts from agricultural applications on groundwater contamination and stormwater runoff.

Research indicates that waste brine byproducts in liquid, solid, and slurry states maintain potential commercial value (Hajbi, Hammi, & M'nif, 2010). Specifically, salt from desalination is a useful component in road base, in the manufacture of dust suppressants, and in the production of hypochlorites (Abdul-Wahab & Jupp, 2009). Alternatively, aquaculture has various uses for brine that are already commercially valid. For example, tilapia and spirulina grow in waters with high alkalinity and salinity (Mohamed, Maraqa, &Al Handhaly, 2005). Alternatively, if land is available, then entrepreneurs could collect and manage the waste brine in solar ponds. Solar ponds hold thermal energy, transfer it to water, and ultimately generate commercial heat, steam, or electricity (Abdul-Wahab & Jupp, 2009).

Desalination is actually a variety of technologies. For example, among thermal technologies there are at least five alternatives (Shatat & Riffat, 2012): multistage flash distillation, multiple-effect distillation, vapor-compression evaporation, cogeneration, and solar water desalination.

Site-specific conditions are likely to dictate the use of each application. Distillation methods that rely on the combustion of carbon-based fuels are likely to be present in areas such as oil-rich nations in the Middle East. Alternatively, cogeneration is more feasible for desalination when an adjacent operation has significant amounts of discharge heat. Furthermore, solar-powered processes or those that rely on forms of renewable energy have the potential to reduce harmful air emissions associated with fossil fuel consumption.

## Alternatives

Environmental health practitioners can play a role in educating the public about well-known alternatives to desalination. For example, water management techniques such as rainwater harvesting and arid landscaping can lower consumption rates of existing sources. When communities bypass such fundamental approaches in favor of desalination, they ignore the advantages of proven techniques. Desalination consumes volumes of ocean water, while conservation minimizes the consumption of ocean and fresh water resources.

Other alternatives to desalination include drip irrigation practices for agriculture and improved water recycling within various industries. While the benefits of these practices are not always immediately evident to the average consumer, they could account for significant reductions across the country.

Administrative changes to drinking water pricing may influence consumption habits in some settings. The general public may not be aware that existing pricing for water does not reflect the true costs of the water—this fact has been known for a long time (Capen, 1939) and continues today with calls for water rights and free markets (Bailey, 2015).

Tiered pricing programs might provide an incentive to curb water consumption, while increasing the feasibility of other technologies. For example, as drinking water prices rise, treated wastewater becomes a more cost-effective technique for recharging existing groundwater sources. The feasibility of this approach increases with improvements in technology and policy learning across jurisdictions.

Alternatives are not limited to new technology, but can also be explored in the different applications of existing technologies. For example, desalination could be restricted to industrial uses only. In such applications, the quality of the distilled water need not be the quality of drinking water, but the industrial use of seawater would reduce resource pressure on freshwater sources.

Finally, technologies continue to improve. Given the evolving nature of technology, price structures, and water availability, the question as to the appropriate role of the environmental health practitioner arises.

## Discussion

Environmental health practitioners can play a significant role in the future of desalination. Their actions should align with social, financial, and environmental aspects of sustainability. Social sustainability derives strength from transparent, democratic practices, while the complexities of environmental sustainability require simplification. Financial sustainability in regional settings requires analysis and attention to cost and ability of ratepayers to absorb such burdens. Going forward, environmental health practitioners should

- participate in the public process by speaking at public hearings or providing input during public comment periods.
- share credible desalination information or educational resources with various stakeholders such as other governmental agencies, the private sector, and nonprofit organizations and community groups.
- anticipate local consequences and call for offsets, compensation, or design modifications during the design and permitting of desalination facilities.

The impacts of consuming vast quantities of seawater are not clear. Therefore, does the ocean need a global water rights system for protection? Such a water rights system could be similar to that for existing freshwater sources. Despite its enormous size, the evidence accumulates on the insults to this vast ecosystem. In the face of this growing evidence, can we afford to continue testing the assimilative capacity of the ocean?

Until now, this finite resource tolerated human impacts and degradation. In decades prior, we did not fully understand the correlation between rising carbon dioxide emissions and ocean acidification. Going forward, environmental health practitioners maintain a critical role in monitoring ocean water consumption and the impacts of desalination. Ultimately, significant desalination decisions should support the existence of future generations.

Solutions to our water supply in general, and more specifically to the permitting of facilities, will inevitably require a multifaceted approach with special attention to three issues:

1. Conservation of existing water resources through changes in behavior or technology.
2. Efficient and effective use of drinking water with alternative grades of water for industrial activities.
3. Long-term financial viability that supports sanitary practices and sustainable economic activity.

It is thus imperative that environmental health practitioners look at all methods of responsible water use. Oceans provide local foods, support recreation, and absorb carbon dioxide emissions. Furthermore, coastal states maintain some of the largest cities in the world. This dynamic context prompts us to ask: Have coastal regions exhausted the alternatives to seawater consumption? That is, have these regions exhausted conservation practices, rainwater harvesting, and administrative techniques such as tiered pricing? The evidence overwhelmingly points against such exhaustion. Similarly, if industrial activity or agribusiness are the big water users, then what have they done in the interest of managing sustainable water supplies for future generations?

These provocative questions require answers. It is not our intent to point fingers at a few critical players. Our larger concern is that environmental health practitioners find a place in the desalination dialog. Moreover, the principles of sustainability and the long-term viability of the ocean as a drinking water resource deserve ongoing evaluation. Consumptive approaches like desalination reduce resource availability over time, while conservation measures reduce pressures on a given resource. In the areas of water, food, and energy, sustainable approaches might derive new strategies to meet the needs of future generations.

***Corresponding Author:*** Brett Koontz, Part-Time Faculty, California State University, Northridge, 18111 Nordhoff Street, Northridge, CA 91330-8412.
E-mail: brett.koontz@csun.edu.

## References

Abdul-Wahab, S.A., & Jupp, B.P. (2009). Levels of heavy metals in subtidal sediments in the vicinity of thermal power/desalination plants: A case study. *Desalination*, *244*(1), 261–282.

Ahmad, N., & Baddour, R.E. (2014). Minimum return dilution method to regulate discharge of brine from desalination plants. *Canadian Journal of Civil Engineering*, *41*(5), 389–395.

Bailey, R. (2015). Markets vs. drought: Is parched California fertile ground for property rights and prices for water? *Reason*, *47*(3), 18–19.

Baztan, J., Carrasco, A., Chouinard, O., Cleaud, M., Gabaldon, J., Huck, T., . . . Vanderlinden, J-P. (2014). Protected areas in the Atlantic facing the hazards of micro-plastic pollution: First diagnosis of three islands in the Canary Current. *Marine Pollution Bulletin*, *80*(1–2), 302–311.

Briffa, K.R., van der Schrier, G., & Jones, P.D. (2009). Wet and dry summers in Europe since 1750: Evidence of increasing drought. *International Journal of Climatology*, *29*(13), 1894–1905.

California Environmental Protection Agency. (2015). *State Water Resources Control Board: Ocean standards*. Retrieved from http://www.swrcb.ca.gov/water_issues/programs/ocean/desalination

Capen, C.H., Jr. (1939) Wholesale cost of water. *Journal of the American Water Works Association*, *31*(7), 1096–1109.

The City of Santa Cruz Water Department and Soquel Creek Water District. (2015). *Permitting*. Retrieved from http://www.scwd2desal.org/Page-Permitting.php

Department of Energy. (2014). *The water-energy nexus: Challenges and opportunities*. Washington, DC: Author. Retrieved from

*continued on page 32*

**References** *continued from page 31*

http://energy.gov/sites/prod/files/2014/07/f17/Water%20Energy%20Nexus%20Full%20Report%20July%202014.pdf

Dimitriou, E., Angeliki, M., Vasiliki, M., Maria, T., & Christina, Z. (2014). Geospatial investigation into groundwater pollution and water quality supported by satellite data: A case study from the Evros River (Eastern Mediterranean). *Pure and Applied Geophysics*, *171*(6), 977–995.

Durack, P.J. (2015). Ocean salinity and the global water cycle. *Oceanography*, 28(1), 20–31.

Ghaffour, N., Lattemann, S., Missimer, T., Ng, K.C., Sinha, S., & Amy, G. (2014). Renewable energy-driven innovative energy-efficient desalination technologies. *Applied Energy*, *136*, 1155–1165.

Gude, V.G., Nirmalakhandan, N., & Deng, S. (2011). Desalination using solar energy: Towards sustainability. *Energy*, *36*(1), 78–85.

Hajbi, F., Hammi, H., & M'nif, A. (2010). Reuse of RO desalination plant reject brine. *Journal of Phase Equilibria and Diffusion*, *31*(4), 341–347.

Hodges, B.R., Furnans, J.E., & Kulis, P.S. (2011). Thin-layer gravity current with implications for desalination brine disposal. *Journal of Hydraulic Engineering*, *137*(3), 356–371.

Laspidou, C., Hadjibiros, K., & Gialis, S. (2010). Minimizing the environmental impact of sea brine disposal by coupling desalination plants with solar saltworks: A case study for Greece. *Water*, 2(1), 75–84.

Mekonnen, M.M., & Hoekstra, A.Y. (2010). *The green, blue and grey water footprint of crops and derived crop products*. (United Nations Educational Scientific and Cultural Organization. Volume 1 Main Report). The Netherlands: UNESCO-IHE Institute for Water Education. Retrieved from http://waterfootprint.org/media/downloads/Report47-WaterFootprintCrops-Vol1.pdf

Melbourne Water. (2014). *Water outlook for Melbourne*. Retrieved from http://www.melbournewater.com.au/getinvolved/saveandreusewater/Documents/Water%20Outlook%20December%202014.pdf

Mohamed, A.M.O., Maraqa, M., & Al Handhaly, J. (2005). Impact of land disposal of reject brine from desalination plants on soil and groundwater. *Desalination*, *182*(1–3), 411–433.

National Drought Mitigation Center. (2015). *U.S. drought monitor*. Retrieved from http://droughtmonitor.unl.edu

National Research Council. (2008). *Desalination: A national perspective* (p. 109). Washington, DC: National Academies Press. Retrieved from http://www.nap.edu/openbook.php?record_id=12184&page=109

Rinne, W.W. (1971). *Waste brine disposal from coastal desalination plants*. Paper presented at the Institute of Electrical and Electronics Engineers: Engineering in the Ocean Environment Conference.

Rogers, P. (2014, October 18). Could desalination solve California's problem? *The Sacramento Bee*. Retrieved from http://www.sacbee.com/news/state/california/water-and-drought/article3017597.html

Schnoor, J.L. (2013). Ocean acidification. *Environmental Science and Technology*, *47*(21), 11919.

Shatat, M., & Riffat, S.B. (2012). Water desalination technologies utilizing conventional and renewable energy source. *International Journal of Low Carbon Technologies*, *9*(1), 1–19.

Sindermann, C.J. (1995). *Ocean pollution: Effects on living resources and humans*. Boca Raton, FL: CRC Marine Science.

United Nations. (2016). *Human settlements along the coast*. Retrieved from http://www.oceansatlas.org/subtopic/en/c/114

U.S. Department of Agriculture. (2012). *Census of agriculture*. Retrieved from http://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_1_State_Level/California

U.S. Geological Survey. (2015). *How much water does the average person use at home per day?* Retrieved from http://water.usgs.gov/edu/qa-home-percapita.html

Wilson, S.G., & Fischetti, T.R. (2010). *Coastline population trends in the United States: 1960 to 2008* (U.S. Census Bureau P25-1139). Washington, DC: Government Printing Office. Retrieved from http://www.census.gov/library/publications/2010/demo/p25-1139.html

World Bank. (2015). *Annual freshwater withdrawals*. Retrieved from http://data.worldbank.org/indicator

World Health Organization. (2007). *Desalination for safe water supply: Guidance for the health and environmental aspects applicable to desalination*. (WHO/SDE/WSH/07/0?). Geneva, Switzerland: Author. Retrieved from http://www.who.int/water_sanitation_health/gdwqrevision/desalination.pdf


## Did You Know?

You can learn more about all of the credentials we offer directly from our credentialing coordinator. View the recorded webinar at www.neha.org/credentialing-webinar for an overview of our credentialing program and the process to attain a NEHA credential, including our premier credential, the Registered Environmental Health Specialist/Registered Sanitarian.

**BUILDING CAPACITY**

Darryl Booth, MBA

# Building Capacity to Respond and Recover

**Editor's Note: A need exists within environmental health agencies to increase their capacity to perform in an environment of diminishing resources. With limited resources and increasing demands, we need to seek new approaches to the business of environmental health.**

**Acutely aware of these challenges, NEHA has initiated a partnership with Accela (formerly Decade Software Company) called *Building Capacity*. *Building Capacity* is a joint effort to educate, reinforce, and build upon successes within the profession, using technology to improve efficiency and extend the impact of environmental health agencies.**

**The *Journal* is pleased to publish this bimonthly column from Accela that will provide readers with insight into the *Building Capacity* initiative, as well as be a conduit for fostering the capacity building of environmental health agencies across the country.**

**The conclusions of this column are those of the author(s) and do not necessarily represent the views of NEHA.**

**Darryl Booth is senior vice president and general manager of environmental health at Accela and has been monitoring regulatory and data tracking needs of agencies across the U.S. for almost 20 years. He serves as technical advisor to NEHA's informatics and technology section.**

The retired environmental health director held the matte black device in his left hand. With the dimensions and weight of a new pack of playing cards, he turned it over slowly, examining its plastic shell and the short, thick wire extending from one end.

The device was a portable USB hard drive with a 500-gigabyte capacity, enough digital storage to capture and retain the history and details of a disaster, along with the federal, state, and local response and recovery. The retired environmental health director was NEHA Past-President Mel Knight, an experienced professional that contributed to the environmental health perspective following the 2015 Butte Fire in California. The details below are specific, but the concepts are worldwide and the events, unfortunately, are all too frequent.

The 2015 Butte Fire, which occurred east of Sacramento in the Sierra Nevada foothills, started September 9 (Figure 1). Likely caused when a powerline came in contact with untrimmed trees, the Butte Fire was among the most destructive fires in California. It burned 70,000 acres, destroyed 921 structures, and tragically killed two civilians.

The fire was contained over 20 days later on October 1. One year has passed since the fire and the government's response is nearing completion.

In Calaveras County, Environmental Health Director Jason Boetzer and Health Officer Dr. Dean Kelaita declared a local health emergency early on, thus allowing many resources to be brought to bear. An emergency management mutual aid request was filed soon after by California's Office of Emergency Services. The call also went out through local emergency services offices and the California Conference of Directors of Environmental Health (CCDEH). Seven registered environmental health specialists from health departments near and far joined the assessment team. Boetzer attests that having a network in place to approach these resources was key to completing this critical first step.

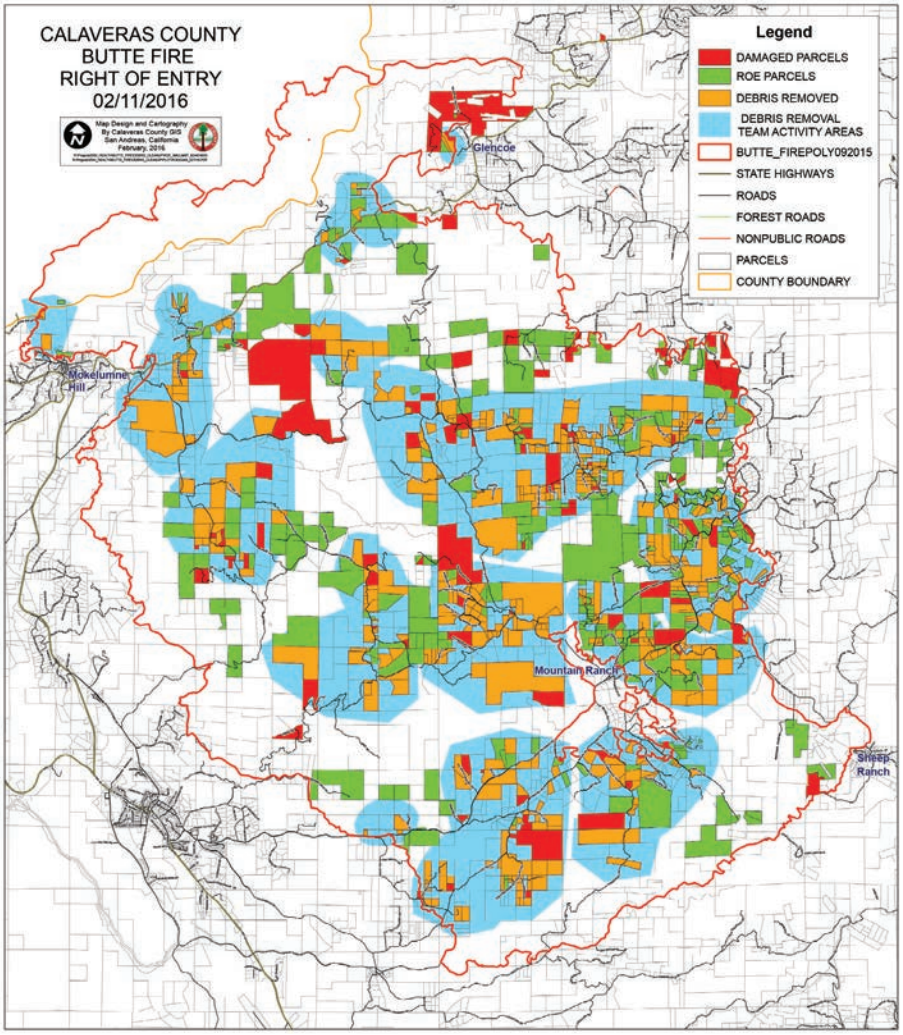
As evacuation orders were lifted, the local Calaveras County Environmental Health Department mobilized to assess 723 residential sites. Can you imagine visiting these remote sites, even as the fire still rages over the next mountaintop and the smoke is thick in the air? It is often said that all disasters are local, and so we initially benefit from local preparedness and expertise.

The county's capable GIS team quickly generated printed maps of parcels, many without addresses. Without reliable street signs and street numbers, and destroyed landmarks, the maps were invaluable to identify each assessed property.

The environmental health concerns included hazardous materials (household hazardous

FIGURE **1**

**GIS Map Representing the Area Affected by the 2015 Butte Fire**




*Complete devastation immediately following the fire. Photo courtesy of Jeff White.*

*Parcel following assessment but prior to cleanup. Photo courtesy of Ali Hossain.*

wastes, asbestos, and heavy metals), damaged onsite wastewater treatment systems, and compromised private wells and casings.

Even as property owners were allowed to return and sift through the remains for their possessions, they exposed themselves to these hazards. To that end, the county quickly compiled kits containing instructions, bottled water, masks, and other utilities to avoid exposure and injury. There were no power, water, heat, or bathrooms at these sites. To avoid further injury and potential illness, the county provided returning property owners with instructions on fundamental sanitation practices.

Figure 1 shows the area affected by the fire and used GIS to track the recovery progress. New map assessments were posted daily by the county's GIS team and were shared with the public to let the community know where teams were active, which provided the basis for predicting when individual properties would be cleared. Figure 1 was generated in February 2016, approximate half way through the recovery process.

The amount of time each environmental health staff member spent on different recovery services was recorded in the county health department's data management system. This database of work hours and services performed helped immensely when submitting for follow-on Federal Emergency Management Agency reimbursement. Other county departments with less regimented time tracking had a more difficult effort accounting for their time.

With the initial assessments completed and the fire suppressed, the cleanup work could begin. The state engaged contractors, which in turn secured environmental health professionals for oversight. The California Association of Environmental Health Administrators (an arm of CCDEH) facilitated the recruitment and contracts. The outside environmental health workers, including Knight and others, allowed the local health department to maintain its regulatory responsibilities.

The first restoration priorities were roads and emergency response facilities (police stations, hospitals, etc.). Clearing evacuation, staging, utility, and environmentally-sensitive areas was the next priority. Residential properties were part of that second priority and so the teams moved quickly. The steps to cleanup, under environmental health supervision, were conveyed as follows:

- household hazardous waste removal such as lead acid batteries from solar systems, materials from "shade tree" mechanics, pesticides, and others household chemicals;

- asbestos inspection and removal;
- site documentation;
- ash and debris removal;
- hazardous tree removal; and
- erosion control.

The cleanup, plus a myriad of administrative services, proceeded in earnest throughout 2015 and into 2016. By the time Knight showed up in my office with the USB hard drive, the physical work had been completed and the agencies involved were now working to close out billing and reimbursement.

In studying this event, we see two capacity building activities of note. The first capacity building activity—common to natural and man-made disasters, but somewhat uncommon in an environmental health mode—was the mutual aid secured through existing, well-maintained networks of environmental health professionals. The declaration of a local health emergency and the state's ready response made these agreements possible.

The second capacity building activity—perhaps more reflective of modern technology—was the consolidation and curation of digital results concerning the event and the services that took place. Calaveras County is now interweaving its own source data with the results to be reintegrated into the county's GIS parcels.

I would advocate making the repository of information from this event, with the exception of sensitive or private information, available for public search. Tools exist for private or public sectors through Google and other search engines to track, collate, and index this information into data for review and improvement planning. More importantly, this wealth of data can be used to create toolkits for future natural disasters.

*Corresponding Author:* Darryl Booth, Senior Vice President and General Manager of Environmental Health, Accela, 2633 Camino Ramon #500, San Ramon, CA 94583.
E-mail: dbooth@accela.com.

## Did You Know?

The NEHA 2017 AEC will be held in Grand Rapids, Michigan. Grand Rapids was ranked 20th on a list of 52 places to go worldwide in 2016 by *The New York Times*. Join us there on July 10–13, 2017! 2017 AEC information can be found at www.neha.org/aec.

## 2017 Joe Beck Educational Contribution Award

This award was established to recognize NEHA members, teams, or organizations for an outstanding educational contribution within the field of environmental health.

Named in honor of the late Professor Joe Beck, this award provides a pathway for the sharing of creative methods and tools to educate one another and the public about environmental health principles and practices. Don't miss this opportunity to submit a nomination to highlight the great work of your colleagues!

**Nomination deadline is March 15, 2017.**

**To access the online application, visit www.neha.org/joe-beck-educational-contribution-award.**

NATIONAL ENVIRONMENTAL HEALTH ASSOCIATION

AEHAP
ASSOCIATION OF ENVIRONMENTAL HEALTH ACADEMIC PROGRAMS

announces

# THE 2017 AEHAP STUDENT RESEARCH COMPETITION

for undergraduate and graduate students enrolled in a National Environmental Health Science and Protection Accreditation Council (EHAC)-accredited program or an environmental health program that is an institutional member of AEHAP.

## Win a $1,000 Award

### and up to $1,000 in travel expenses

Students will be selected to present a 20-minute platform presentation and poster at the National Environmental Health Association's Annual Educational Conference & Exhibition in Grand Rapids, MI, July 10–13, 2017.

**Entries must be submitted by Tuesday, February 28, 2017,** to
Leslie Mitchell
AEHAP Coordinator
E-mail: info@aehap.org
Phone: 206-522-5272

For additional information and research submission guidelines, please visit www.aehap.org.

AEHAP gratefully acknowledges the volunteer efforts of AEHAP members who serve on the advisory committee for this competition.

# Opportunity for Students

## From EHAC-Accredited Environmental Health Degree Programs to Win a $3,500 PAID INTERNSHIP

The Association of Environmental Health Academic Programs (AEHAP), in partnership with NSF International, is offering a paid internship project to students from National Environmental Health Science and Protection Accreditation Council (EHAC)-accredited programs. The NSF International Scholarship Program is a great opportunity for an undergraduate student to gain valuable experience in the environmental health field. The NSF Scholar will be selected by AEHAP and will spend 8–10 weeks (March–May 2017) working on a research project identified by NSF International.

**Project Description**
The applicant shall work with a professor from their degree program who will serve as a mentor/supervisor and agree to providing a host location from which to do the research. Research will focus on identifying how federal, state, and local jurisdictions regard or reference NSF standards and products in administrative codes or regulations. Candidate topics include drinking water, waste water, plumbing, food safety, or recreational water.

**Application deadline: January 15, 2017**

For more details and information on how to apply please go to www.aehap.org/nsf-paid-summer-internship-opportunity-for-students

For more information, contact info@aehap.org or call 206-522-5272.

NSF

AEHAP
ASSOCIATION OF ENVIRONMENTAL HEALTH ACADEMIC PROGRAMS

**DIRECT FROM ATSDR**


# Integrating a Biorepository Into the National Amyotrophic Lateral Sclerosis Registry

D. Kevin Horton, MSPH, DrPH
*Agency for Toxic Substances and Disease Registry*

Wendy Kaye, PhD
Laurie Wagner, MPH [no photo]
*McKing Consulting Corporation*

**Editor's Note: As part of our continuing effort to highlight innovative approaches to improving the health and environment of communities, the *Journal* is pleased to publish a bimonthly column from the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is a federal public health agency of the U.S. Department of Health and Human Services (HHS) and shares a common office of the Director with the National Center for Environmental Health (NCEH) at the Centers for Disease Control and Prevention (CDC). ATSDR serves the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances.**

**The purpose of this column is to inform readers of ATSDR's activities and initiatives to better understand the relationship between exposure to hazardous substances in the environment and their impact on human health and how to protect public health. We believe that the column will provide a valuable resource to our readership by helping to make known the considerable resources and expertise that ATSDR has available to assist communities, states, and others to assure good environmental health practice for all is served.**

**The conclusions of this column are those of the author(s) and do not necessarily represent the views of ATSDR, CDC, or HHS.**

**Kevin Horton is chief of the Environmental Health Surveillance Branch within the Division of Toxicology and Human Health Sciences at ATSDR. Wendy Kaye is a senior epidemiologist at McKing Consulting Corporation. Laurie Wagner is a research associate at McKing Consulting Corporation.**

## Introduction

Amyotrophic lateral sclerosis (ALS), also known as Lou Gehrig's disease, is a progressive, fatal neurodegenerative disorder that causes the loss of motor neurons, typically resulting in paralysis, respiratory failure, and death within 3–5 years of symptom onset (Mitsumoto, Chad, & Pioro, 1998). Despite ALS being initially identified in 1869, the actual pathogenesis and cause remain unknown and there is currently no cure. An estimated 5%–10% of cases are attributed to heredity, while the remaining 90%–95% are of unknown etiology (Andersen, 2006). For these latter sporadic cases, many potential risk factors have been explored such as smoking and alcohol consumption; exposures to heavy metals, pesticides, and volatile organic compounds; head trauma; and occupational exposures (Oskarsson, Horton, & Mitsumoto, 2015). The most consistently known risk factors for sporadic cases are being male, Caucasian, and older in age (Chiò et al., 2013; Hirtz et al., 2007; Mehta et al., 2016).

New advances in science, particularly in the area of high-dimensional biology (e.g., genomics, proteomics, metabolomics, transcriptomics), are leading to an improved understanding of diseases like ALS on a molecular level (Horgan & Kenny, 2011). To keep up with "omic" technologies, there is a critical need for high-quality biospecimens for analysis (e.g., blood, serum, tissue). Biospecimens are a vital resource for studying biochemical and genetic differences among diseased and nondiseased individuals (Vaught et al., 2011). Moreover, biospecimens are useful for current and future etiological research studies and for the potential development of new diagnostic markers and therapeutic targets. Biospecimen analysis has already proven useful in the discovery of important genes related to ALS and other motor neuron diseases (Renton, Chiò, & Traynor, 2014).

Because ALS is considered a rare disease, with an estimated U.S. prevalence rate of 5.0 cases per 100,000 population (Mehta et al., 2016) and an incidence rate of 1.5 per 100,000 person-years (Wagner et al., 2015), obtaining biospecimens on an ongoing basis can be challenging for researchers. While there are some local and regional biorepositories (i.e., facilities that collect and store

FIGURE **1**

**Map of In-Home Participants**

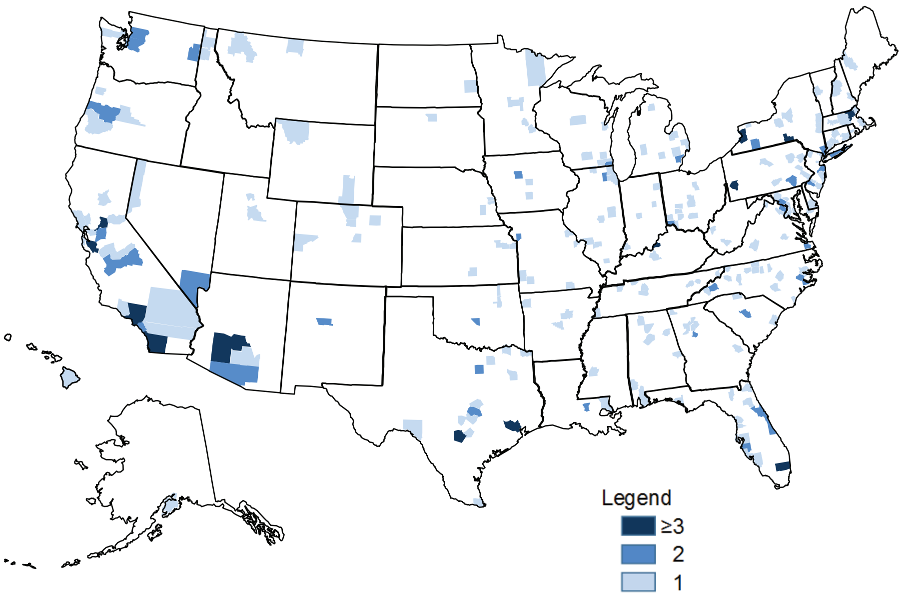



TABLE **1**

**Number of Specimen Types Collected**

| Specimen Type | # of 1st Collection Participants (*N* = 330) | # of 2nd Collection Participants (*N* = 266) |
|---|---|---|
| Whole blood (plasma, buffy coat, RBC) | 309 | 255 |
| Whole blood (metals free) | 308 | 248 |
| Plain blood (serum) | 302 | 246 |
| PAXgene1 (RNA) | 303 | 248 |
| PAXgene2 (RNA) | 303 | 247 |
| Urine | 321 | 256 |
| Hair | 310 | 264 |
| Nails | 326 | 271 |
| Saliva | 15 | 0 |

RBC = red blood cells.

samples of biological material) that include biospecimens from persons with ALS, these biorepositories tend to be limited by specimen type and availability, sample size, geographical coverage, and demographic characteristics. To help address this scientific gap, the Agency for Toxic Substances and Disease Registry (ATSDR) recently conducted a 4-year pilot study to test the practicality, utility, and feasibility of creating a national biorepository of pre and postmortem biospecimens from persons with ALS enrolled in ATSDR's congressionally-mandated National ALS Registry. Briefly, the purpose of the National ALS Registry (Registry) is to quantify the incidence and prevalence of ALS in the U.S., describe the demographics of persons with ALS, and examine risk factors for the disease (Antao & Horton, 2012; Horton, Mehta, & Antao, 2014; Mehta et al., 2016).

## Biorepository Pilot Study

During 2011–2015, ATSDR conducted a study to pilot methods for collecting and banking biospecimens from participants in ATSDR's Registry. Throughout this pilot study, ATSDR held a series of expert panel meetings to solicit guidance and recommendations on topics such as sample types, storage, and biospecimen governance. The expert panel included prominent neurologists, laboratorians, researchers, and bioethicists from around the country. Once the pilot study protocol was developed and approved by ATSDR and the institutional review board, consent, recruitment, and specimen collection began in 2013 on a nationally representative sample of patients enrolled in the Registry. The pilot study included two specimen collection components: biological specimens from living participants (in-home) and postmortem specimens. The in-home collection aimed to enroll approximately 300 participants, from whom specimens would be collected on two occasions by trained phlebotomists, approximately six months apart. In-home samples collected included blood, urine, hair, and nails (saliva was collected from those who could not provide a blood sample). The postmortem component aimed to enroll 30 participants, who could have also participated in the in-home study. Postmortem collection included brain, spinal cord, cerebrospinal fluid, muscle, bone, and skin specimens for the creation of cell lines.

There were 330 in-home participants (~61% male), from all 50 states, who completed the first specimen collection (Figure 1). Of these, 309 (93.6%) provided at least one blood specimen. Most participants (80.6%) were able to provide specimens at both collection appointments (Table 1). The reasons for not completing the second draw included death (*n* = 36), too ill or unable to contact (*n* = 9), and no longer interested or scheduling difficulties (*n* = 13). DNA and RNA were extracted from blood and other blood specimens were processed into aliquots of plasma, serum, and whole blood. There were 30 postmortem participants with equal numbers of males and females. Eighteen postmortem participants have donated tissues as of May 31, 2016. The length of time in the study for these participants from date of consent to date of death ranged from 1–24 months. The age at death for the deceased participants ranged from 43–76 years of age.

Creating a geographically diverse biorepository for this pilot study had unique challenges. Recruitment was slower than expected, finding reliable phlebotomists across the country was difficult, and there were unexpected issues related to shipping specimens, including higher than average temperatures and mechanical failure. In addition, after the first specimens were collected, there was a larger than expected number of individuals who could not participate in the second specimen collection (i.e., were too sick or deceased), thereby decreasing the number of paired specimens. ATSDR was able, however, to recruit the target sample size and process the various specimen types.

The pilot study, which concluded in September 2015, demonstrated that a nationwide collection of pre and postmortem biospecimens from Registry enrollees is feasible, warranted, and can be done in a cost-effective manner. Based on these finding, the expert panel recommended that ATSDR establish a permanent biorepository as part of the Registry (McKing Consulting Corporation, 2015). In the meantime, biospecimens collected through the pilot study are available for researchers to use by contacting the Registry (alsbiorepository@secure.mcking.com).

## The National ALS Biorepository

ATSDR is currently moving forward with integrating the National ALS Biorepository (Biorepository) into the Registry. Once the appropriate governmental approvals have been obtained, ATSDR anticipates launching the Biorepository in fall 2016. Although much of the pilot study's standard operating procedures will be used in the Biorepository, changes based upon lessons learned and recommendations from the expert panel will be implemented, such as increasing/decreasing biospecimen collection type based upon researcher demand, modifying collection frequency, and marketing the Biorepository to ensure maximum use. Once the Biorepository is launched, researchers will be able to complete an online application through the Registry Web site to request samples.

By design, the Biorepository is significantly different from other biorepositories in that it links risk factor data (e.g., occupational, military, and smoking history) with biospecimens, is nationally representative, and uses phlebotomists for in-home collection.

## Conclusions

The Registry is the largest cohort of ALS patients in the U.S. Therefore, the Registry is the ideal group in which to collect biologic specimens on a large geographically representative group of persons with ALS. Furthermore, combining biospecimens with risk factor data currently being collected through the Registry is a unique and invaluable resource to help researchers in the U.S. and abroad better understand the etiology of ALS. More information on the Registry and Biorepository can be found at www.cdc.gov/als.

*Acknowledgement:* The authors thank the many people living with ALS across the U.S. for their generosity in contributing valuable epidemiological data and biospecimens to the Registry.

*Corresponding Author:* D. Kevin Horton, Chief, Environmental Health Surveillance Branch, Division of Toxicology and Human Health Sciences, Agency for Toxic Substances and Disease Registry, 4770 Buford Highway NE, MS F-57, Atlanta, GA 30341-3717.
E-mail: dhorton@cdc.gov.

## References

Andersen, P.M. (2006). Amyotrophic lateral sclerosis associated with mutations in the CnZn superoxide dismutase gene. *Current Neurology and Neuroscience Reports*, *6*(1), 37–46.

Antao, V.C., & Horton, D.K. (2012). The National Amyotrophic Lateral Sclerosis (ALS) Registry. *Journal of Environmental Health*, *75*(1), 28–30.

Chiò, A., Logroscino, G., Traynor, B.J., Simeone, J.C., Goldstein, L.A., & White, L.A. (2013). Global epidemiology of amyotrophic lateral sclerosis: A systematic review of the published literature. *Neuroepidemiology*, *41*(2), 118–130.

Hirtz, D., Thurman, D.J., Gwinn-Hardy, K., Mohamed, M., Chaudhuri, A.R., & Zalutsky, R. (2007). How common are the "common" neurologic disorders? *Neurology*, *68*(5), 326–337.

Horgan, R.P., & Kenny, L.C. (2011). 'Omic' technologies: Genomics, transcriptomics, proteomics and metabolomics. *The Obstetrician & Gynaecologist*, *13*(3), 189–195.

Horton, K., Mehta, P., & Antao, V.C. (2014). Quantifying a nonnotifiable disease in the United States: The National Amyotrophic Lateral Sclerosis Registry model. *The Journal of the American Medical Association*, *312*(11), 1097–1098.

McKing Consulting Corporation. (2015). *National ALS Biorepository pilot study: Summary report*. Atlanta, GA: Author. Retrieved from https://wwwn.cdc.gov/als/Download/ALS%20Biorepository%20Pilot%20Study%20Summary%20Report.pdf

Mehta, P., Kaye, W., Bryan, L., Larson, T., Copeland, T., Wu, J., . . . Horton, D.K. (2016). Prevalence of amyotrophic lateral sclerosis—United States, 2012–2013. *Morbidity and Mortality Weekly Report*, *65*(8), 1–12. Retrieved from http://www.cdc.gov/mmwr/volumes/65/ss/ss6508a1.htm

Mitsumoto, H., Chad, D.A., & Pioro, E.P. (Eds.). (1998). *Differential diagnoses in amyotrophic lateral sclerosis*. Philadelphia, PA: F.A. Davis Company.

Oskarsson, B., Horton, D.K., & Mitsumoto, H. (2015). Potential environmental factors in amyotrophic lateral sclerosis. *Neurologic Clinics*, *33*(4), 877–888.

Renton, A.E., Chiò, A., & Traynor, B.J. (2014). State of play in amyotrophic lateral sclerosis genetics. *Nature Neuroscience*, *17*(1), 17–23.

Vaught, J., Rogers, J., Myers, K., Lim, M.D., Lockhart, N., Moore, H., . . . Compton, C. (2011). An NCI perspective on creating sustainable biospecimen resources. *Journal of the National Cancer Institute. Monographs*, *42*, 1–7.

Wagner, L., Rechtman, L., Jordan, H., Ritsick, M., Sanchez, M., Sorenson, E., & Kaye, W. (2015). State and metropolitan area-based amyotrophic lateral sclerosis (ALS) surveillance. *Amyotrophic Lateral Sclerosis Frontotemporal Degeneration*, *17*(1–2), 128–134.

# U.S. Postal Service Statement of Ownership

UNITED STATES POSTAL SERVICE®

**Statement of Ownership, Management, and Circulation (All Periodicals Publications Except Requester Publications)**

1. Publication Title: Journal of Environmental Health
2. Publication Number: 2 7 9 - 9 0 0
3. Filing Date: 9/26/2016
4. Issue Frequency: Once per month except for two bimonthly issues (January/February and July/August)
5. Number of Issues Published Annually: 10 issues
6. Annual Subscription Price: $135.00
7. Complete Mailing Address of Known Office of Publication *(Not printer) (Street, city, county, state, and ZIP+4®)*: 720 S. Colorado Blvd., Ste. 1000-N, Denver, CO 80246-1926
   Contact Person: Kristen Ruby-Cisneros
   Telephone *(Include area code)*: 303.756.9090, ext. 341
8. Complete Mailing Address of Headquarters or General Business Office of Publisher *(Not printer)*: National Environmental Health Association, 720 S. Colorado Blvd., Ste. 1000-N, Denver, CO 80246-1926
9. Full Names and Complete Mailing Addresses of Publisher, Editor, and Managing Editor *(Do not leave blank)*
   Publisher *(Name and complete mailing address)*: National Environmental Health Association, 720 S. Colorado Blvd., Ste. 1000-N, Denver, CO 80246-1926
   Editor *(Name and complete mailing address)*: Kristen Ruby-Cisneros, National Environmental Health Association, 720 S. Colorado Blvd., Ste. 1000-N, Denver, CO 80246-1926
   Managing Editor *(Name and complete mailing address)*: Kristen Ruby-Cisneros, National Environmental Health Association, 720 S. Colorado Blvd., Ste. 1000-N, Denver, CO 80246-1926
10. Owner *(Do not leave blank. If the publication is owned by a corporation, give the name and address of the corporation immediately followed by the names and addresses of all stockholders owning or holding 1 percent or more of the total amount of stock. If not owned by a corporation, give the names and addresses of the individual owners. If owned by a partnership or other unincorporated firm, give its name and address as well as those of each individual owner. If the publication is published by a nonprofit organization, give its name and address.)*

| **Full Name** | **Complete Mailing Address** |
|---|---|
| National Environmental Health Association | 720 S. Colorado Blvd., Ste. 1000-N, Denver, CO 80246-1926 |

11. Known Bondholders, Mortgagees, and Other Security Holders Owning or Holding 1 Percent or More of Total Amount of Bonds, Mortgages, or Other Securities. If none, check box → ☑ None

| **Full Name** | **Complete Mailing Address** |
|---|---|
| | |

12. Tax Status *(For completion by nonprofit organizations authorized to mail at nonprofit rates) (Check one)*
    The purpose, function, and nonprofit status of this organization and the exempt status for federal income tax purposes:
    ☑ Has Not Changed During Preceding 12 Months
    ☐ Has Changed During Preceding 12 Months *(Publisher must submit explanation of change with this statement)*

PS Form **3526,** July 2014 *[Page 1 of 4 (see instructions page 4)]* PSN: 7530-01-000-9931 **PRIVACY NOTICE:** See our privacy policy on *www.usps.com.*

13. Publication Title: Journal of Environmental Health
14. Issue Date for Circulation Data Below: September 2016

| 15. **Extent and Nature of Circulation** | **Average No. Copies Each Issue During Preceding 12 Months** | **No. Copies of Single Issue Published Nearest to Filing Date** |
|---|---|---|
| a. Total Number of Copies *(Net press run)* | 1803 | 1775 |
| b. Paid Circulation *(By Mail and Outside the Mail)* (1) Mailed Outside-County Paid Subscriptions Stated on PS Form 3541 (Include paid distribution above nominal rate, advertiser's proof copies, and exchange copies) | 1515 | 1490 |
| (2) Mailed In-County Paid Subscriptions Stated on PS Form 3541 *(Include paid distribution above nominal rate, advertiser's proof copies, and exchange copies)* | 0 | 0 |
| (3) Paid Distribution Outside the Mails Including Sales Through Dealers and Carriers, Street Vendors, Counter Sales, and Other Paid Distribution Outside USPS® | 0 | 0 |
| (4) Paid Distribution by Other Classes of Mail Through the USPS (e.g., First-Class Mail®) | 0 | 0 |
| c. Total Paid Distribution *[Sum of 15b (1), (2), (3), and (4)]* | 1515 | 1490 |
| d. Free or Nominal Rate Distribution *(By Mail and Outside the Mail)* (1) Free or Nominal Rate Outside-County Copies included on PS Form 3541 | 0 | 0 |
| (2) Free or Nominal Rate In-County Copies Included on PS Form 3541 | 0 | 0 |
| (3) Free or Nominal Rate Copies Mailed at Other Classes Through the USPS (e.g., First-Class Mail) | 0 | 0 |
| (4) Free or Nominal Rate Distribution Outside the Mail *(Carriers or other means)* | 0 | 0 |
| e. Total Free or Nominal Rate Distribution *(Sum of 15d (1), (2), (3) and (4))* | 0 | 0 |
| f. Total Distribution *(Sum of 15c and 15e)* | 1515 | 1490 |
| g. Copies not Distributed *(See Instructions to Publishers #4 (page #3))* | 288 | 285 |
| h. Total *(Sum of 15f and g)* | 1803 | 1775 |
| i. Percent Paid *(15c divided by 15f times 100)* | 100% | 100% |

* If you are claiming electronic copies, go to line 16 on page 3. If you are not claiming electronic copies, skip to line 17 on page 3.

PS Form **3526,** July 2014 *(Page 2 of 4)*

UNITED STATES POSTAL SERVICE®

**Statement of Ownership, Management, and Circulation (All Periodicals Publications Except Requester Publications)**

| 16. Electronic Copy Circulation | **Average No. Copies Each Issue During Preceding 12 Months** | **No. Copies of Single Issue Published Nearest to Filing Date** |
|---|---|---|
| a. Paid Electronic Copies | 4474 | 4670 |
| b. Total Paid Print Copies (Line 15c) + Paid Electronic Copies (Line 16a) | 5989 | 6160 |
| c. Total Print Distribution (Line 15f) + Paid Electronic Copies (Line 16a) | 5989 | 6160 |
| d. Percent Paid (Both Print & Electronic Copies) (16b divided by 16c × 100) | 100% | 100% |

☐ **I certify that 50% of all my distributed copies (electronic and print) are paid above a nominal price.**

17. Publication of Statement of Ownership
    ☑ If the publication is a general publication, publication of this statement is required. Will be printed in the November 2016 issue of this publication.
    ☐ Publication not required.

18. Signature and Title of Editor, Publisher, Business Manager, or Owner: Kristen Ruby-Cisneros, Managing Editor — Date: 9/26/2016

I certify that all information furnished on this form is true and complete. I understand that anyone who furnishes false or misleading information on this form or who omits material or information requested on the form may be subject to criminal sanctions (including fines and imprisonment) and/or civil sanctions (including civil penalties).

PS Form **3526,** July 2014 *(Page 3 of 4)* **PRIVACY NOTICE:** See our privacy policy on *www.usps.com.*

**DIRECT FROM CDC** ENVIRONMENTAL HEALTH SERVICES BRANCH

Elaine Curtiss

# Environmental Health Resources by Essential Services

**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.**

**Elaine Curtiss is a contract public health analyst working on communications projects within EHSB.**

The Centers for Disease Control and Prevention (CDC) provides tools and guidance, training, and research for practitioners and programs delivering environmental health services in states, tribes, localities, and territories. In this column we outline some of our resources organized by the 10 Essential Environmental Public Health Services. These services identify the actions necessary to protect and improve environmental public health and are adapted from the 10 Essential Public Health Services (Figure 1). These tools can help your program fill performance gaps and contribute to larger performance improvement efforts such as voluntary public health department accreditation.

1. **Monitor environmental and health status to identify and solve community environmental public health problems.**
   - National Environmental Assessment Reporting System: Captures environmental assessment data from foodborne illness outbreaks to help prevent outbreaks associated with restaurants and other food venues. Is your jurisdiction registered?
   - Protocol for Assessing Community Excellence in Environmental Health: Helps programs work with communities to identify and address local environmental health issues.
2. **Diagnose and investigate environmental public health problems and health hazards in the community.**
   - *Integrated Pest Management: Conducting Urban Rodent Surveys:* Updates CDC's *Urban Rodent Surveys Manual*, including information about integrated pest management.
   - Network for Aquatic Facility Inspection Surveillance: Receives aquatic facility inspection data collected by environmental health practitioners when assessing the operation and maintenance of public aquatic facilities.
3. **Inform, educate, and empower people about environmental public health issues.**
   - Drinking Water Advisory Communication Toolbox: Provides resources to help communities with all phases of water advisories including guidance, recommendations, instructions, templates, and other tools.
   - Environmental Health Specialists Network (EHS-Net) Plain Language Study Findings: Outlines food safety study findings and recommendations from our research program to identify environmental causes of outbreaks in the restaurant setting.
4. **Mobilize community partnerships and actions to identify and solve environmental health problems.**
   - *Emergency Water Supply Planning Guide for Hospitals and Healthcare Facilities:* Summarizes how to develop a plan to prepare for, respond to, and recover from interruptions in the normal water supply at healthcare facilities.
   - Environmental Public Health Performance Standards (EnvPHPS) Assessment Toolkit: Assists with preparing for, conducting, and acting upon your EnvPHPS assessment with tools such as a facilitator guide, response analysis tool, report templates, and more.
5. **Develop policies and plans that support individual and community environmental public health efforts.**
   - *When Every Drop Counts: Protecting Public Health During Drought Conditions—A Guide for Public Health Professionals*: Explains how public health professionals can prepare for drought in their community.
   - *Guidance on Microbial Contamination in Previously Flooded Outdoor Areas*:

FIGURE **1**

**Ten Services Adapted From the 10 Essential Public Health Services That Identify Actions Necessary to Protect and Improve Environmental Public Health**


**These and other resources are available at www.cdc.gov/nceh/ehs/10-essential-services/resources.html.**

Assists with assessing the public health risks for using areas after a flood with potential exposure to microbial contamination.

6. **Enforce laws and regulations that protect environmental public health and ensure safety.**
   *Note: CDC's Environmental Health Services Branch (EHSB) is not a regulatory agency. The following EHSB resources may be useful for agencies responsible for enforcing laws and regulations.*
   - Model Aquatic Health Code: Provides free, science-based guidelines to help reduce risk for waterborne illness outbreaks, drowning, and chemical poisoning at public pools and other aquatic venues.
   - Food Safety Prevention Status Report: Reports on state adoption of selected foodborne disease related provisions from the 2013 Food and Drug Administration *Food Code* with a new food safety indicator.
7. **Link people to needed environmental public health services and assure the provision of environmental public health services when otherwise unavailable.**
   - Safe Water for Community Health: Recommends ways to strengthen the performance of your drinking water program to address problems with wells and other private drinking water sources in your community.
8. **Assure a competent environmental public health workforce.**
   - e-Learning on Environmental Assessment of Foodborne Illness Outbreaks: Teaches users to conduct environmental assessments as part of outbreak investigations and allows them to practice new skills in an interactive, virtual learning environment.
   - Environmental Public Health Online Courses: Offers a collection of 15 e-learning courses on a variety of environmental health topics.
   - Environmental Health Training in Emergency Response: Helps prepare environmental health practitioners and other emergency response personnel by providing them with the necessary knowledge, skills, and resources to address the environmental health impacts of emergencies and disasters.
9. **Evaluate effectiveness, accessibility, and quality of personal and population-based environmental public health services.**
   - EnvPHPS: Provides standards to improve delivery of the 10 Essential Environmental Public Health Services in your community.
   - *Improving Environmental Public Health Services Performance to Meet Community Needs*: Explores approaches for improving and aligning programs with broader public health department initiatives.
10. **Research for new insights and innovative solutions to environmental public health problems.**
    - EHS-Net: Conducts research to identify environmental causes of outbreaks in the restaurant setting.

CDC's EHSB hopes you find these tools informative and helpful in delivering quality services to your community. To find out more about these and other resources, please visit www.cdc.gov/nceh/ehs.

*Corresponding Author:* Elaine Curtiss, Public Health Analyst, Carter Consulting, Inc., National Center for Environmental Health, 4770 Buford Highway NE, MS F-58, Atlanta, GA 30341. E-mail: ECurtiss@cdc.gov.

# CAREER OPPORTUNITIES

### Food Safety Inspector

UL Everclean is a leader in retail inspections. We offer opportunities across the country. We currently have openings for trained professionals to conduct audits in restaurants and grocery stores. Past or current food safety inspection experience is required.

**United States**
Albany, NY
Alexandria, LA
Atlanta, GA
Bakersfield, CA
Baton Rouge, LA
Billings, MT
Bismarck, ND
Boise, ID
Boston, MA
Buffalo, NY
Butte, MT
Charlotte, NC
Des Moines, IA
Grand Junction, CO
Green Bay, WI
Guam
Honolulu, HI
Iowa
Jacksonville, FL
Kalamazoo, MI
Kansas City, MO/KS
Little Rock, AR
Milwaukee, WI
Minneapolis, MN
Owatonna, MN
Pensacola, FL
Philadelphia, PA
Phoenix, AZ
Pocatello, ID
Raleigh, NC
Rapid City, SD
Rochester, NY
San Antonio, TX
San Diego, CA
San Francisco, CA
Shreveport, LA
Sioux City, IA
Sioux Falls, SD
Spearfish, SD
Springfield, MO
St. Louis, MO
St. Paul, MN
Syracuse, NY
Tulsa, OK
Wichita, KS
Yuma, AZ

**Canada**
British Columbia
Toronto

If you are interested in an opportunity near you, please send your resume to: ATTN Bill Flynn at LST.RAS.RESUMES@UL.COM or visit our Web site at www.evercleanservices.com.

# EH CALENDAR

## UPCOMING NEHA CONFERENCE

**July 10–13, 2017: NEHA 2017 Annual Educational Conference & Exhibition**, Grand Rapids, MI. For more information, visit www.neha.org/aec.

## NEHA AFFILIATE AND REGIONAL LISTINGS

**California**
**April 10–13, 2017: 66th Annual Education Symposium**, hosted by the California Environmental Health Association, Garden Grove, CA. For more information, visit www.ceha.org.

**Illinois**
**December 7–8, 2016: Annual Education Conference**, hosted by the South Chapter of the Illinois Environmental Health Association, Belleville, IL. For more information, visit http://iehaonline.org.

**Kentucky**
**February 15–17, 2017: Annual Conference**, hosted by the Kentucky Environmental Health Association, Lexington, KY. For more information, visit www.kyeha.org.

# 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!*

NEHA BOOKSTORE
www.neha.org/store

## Certified Professional-Food Safety Manual (Third Edition)

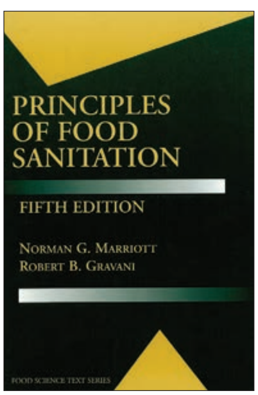
*National Environmental Health Association (2014)*


The Certified Professional-Food Safety (CP-FS) credential is well respected throughout the environmental health and food safety field. This manual has been developed by experts from across the various food safety disciplines to help candidates prepare for NEHA's CP-FS exam. This book contains science-based, in depth information about causes and prevention of foodborne illness, HACCP plans and active managerial control, cleaning and sanitizing, conducting facility plan reviews, pest control, risk-based inspections, sampling food for laboratory analysis, food defense, responding to food emergencies and foodborne illness outbreaks, and legal aspects of food safety.

*358 pages / Spiral-bound paperback*
*Member: $179 / Nonmember: $209*

## Principles of Food Sanitation (Fifth Edition)

*Norman G. Marriott and Robert B. Gravani (2006)*

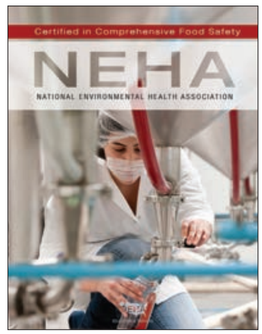



This book provides sanitation information needed to ensure hygienic practices and safe food for food industry and regulatory professionals. It addresses the principles related to contamination, cleaning compounds, sanitizing, and cleaning equipment. It also presents specific directions for applying these concepts to attain hygienic conditions in food processing or preparation operations. The book includes chapters that address biosecurity and allergens as they relate to food sanitation, as well as updated chapters on the fundamentals of food sanitation, contamination sources and hygiene, HACCP, cleaning and sanitizing equipment, and waste handling disposal. Study reference for NEHA's REHS/RS and CP-FS exams.

*413 pages / Hardback*
*Member: $84 / Nonmember: $89*

## Certified in Comprehensive Food Safety Manual

*National Environmental Health Association (2014)*

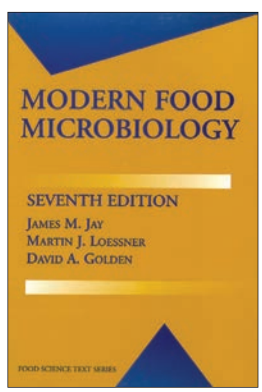



The Food Safety Modernization Act has recast the food safety landscape, including the role of the food safety professional. To position this field for the future, NEHA is proud to announce its newest credential—Certified in Comprehensive Food Safety (CCFS). The CCFS is a midlevel credential for food safety professionals that demonstrates expertise in how to ensure food is safe for consumers throughout the manufacturing and processing environment. It can be utilized by anyone wanting to continue a growth path in the food safety sector, whether in a regulatory/oversight role or in a food safety management or compliance position within the private sector. The *CCFS Manual* has been carefully developed to help prepare candidates for the CCFS exam and deals with the information required to perform effectively as a CCFS.

*356 pages / Spiral-bound paperback*
*Member: $179 / Nonmember: $209*

## Modern Food Microbiology (Seventh Edition)

*James M. Jay, Martin J. Loessner, and David A. Golden (2005)*




This text explores the fundamental elements affecting the presence, activity, and control of microorganisms in food. It includes an overview of microorganisms in food and what allows them to grow; specific microorganisms in fresh, fermented, and processed meats, poultry, seafood, dairy products, fruits, vegetables, and other products; methods for finding and measuring microorganisms and their products in foods; methods for preserving foods; food safety and quality controls; and foodborne diseases. Other section topics include biosensors, biocontrol, bottled water, *Enterobacter sakazakii*, food sanitizers, milk, probiotics, proteobacteria, quorum sensing, and sigma factors. Study reference for NEHA's CP-FS exam.

*790 pages / Hardback*
*Member: $84 / Nonmember: $89*

# SUPPORT THE NEHA ENDOWMENT FOUNDATION

The NEHA Endowment Foundation was established to enable NEHA to do more for the environmental health profession than its annual budget might allow. Special projects and programs supported by the foundation will be carried out for the sole purpose of advancing the profession and its practitioners.

Individuals who have contributed to the foundation are listed below by club category. These listings are based on what people have actually donated to the foundation—not what they have pledged. Names will be published under the appropriate category for one year; additional contributions will move individuals to a different category in the following year(s). For each of the categories, there are a number of ways NEHA recognizes and thanks contributors to the foundation. If you are interested in contributing to the Endowment Foundation, please call NEHA at 303.756.9090. You can also donate online at www.neha.org/donate.

*Thank you.*

## DELEGATE CLUB ($25–$99)

*Name in the Journal for one year and endowment pin.*

**Richard W. Mitzelfelt**
Edgewood, NM

## HONORARY MEMBERS CLUB

($100–$499)
*Letter from the NEHA president, name in the Journal for one year, and endowment pin.*

**Tim Hatch, MPA, REHS**
Montgomery, AL

**Adam E. London, RS, MPA**
Grand Rapids, MI

**Ned Therien, MPH**
Olympia, WA

## 21st CENTURY CLUB ($500–$999)

*Name submitted in drawing for a free one-year NEHA membership, name in the Journal for one year, and endowment pin.*

**Bob Custard, REHS, CP-FS**
Lovettsville, VA

**David T. Dyjack, DrPH, CIH**
Denver, CO

**Bette J. Packer**
Ham Lake, MN

**Peter M. Schmitt**
Shakopee, MN

**LCDR James Speckhart, MS**
Silver Spring, MD

## SUSTAINING MEMBERS CLUB

($1,000–$2,499)
*Name submitted in drawing for a free two-year NEHA membership, name in the Journal for one year, and endowment pin.*

**James J. Balsamo, Jr., MS, MPH, MHA, RS, CP-FS**
Metairie, LA

**Gavin F. Burdge**
Lemoyne, PA

**George A. Morris, RS**
Dousman, WI

## AFFILIATES CLUB

($2,500–$4,999)
*Name submitted in drawing for a free AEC registration, name in the Journal for one year, and endowment pin.*

**Vince Radke, MPH, REHS, CP-FS, DAAS, CPH**
Atlanta, GA

## EXECUTIVE CLUB AND ABOVE

($5,000–$100,000)
*Special invitation to the AEC President's Reception, name in the Journal for one year, and endowment pin.*

## NEHA ENDOWMENT FOUNDATION PLEDGE CARD

**I pledge to be a NEHA Endowment Foundation Contributor in the following category:**

❍ Delegate Club ($25)
❍ Honorary Members Club ($100)
❍ 21st Century Club ($500)
❍ Sustaining Members Club ($1,000)
❍ Affiliates Club ($2,500)
❍ Executive Club ($5,000)
❍ President's Club ($10,000)
❍ Endowment Trustee Society ($25,000)
❍ Visionary Society ($50,000)
❍ Futurists Society ($100,000)
❍ **You have my permission to disclose the fact and amount (by category) of my contribution and pledge.**

I plan to make annual contributions to attain the club level of ________________________________ over the next _________ years.

Signature ______________________ Print Name ______________________

Organization ______________________ Phone ______________________

Street Address ______________________ City ____________ State ________ Zip ________

❍ Enclosed is my check in the amount of $____________ payable to **NEHA Endowment Foundation**.

❍ Please bill my: MasterCard/Visa/American Express #____________________________________________ Exp. Date ______________ CVV ____________

Signature ______________________

**MAIL TO: NEHA, 720 S. Colorado Blvd., Suite 1000-N, Denver, CO 80246, or FAX to: 303.691.9490.**

1611JEHEND

# SPECIAL NEHA MEMBERS

## Sustaining Members

**Advanced Fresh Concepts Corp.**
www.afcsushi.com

**Albuquerque Environmental Health Department**
www.cabq.gov/environmentalhealth

**Allegheny County Health Department**
www.achd.net

**American Chemistry Council**
www.americanchemistry.com

**Anua**
www.anuainternational.com

**Arlington County Public Health Division**
www.arlingtonva.us

**Ashland-Boyd County Health**
www.abchdkentucky.com

**Association of Environmental Health Academic Programs**
www.aehap.org

**Black Hawk County Health Department**
www.co.black-hawk.ia.us/258/Health-Department

**Cabell-Huntington Health Department**
www.cabellhealth.org

**Chemstar Corporation**
www.chemstarcorp.com

**City of Bloomington**
www.bloomingtonmn.gov

**City of Milwaukee Health Department, Consumer Environmental Health**
http://city.milwaukee.gov/Health

**City of St. Louis Department of Health**
www.stlouis-mo.gov/government/departments/health

**Coconino County Public Health**
www.coconino.az.gov

**Colorado Department of Public Health & Environment, Division of Environmental Health and Sustainability, DPU**
www.colorado.gov/pacific/cdphe/dehs

**Custom Data Processing, Inc.**
www.cdpehs.com

**Denver Department of Environmental Health**
www.denvergov.org/DEH

**Diversey, Inc.**
www.diversey.com

**Douglas County Health Department**
www.douglascountyhealth.com

**DuPage County Health Department**
www.dupagehealth.org

**Eastern Idaho Public Health District**
www.phd7.idaho.gov

**Ecobond Lead Defender**
www.ecobondlbp.com

**Ecolab**
www.ecolab.com

**EcoSure**
gail.wiley@ecolab.com

**Elite Food Safety Training**
www.elitefoodsafety.com

**Florida Department of Health in Sarasota County**
http://sarasota.floridahealth.gov

**Georgia Department of Public Health, Environmental Health Section**
http://dph.georgia.gov/environmental-health

**Gila River Indian Community: Environmental Health Service**
www.gilariver.org

**GLO GERM/Food Safety First**
www.glogerm.com

**Hawkeye Area Community Action**
www.hacap.org

**Health Department of Northwest Michigan**
www.nwhealth.org

**HealthSpace USA Inc**
www.healthspace.com

**Heuresis Corporation**
www.heuresistech.com

**Hoot Systems, LLC**
http://hootsystems.com

**Industrial Test Systems, Inc.**
www.sensafe.com

**INGO, LLC**
www.ingoforms.com

**Inspect2GO Health Inspection Software**
www.inspect2go.com/ehs

**InspekPro, LLC**
www.inspekpro.com

**International Association of Plumbing and Mechanical Officials (IAPMO) R & T**
www.iapmo.org

**ITW Pro Brands**
http://itwprofessionalbrands.com

**Jackson County Environmental Health**
www.jacksongov.org/EH

**Jefferson County Public Health (Colorado)**
http://jeffco.us/health

**Kanawha-Charleston Health Department**
www.kchdwv.org

**Kenosha County Division of Health**
www.co.kenosha.wi.us/index.aspx?NID=297

**LaMotte Company**
www.lamotte.com

**Lenawee County Health Department**
www.lenaweehealthdepartment.org

**Linn County Public Health**
www.linncounty.org/health

**Macomb County Environmental Health Association**
jarrod.murphy@macombgov.org

**Maricopa County Environmental Services**
www.maricopa.gov/envsvc

**Metro Public Health Department**
www.nashville.gov

**Micro Essential Lab**
www.microessentiallab.com

**Mid-Iowa Community Health**
www.micaonline.org

**Multnomah County Environmental Health**
www.multco.us/health

**Nashua Department of Health**
Nashua, NH

**National Center for Healthy Housing**
www.nchh.org

**National Environmental Health Science and Protection Accreditation Council**
www.ehacoffice.org

**National Restaurant Association**
www.restaurant.org

**National Swimming Pool Foundation**
www.nspf.org

**New Mexico Environment Department**
www.env.nm.gov

**New York City Department of Health & Mental Hygiene**
www.nyc.gov/health

**North Bay Parry Sound District Health Unit**
www.myhealthunit.ca/en/index.asp

**Nova Scotia**
Truro, NS, Canada

**Omaha Healthy Kids Alliance**
www.omahahealthykids.org

**Ozark River Hygienic Hand-Wash Station**
www.ozarkriver.com

**Polk County Public Works**
www.polkcountyiowa.gov/publicworks

**Pride Community Services**
www.prideinlogan.com

**Procter & Gamble Co.**
www.pg.com

**Professional Laboratories, Inc.**
www.prolabinc.com

**Prometric**
www.prometric.com

**Protec Instrument Corporation**
www.protecinstrument.com

**Racine City Department of Health**
www.cityofracine.org/Health

**San Jamar**
www.sanjamar.com

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

**Seminole Tribe of Florida**
www.semtribe.com

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

**Skillsoft**
www.skillsoft.com

**Skogen's Festival Foods**
www.festfoods.com

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

**Southwest District Health Department**
www.swdh.org

**Southwest Utah Health Department**
www.swuhealth.org

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

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

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

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

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

**Taylor Technologies, Inc.**
www.taylortechnologies.com

**Texas Roadhouse**
www.texasroadhouse.com

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

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

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

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

**XTIVIA**
www.xtivia.com

## Educational Institution Members

**Baylor University**
www.baylor.edu

**East Carolina University**
www.ecu.edu/cs-hhp/hlth

**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

**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

# SPECIAL LISTING

The board of directors includes NEHA's nationally elected officers and regional vice-presidents. Affiliate presidents (or appointed representatives) comprise the Affiliate Presidents Council. Technical advisors, the executive director, and all past presidents of the association are ex-officio council members. This list is current as of press time.

*Priscilla Oliver, PhD*
*Second Vice-President*

## National Officers

**President—David E. Riggs, MS, REHS/RS,** Longview, WA.
davideriggs@comcast.net

**President-Elect—Adam London, MPA, RS,** Health Officer, Kent County Health Department, Grand Rapids, MI.
adam.london@kentcountymi.gov

**First Vice-President—Vince Radke, MPH, RS, CP-FS, DAAS, CPH,** Environmental Health Specialist, Atlanta, GA.
vradke@bellsouth.net

**Second Vice-President—Priscilla Oliver, PhD,** Life Scientist, U.S. EPA, Atlanta, GA.
POliverMSM@aol.com

**Immediate Past-President—Bob Custard, REHS, CP-FS,** Lovettsville, VA.
BobCustard@comcast.net

**NEHA Executive Director—David Dyjack, DrPH, CIH,** (nonvoting ex-officio member of the board of directors), Denver, CO.
ddyjack@neha.org

## Regional Vice-Presidents

**Region 1—Ned Therien, MPH,** Olympia, WA.
nedinoly@juno.com
Alaska, Idaho, Oregon, and Washington. Term expires 2017.

**Region 2—Keith Allen, MPA, REHS, DAAS,** Environmental Health Operations Officer, Long Beach Dept. of Health & Human Services, Long Beach, CA.
kallenrehs@yahoo.com
Arizona, California, Hawaii, and Nevada. Term expires 2018.

**Region 3—Roy Kroeger, REHS,** Environmental Health Supervisor, Cheyenne/Laramie County Health Department, Cheyenne, WY.
roykehs@laramiecounty.com
Colorado, Montana, Utah, Wyoming, and members residing outside of the U.S. (except members of the U.S. armed forces). Term expires 2018.

**Region 4—Sharon Smith, REHS/RS,** Sanitarian Supervisor, Minnesota Department of Health, Underwood, MN.
sharon.l.smith@state.mn.us
Iowa, Minnesota, Nebraska, North Dakota, South Dakota, and Wisconsin. Term expires 2019.

**Region 5—Sandra Long, REHS, RS,** Inspection Services Supervisor, City of Plano Health Department, Plano, TX.
sandral@plano.gov
Arkansas, Kansas, Louisiana, Missouri, New Mexico, Oklahoma, and Texas. Term expires 2017.

**Region 6—Lynne Madison, RS,** Environmental Health Division Director, Western UP Health Department, Hancock, MI.
lmadison@hline.org
Illinois, Indiana, Kentucky, Michigan, and Ohio. Term expires 2019.

**Region 7—Tim Hatch, MPA, REHS,** Environmental Programs, Planning, and Logistics Director, Center for Emergency Preparedness, Alabama Department of Public Health, Montgomery, AL.
tim.hatch@adph.state.al.us
Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina, and Tennessee. Term expires 2017.

**Region 8—LCDR James Speckhart, MS, USPHS,** Health and Safety Officer, FDA, CDRH-Health and Safety Office, Silver Spring, MD.
jamesmspeckhart@gmail.com
Delaware, Maryland, Pennsylvania, Virginia, Washington, DC, West Virginia, and members of the U.S. armed forces residing outside of the U.S. Term expires 2018.

**Region 9—Larry Ramdin, REHS, CP-FS, HHS,** Health Agent, Salem Board of Health, Salem, MA.
lramdin@salem.com
Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. Term expires 2019.

## Affiliate Presidents

**Alabama—Stacy Williamson, MSM, REHS,** Public Health Environmental Supervisor, Covington County Health Dept., Red Level, AL.
president@aeha-online.com

**Alaska—Chris Dankmeyer,** Kotzebue, AK.
chris.dankmeyer@maniilaq.org

**Arizona—Steve Wille,** Maricopa County Environmental Services Dept., Phoenix, AZ.
swille@mail.maricopa.gov

**Arkansas—Jeff Jackson,** Camden, AR.
jeff.jackson@arkansas.gov

**Business & Industry—Shelly Wallingford, MS, REHS,** Retail Quality Assurance Manager, Starbucks, Denver, CO.
swalling@starbucks.com

**California—Ric Encarnacion, REHS, MPH,** Assistant Director, County of Monterey Environmental Health Bureau, Salinas CA.
EncarnacionR@co.monterey.ca.us

**Colorado—Alexandra Hawley,** Colorado Dept. of Public Health and Environment, Denver, CO.
alex.hawley@state.co.us

**Connecticut—Stacey Herbette,** Town of Wallingford, CT.
stacey.herbette@gmail.com

**Florida—Michael Crea,** Sarasota, FL.
crea@zedgepiercing.com

**Georgia—Tamika Pridgon.**
tamika.pridgon@dpa.ga.gov

**Hawaii—John Nakashima,** Sanitarian IV, Food Safety Education Program, Hawaii Dept. of Health, Hilo, HI.
john.nakashima@doh.hawaii.gov

**Idaho—Tyler Fortunati,** Idaho Dept. of Environmental Quality, Meridian, ID.
tyler.fortunati@deq.idaho.gov

**Illinois—Katie Lynn,** Fulton County Health Dept., Canton, IL.
klynn@fultonco.org

**Indiana—Mike Sutton,** Dept. of Environmental Management, Indianapolis, IN.
msutton@idem.in.gov

**Iowa—Sandy Bubke, CEHT, HHS,** Manager, Monona County Environmental Health, Onawa, IA.
mocoenvr@longlines.com

**Jamaica—Rowan Stephens,** St. Catherine, Jamaica.
info@japhi.org.jm

**Kansas—Ed Kalas, RS,** Plus or Minus 2 Degrees, LLC, Silver Lake, KS.
ed.kalas@yahoo.com

**Kentucky—Erica L. Brakefield, RS,** Technical Consultant, Kentucky Dept. of Public Health, Frankfort, KY.
kentuckyeha@gmail.com

**Louisiana—Bill Schramm,** Louisiana Dept. of Environmental Quality, Baton Rouge, LA.
bill.schramm@la.gov

**Maryland—James Lewis,** Westminster, MD.
jlewis@mde.state.md.us

**Massachusetts—Leon Bethune,** Director, Boston Public Health Commission, West Roxbury, MA.
bethleon@aol.com

**Michigan—Mary Farmer,** Jackson County Health Dept., Jackson, MI.
mfarmer@meha.net

**Minnesota—Jeff Luedeman, REHS,** Minnesota Dept. of Agriculture, St. Paul, MN.
jeff.luedeman@state.mn.us

**Mississippi—Susan Bates,** Mississippi Dept. of Health/Webster County Health Dept., Pheba, MS.
susan.bates@msdh.state.ms.us

**Missouri—Kala Wekenborg-Tomke, MHA,** Environmental Public Health Supervisor, Columbia/Boone Country Public Health, Columbia, MO.
michala.wekenborg@como.gov

**Missouri Milk, Food, and Environmental Health Association—James O'Donnell,** Food Safety and Sustainability Leader, Hussman Corporation, Bridgeton, MO.
james.odonnell@hussman.com

**Montana—Erik Leigh, RS,** Public Health Sanitarian, State of Montana DPHHS, Helena, MT.
eleigh@mt.gov

**National Capitol Area—Shannon McKeon, REHS,** Environmental Health Specialist III, Fairfax County Health Dept., Fairfax, VA.
smckeon@ncaeha.com

**Nebraska—Sarah Pistillo,** Douglas County Health Dept., Omaha, NE.
sarah.pistillo@douglascounty-ne.gov

**Nevada—Erin Cavin, REHS,** Environmental Health Specialist II, Southern Nevada Health District, Las Vegas, NV.
nevadaeha@gmail.com

**New Jersey—Robert Uhrik,** Senior REHS, South Brunswick Township Health Dept., Township of South Brunswick, NJ.
ruhrik@sbtnj.net

**New Mexico—Esme Donato,** Environmental Health Scientist, Bernalillo County, Albuquerque, NM.
edonato@bernco.gov

**New York—Contact Region 9 Vice-President Larry Ramdin.**
lramdin@salem.com

**North Carolina—Stacey Robbins,** Brevard, NC.
stacey.robbins@transylvaniacounty.org

**North Dakota—Grant Larson,** Fargo Cass Public Health, Fargo, ND.
glarson@cityoffargo.com

**Northern New England Environmental Health Association—Co-president Brian Lockard,** Health Officer, Town of Salem Health Dept., Salem, NH.
blockard@ci.salem.nh.us
**Co-president Thomas Sloan, RS,** Agricultural Specialist, New Hampshire Dept. of Agriculture, Concord, NH.
tsloan@agr.state.nh.us

**Ohio—Chad Brown, RS, REHS, MPH,** Licking County Health Dept., Newark, OH.
cbrown@lickingcohealth.org

**Oklahoma—James Splawn, RPS, RPES,** Sanitarian, Tulsa City-County Health Dept., Tulsa, OK.
tsplawn@tulsa-health.org

**Oregon—William Emminger,** Corvallis, OR.
bill.emminger@co.benton.or.us

**Past Presidents—Carolyn Harvey, PhD, CIH, RS, DAAS, CHMM,** Professor, Director of MPH Program, Dept. of Environmental Health, Eastern Kentucky

University, Richmond, KY.
carolyn.harvey@eku.edu.

**Rhode Island—Dottie LeBeau, CP-FS,** Food Safety Consultant and Educator, Dottie LeBeau Group, Hope, RI.
deejaylebeau@verizon.net

**South Carolina—Melissa Tyler,** Environmental Health Manager II, SCDHEC, Cope, SC.
tylermb@dhec.sc.gov

**South Dakota—John Osburn,** Pierre, SD.
john.osburn@state.sd.us

**Tennessee—Eric L. Coffey,** Chattanooga, TN.
tehapresident@gmail.com

**Texas—Monty McGuffin,** Senior Sanitarian, City of San Antonio, TX.
mmcguffin@sanantonio.gov

**Uniformed Services—CDR Katherine Hubbard, MPH, REHS,** Senior Institutional Environmental Health Consultant, Alaska Native Tribal Health Consortium, Anchorage, AK.
knhubbard@anthc.org

**Utah—Rachelle Blackham,** Davis County, Farmington, UT.
rblackham@co.davis.ut.us

**Virginia—Mark Cranford, REHS, CP-FS,** Environmental Health Specialist, Virginia Dept. of Health, Charlottesville, VA.
mark.cranford@vdh.virginia.gov

**Washington—Michael Baker, MS, PhD,** Dept. of Environmental Health Director, Whitman County Public Health, Pullman, WA.
michael.baker@whitmancounty.net

**West Virginia—James Casdorph,** Charleston, WV.
james.e.casdorph@wv.gov

**Wisconsin—Sonja Dimitrijevic,** Dept. of Agriculture, Trade, and Consumer Protection, WI.
sonja.dimitrijevic@wisconsin.gov.

**Wyoming—Tiffany Gaertner, REHS, CP-FS,** EHS II, Cheyenne-Laramie County Health Dept., Cheyenne, WY.
tgaertner@laramiecounty.com

## Technical Advisors

**Air Quality—David Gilkey, PhD,** Associate Professor, Colorado State University, Ft. Collins, CO.
dgilkey@colostate.edu

**Aquatic Health/Recreational Health—Tracynda Davis, MPH,** President, Davis Strategic Consulting, LLC, Colorado Springs, CO.
tracynda@gmail.com

**Aquatic Health/Recreational Health—CDR Jasen Kunz, MPH, REHS, USPHS,** CDC/NCEH, Sugar Hill, GA.
izk0@cdc.gov

**Children's Environmental Health—Anna Jeng, MS, ScD,** Associate Professor and Graduate Program Director, Old Dominion University, Norfolk, VA.
hjeng@odu.edu

**Climate Change—Leon Vinci, DHA, RS,** Founder & CEO, Health Promotion Consultants, Roanoke, VA.
lfv6@aol.com

**Drinking Water/Environmental Water Quality—Sharon Smith, REHS/RS,** Sanitarian Supervisor, Minnesota Dept. of Health, Underwood, MN.
sharon.l.smith@state.mn.us

**Emergency Preparedness and Response—Marcy Barnett, MA, MS, REHS,** Emergency Preparedness Liaison, California Dept. of Public Health, Center for Environmental Health, Sacramento, CA.
marcy.barnett@cdph.ca.gov

**Emergency Preparedness and Response—Martin Kalis,** Public Health Advisor, CDC, Atlanta, GA.
mkalis@cdc.gov

**Food (including Safety and Defense)—Eric Bradley, MPH, REHS, CP-FS, DAAS,** Environmental Health Coordinator, Scott County Health Dept., Davenport, IA.
eric.bradley@scottcountyiowa.com

**Food (including Safety and Defense)—John Marcello, CP-FS, REHS,** Regional Retail Food Specialist, FDA, Tempe, AZ.
john.marcello@fda.hhs.gov

**General Environmental Health—Tara Gurge,** Environmental Health Agent, Needham Health Dept., Needham, MA.
tgurge@needhamma.gov

**General Environmental Health—ML Tanner, HHS,** Former Program Manager, Swansea, SC.
mlacesmom@gmail.com

**Hazardous Materials/Toxic Substances—Sarah Keyes, MS,** Health, Safety, and Environmental Manager, Peter Cremer North America, LP, Cold Spring, KY.
skeyes@petercremerna.com

**Hazardous Materials/Toxic Substances—Crispin Pierce, PhD,** Assistant Professor, University of Wisconsin-Eau Claire, Eau Claire, WI.
piercech@uwec.edu

**Hazardous Materials/Toxic Substances—Stew Whitney,** Waste Program Supervisor, Ottawa County Health Dept., Holland, MI.
swhitney@miottawa.org

**Healthy Communities/Built Environment—Vacant**

**Healthy Homes and Housing—Judeth Luong,** Program Manager, City of Long Beach Health Dept., Fountain Valley, CA.
Judeth.Luong@longbeach.gov

**Healthy Homes and Housing—Ruth Ann Norton,** President & CEO, Green & Healthy Homes Initiative, Baltimore, MD.
ranorton@ghhi.org

**Informatics and Technology—Darryl Booth, MPA,** President/General Manager Environmental Health, Accela, Fresno, CA.
dbooth@accela.com

**Injury Prevention—Alan Dellapenna, RS,** Branch Head, Injury and Violence Prevention Branch, North Carolina Division of Public Health, Raleigh, NC.
alan.dellapenna@dhhs.nc.gov

**Institutions—Robert W. Powitz, MPH, PhD, RS, CP-FS, DLAAS,** Principal Consultant, R.W. Powitz & Associates, PC, Old Saybrook, CT.
powitz@sanitarian.com

**International Environmental Health—Sylvanus Thompson, PhD, CPHI(C),** Associate Director, Toronto Public Health, Toronto, ON, Canada.
sthomps@toronto.ca

**Land Use Planning and Design—Robert Washam, MPH, RS,** Jensen Beach, FL.
b_washam@hotmail.com

**Occupational Health/Safety—Tracy Zontek, PhD,** Assistant Professor, Environmental Health Program, Western Carolina University, Cullowhee, NC.
zontek@email.wcu.edu

**Onsite Wastewater—Joelle Wirth, RS,** Program Manager II, Environmental Quality Division, Coconino County Health Dept., Flagstaff, AZ.
jwirth@coconino.az.gov

**Onsite Wastewater—Denise Wright,** Training Officer, Indiana State Dept. of Health, Indianapolis, IN.
dhwright@isdh.in.gov

**Radiation/Radon—Bob Uhrik,** Senior REHS, South Brunswick Township, Monmouth Junction, NJ.
ruhrik@sbtnj.net

**Risk Assessment—Jason Marion, PhD,** Assistant Professor, Eastern Kentucky University, Richmond, KY.
jason.marion@eku.edu

**Risk Assessment—Kari Sasportas, MPH, REHS/RS,** Environmental Health Specialist, Cambridge Public Health Dept., Cambridge, MA.
ksasportas@challiance.org

**Schools—Stephan Ruckman,** Environmental Health Manager, Worthington City Schools, Dublin, OH.
mphosu@yahoo.com

**Sustainability—Tim Murphy, PhD, RESH/RS, DAAS,** Associate Professor and Dept. Chair, The University of Findlay, Findlay, OH.
murphy@findlay.edu

**Vector Control/Zoonotic Disease Control—Zia Siddiqi, PhD, BCE,** Director of Quality Systems, Orkin/Rollins Pest Control, Atlanta, GA.
zsiddiqi@rollins.com

**Workforce Development, Management, and Leadership—CAPT Michael Herring, MPH, REHS, USPHS (ret.),** Surf City, NC.
captmike@hotmail.com

**Workforce Development, Management, and Leadership—George Nakamura, MPA, REHS, RS, CP-FS, DAAS,** CEO, Nakamura Leasing, Sunny Vale, CA.
gmlnaka@comcast.net

## NEHA Staff: (303) 756-9090

**Seth Arends,** Graphic Artist, NEHA Entrepreneurial Zone (EZ), ext. 318, sarends@neha.org

**Rance Baker,** Program Administrator, NEHA EZ, ext. 306, rbaker@neha.org

**Trisha Bramwell,** Sales and Training Support, NEHA EZ, ext. 340, tbramwell@neha.org

**Laura Brister,** Education Coordinator, ext. 313, lbrister@neha.org

**Ellen Cornelius,** Project Specialist, Program and Partnership Development (PPD), ext. 307, ecornelius@neha.org

**Vanessa DeArman,** Project Coordinator, PPD, ext. 311, vdearman@neha.org

**Alex Dechant,** Administrative and Logistics Support, NEHA EZ, ext. 345, adechant@neha.org

**David Dyjack,** Executive Director, ext. 301, ddyjack@neha.org

**Santiago Ezcurra,** Media Production Specialist, NEHA EZ, ext. 318, sezcurra@neha.org

**Eric Fife,** Learning Media Manager, NEHA EZ, ext. 344, efife@neha.org

**Soni Fink,** Strategic Sales Coordinator, ext. 314, sfink@neha.org

**Nancy Finney,** Technical Editor, NEHA EZ, ext. 326, nfinney@neha.org

**Michael Gallagher,** Operations and Logistics Planner, NEHA EZ, ext. 343, mgallagher@neha.org

**TJay Gerber,** Credentialing Coordinator, ext. 328, tgerber@neha.org

**Arwa Hurley,** Website and Digital Media Specialist, ext. 327, ahurley@neha.org

**Faye Koeltzow,** Business Analyst, ext. 302, fkoeltzow@neha.org

**Elizabeth Landeen,** Assistant Manager, PPD, (702) 802-3924, elandeen@neha.org

**Matt Lieber,** Database Administrator, ext. 325, mlieber@neha.org

**Chelsea Maralason,** Marketing and Communications Specialist, ext. 338, cmaralason@neha.org

**Bobby Medina,** Credentialing Dept. Customer Service Coordinator, ext. 310, bmedina@neha.org

**Marissa Mills,** Human Resources Manager, ext. 304, mmills@neha.org

**Eileen Neison,** Credentialing Specialist, ext. 339, eneison@neha.org

**Carol Newlin,** Credentialing Specialist, ext. 337, cnewlin@neha.org

**Solly Poprish,** CDC Public Health Associate Program Intern, ext. 335, spoprish@neha.org

**Barry Porter,** Financial Coordinator, ext. 308, bporter@neha.org

**Kristen Ruby-Cisneros,** Managing Editor, *Journal of Environmental Health*, ext. 341, kruby@neha.org

**Rachel Sausser,** Member Services/Accounts Receivable, ext. 300, rsausser@neha.org

**Clare Sinacori,** Marketing and Communications Manager, ext. 319, csinacori@neha.org

**Christl Tate,** Project Coordinator, PPD, ext. 305, ctate@neha.org

**Sharon Unkart,** Instructional Designer, NEHA EZ, ext. 317, sdunkart@neha.org

**Gail Vail,** Director, Finance, ext. 309, gvail@neha.org

**Sandra Whitehead,** Director, PPD, swhitehead@neha.org

**Joanne Zurcher,** Director, Government Affairs, jzurcher@neha.org

# A Tribute

## to Our 25-Year Members

We would like to thank and honor the individuals listed below who have been members of the association for 25 years or longer. We sincerely appreciate their commitment to the association and the environmental health profession.

### a

James M. Abbott, RS

Warren Abrahams, REHS, MSPH

Karen L. Ahrendt, RS

Anthony C. Aiken, Sr.

Thomas J. Anderson

Peter R. Andrews

Louis E. Anello

Bennett H. Armstrong, MEd, RS

Thomas W. Ashton, LPSS, REHS

### b

Corey Bain

Dale A. Baker

Gary Baker

Ned E. Baker, RS

James J. Balsamo, Jr., MS, MPH, MHA, RS, CP-FS

Darryl B. Barnett, MPH, DrPH, RS, DAAS

John M. Barry, PhD

Dale M. Bates, REHS

Davies H. Batterton

Vance E. Baucom

Renee L. Beckham, RS

Frank L. Bedey, RS

Delbert Bell

John E. Benko

Anthony E. Bennett

Steve L. Berry, REHS, DAAS

Chirag H. Bhatt

Michael E. Bish

Rob Blake, MPH, REHS

Lee A. Bland

James D. Blaylock, REHS

Arthur W. Bloom

Dean Bodager, RS, DAAS, MPA

Patrick O. Bohan, PhD, RS

Robert T. Bowland

James H. Bowles

David C. Breeding, PhD

Kevin P. Breen, MPH

Robert E. Brewster, RS, LEHP, MPA

Edward L. Briggs, REHS

Corwin D. Brown

Jackson C. Burgess

Thomas J. Butts, MSc, REHS, RHSP

### c

Dennis P. Campbell, RS, REHS

Dorothy A. Campbell, RS

Elizabeth Archer Campbell

Robert J. Canning, RS

Thomas G. Carbone, RS

John W. Carr

Harold D. Carrasquillo

Carl I. Carroll, REHS, MBA

Karen A. Casale, REHS

James L. Casaus, REHS

Charles Catlin, RS

Ofelia C. Cavazos-Edmondson

Paula J. Champagne

Robin L. Chapell

Jeffrey A. Church

Kenneth A. Clare

Richard W. Clark, REHS

John W. Clayton, RS

Gordon Clemans

Curtis Cloaninger

Troy Cole, RS

Dora M. Coleman

Gary E. Coleman, RS, DAAS, CP-FS

Holly H. Coleman, MS, REHS

Brian K. Collins, MS, REHS, DAAS

Richard F. Collins, MSEH, RS, DAAS

William D. Compton, REHS-E

David R. Conrad, RS

Kenneth L. Conright, REHS

Keith W. Cook

Ralls M. Coston

Wayne T. Craney

Alan M. Croft, REHS

Joseph Ferrell Curlee, Jr., MEd

Robert W. Custard, REHS/RS, CP-FS

### d

Richard A. Daugherty

Trenton G. Davis

Melburn R. Dayton

Daniel De La Rosa

Nancy E. Deal, MS, RS

Edward A. Deep

Vincent DeFilippo

Joseph Del Ferro, RS

Alan J. Dellapenna

James E. Devore, REHS

James D. Dingman, MS, REHS, RS, DLAAS

Elise A. Dixon, REHS

Henry A. Drake, RS

Bernard Alan Dreher

Jozaier Tyrone DuGlas, Sr., REHS, CP-FS

Thomas S. Dunlop, MPH, REHS

Donna R. Dunn

James A. Dunning

## e

Diane R. Eastman

Douglas J. Ebelherr

Jean V. Edsall, RS/REHS

Fred Einerman, RS/REHS

Amer El-Ahraf

Terry L. Elichuk, RS

Gary W. Elliott, REHS/RS

Brian P. Emanuel

William B. Emminger, Sr.

Russell E. Enscore

Christopher C. Etcheson, RS

Bruce M. Etchison, RS

Diane L. Evans

## f

Wendy L. Fanaselle, MS, DAAS

Donald T. Fanning

Saba F. Fattaleh, REHS

Thomas M. Fazzini, MPH, RS

Frank S. Ferro, RS, CP-FS

Albert L. Fishback, RS

LuAnn M. Ford

Morris V. Forsting, REHS/RS

Thomas M. Frank, HO

David P. Franken, RS

Norman Franks, RS

Gary Fraser

Anthony Fraundorf

Peggy D. French, RS

## g

Frank A. Gabrian

Jeanne M. Galloway, REHS/RS

Galen W. Garst, Jr., MS

James V. Giranda, MS, ASQ-CHA, REHS

Ginger L. Gist, PhD

Scott R. Golberg

Scott M. Golden, RS, MSEH

Francis J. Goldsmith, RS

Maurice Goldstein, RS

Eugene T. Goode

Larry J. Gordon, MS, MPH, DHL

Charles R. Gossett, RS

Carolyn J. Gray, RS

Harry E. Grenawitzke, Jr., RS, MPH, DAAS

Ron L. Grimes, RS, MPH, DAAS

Steven F. Grover, REHS

John G. Gurrisi

John J. Guzewich, MPH

## h

Gary R. Hague

Aggie R. Hale

Michael G. Halko, MS, RS, DAAS

John M. Halliwill, REHS

Marlena M. Hamann, MS, REHS

Michael C. Hanika

Mark Andrew Hansell

Daniel M. Harper, Sr.

F. Charles Hart, PhD, CIH, CSP, RS

Mark A. Harvley

Jack B. Hatlen, MS

Alan B. Hauck, RS

Anne R. Hawkins-Badge

Cathy S. Hayden

William H. Hayes, Jr., LEHP

Robert S. Hays, REHS

Gregory M. Heck

Cory D. Hedman

Charles H. Henry

Donna K. Heran, REHS

Robert E. Herr

Michael E. Herring

Peter Heywood

Peter W. Hibbard, REHS

Gary M. Hickman

Charles L. Higgins, REHS

Thomas A. Hill, RS

John E. Hiramoto, REHS

Kirk B. Hodges, RS

James A. Holley

Richard L. Holmer

Scott E. Holmes

Randall C. Holveck, RS

Joseph L. Hughart

## i

Nancy Ellis Ice, RS

Michael W. Israel

## j

William Jacovina

Conrad A. Janus, RS

Keith M. Johnson

Bruce A. Jones, RS

Horace E. Jones, Jr., REHS

Lisa M. Jones, RS

Lynn P. Jones

## k

Brian P. Kaiser, CSP, CHMM, RPIH

Samuel R. Kalafat

Richard Kebabjian

Frank E. Kellogg, REHS, RS, MPH

William M. Kelly

Joy Keniston-Longrie

Robert L. Kennedy

Alan D. Knapp, RS

David A. Knauf

Paul L. Knechtges, REHS

Mel Knight, REHS

Bill R. Kok

Peter J. Kolodziej, RS

Herman Koren

Jerry E. Kral, RS

Melvin N. Kramer, MPH, PhD, REHS/RS

Larry E. Krebsbach

Marilyn Krichbaum, REHS

Keith L. Krinn, MA, RS, DAAS

Dennis K. Kroll

Bruce E. Kummer

Cynthia C. Kunkel, RS

George A. Kupfer, RS, DAAS

## l

James P. LaFleur, REHS/RS-E, CP-FS-E

Bruce K. Lane

Jonathan Langer, RS

Jim Langevin, RS

Roland Everett Langford, PhD

Oren L. Larson

*continued on page 52*

*continued from page 51*

John P. Leffel, REHS

Mike A. Lester, RS

Dody E. LeSueur, RS

Michael A. Letry

Stephanie J. Levell

Allan R. Levesque, RQAP-GLP, REHS

Glenda R. Lewis

Richard L. Licari, RS

Tim A. Link, RS/REHS, CP-FS, MT

Frank S. Lisella

Patricia A. Livingston

Robert M. Livingston, RS

Percell Locklear, Jr.

Gus T. Lopez

Thomas I. Lovey, REHS

David F. Ludwig, MPH, REHS, RS, CPM

Ross D. Lytle, RS, MS

## *m*

Scott L. Maass

Amy A. MacKenzie-Sanders

Gloria T. Mackie

Kathleen MacVarish, RS/REHS

Theron E. Magers

Kathleen A. Mallet, CQA

Patrick J. Maloney, RS, CHO, MPAH

Kenneth Malveaux, RS

Pamela A. Mancini

Richard D. Manney, REHS/RS

John A. Marcello

Boyd T. Marsh, RS

Joel S. Martens, REHS

Eric D. Martin

Glenn L. Martin

Joseph H. Martin, RS

Anthony J. Matarazzo

Isao Matoi, RS

James H. Mattox, Jr., REHS

Ann Mayo

Paul A. Mazzuchelli, REHS/RS

Theresa McDarmont, REHS

Harold C. McDowell, REHS

Allen R. McKay, RS

Thomas McKean, RS, CHO

Scott A. McKenzie, MPA, REHS

Dwayne R. McLin

David H. McMahon

Jerry C. McNamar, MPH, RS

Barry L. McNulty

David Z. McSwane, HSD

Christopher T. Melchert

Stephen L. Melega

Raymond P. Merry, REHS

Jerrold M. Michael

Edward Michalewicz

William R. Milardo, Jr.

David L. Miles

Robert Miller

Tomeji Miller

Peter M. Mirandi, RS, MPH

Lloyd W. Mitchell, MPH, PhD, RS

Richard W. Mitzelfelt

Nicholas G. Molchan, MPA, REHS

Robert E. Moore, MPH

Wendell A. Moore, RS, REHS, DAAS

Monroe T. Morgan

Kirsten K. Morlock, REHS

John E. Morrell, PhD, REHS/RS, CHO

George A. Morris, RS

Gene L. Mossing

Ronald J. Muncie

Brian Murphy, DrPH, REHS

Bruce Murphy

Timothy J. Murphy, PhD, REHS, DAAS

## *n*

George M. Nakamura

Robert R. Nelson, PhD

Bart Nighswonger

John P. Nordin, RS

John G. Norris, RS

Naphtali O. Nyagwachi

Eric R. Nystuen

## *o*

Mary B. O'Connor

MaryAnn Orapello

Carl S. Osaki

Ronald J. Osterholm

Charles S. Otto, MPA, RS, CP-FS

## *p*

Bette J. Packer, REHS

Jill Pahl

Richard A. Pantages

Alan G. Parham

Joseph Michael Parker, REHS

Dan L. Partridge, RS, MPH

Clark A. Pearson, REHS/RS, CP-FS

Gregory C. Peters, MHS, REHS

Rick Petersen, RS

Colleen F. Petullo, REHS, RN

Edward A. Pfister, MSPH, REHS

Graham C. Phuvanatnaranubala, REHS

Douglas C. Pickup, CIH, REHS

James E. Pierce, REHS

Mary M. Plaskon

Michael R. Plemons, RS

Robert D. Poole

Wayne A. Potter, REHS

Robert W. Powitz, MPH, PhD, RS, CP-FS

Lewis J. Pozzebon

Theodore E. Pumo, Jr., LEHP

## *q*

Marlene H. Quibell

## *r*

Laura A. Rabb, REHS, CIH

Vincent J. Radke

Earle M. Rafuse, Jr.

Roger T. Reid

Michael L. Reiss, MPH, REHS/RS

Scott Mather Reynolds

Leonard F. Rice, RS

David E. Riggs, REHS/RS

Janet E. Rittenhouse, RS

Reed S. Roberts

Richard L. Roberts, MPH

Welford C. Roberts

Perry L. Robinson, RS, REHS

Adam R. Rocke

Connie Rocke, REHS

Dwight E. Roepenack, LEHP

David J. Rogers, REHS

John Rogers

Eldon C. Romney, REHS

Deborah M. Rosati, REHS/RS

Paul Rosile, MPH, PhD, RS

M. Alyssa Rusiecki

Thomas L. Russell, REHS

Douglas L. Ryan, REHS

*s*

Richard Sanchez

Vickie M. Sandoval, MPH, REHS

Peter H. Sansone, RS

Joseph M. Sarcone, RS

John P. Sarisky, MPH

Wade D. Saucier, RS, CHO, REHS/RS

Eldon P. Savage, MPH, PhD

Paul J. Scaglione

Alan R. Scheere, REHS

Sue Scheurer

John E. Schillinger

Vickie Sue Schleuning

Peter M. Schmitt

Garry M. Schneider

Jacqueline L. Schnider

James W. Schothorst

Julia H. Schott

Bruce E. Schroer, RS

Ellen M. Schroth, RS

Frank S. Sedzielarz, RS

Deborah Seeck

Ricardo M. Serrano

Thomas B. Sexton, Jr.

Ginger L. Shaffer

Brian P. Sheehan, MPH, LEHP, RS

Charles Shepherd, III, RS

Craig A. Shepherd

Richard A. Sherman

John H. Shrader, REHS/RS, CP-FS

Gary Skillett

Aubrey C. Smelley, MSEH, DAAS

Doug R. Smith

Jeffrey J. Smith, RS

Sharon L. Smith

Marcia G. Snyder, REHS

Stanley J. Sosnicki

Will Spates

Vincent A. Spencer

Steven D. Spurlock, RS

Philip D. St. Onge

Carl W. Stein

Grace E. Steinke, RS

John A. Steward, REHS, MPH

Jeffrey T. Stout, RS/REHS

Allen J. Stroh

Alex H. Stubner, PhD

Laura Studevant, RS

Sandra M. Supinski

J. Shannon Swann, PhD, RS, REHS

Jill M. Swanson

Neil R. Swanson, RS

Mark D. Swartz

Gilbert M. Swe

*t*

Stephen R. Tackitt, RS, MPH, DAAS

Ryan Talken

David C. Taylor, BCE

John V. Teyhen, MPH, REHS

David W. Tharp, CAE

Dennis Thayer, RS

Peter D. Thornton, MPH, RS

Richard J. Thoune, RS, MS, MPH

John G. Todd, DrPH, RS

Leroy E. Todd

Steven E. Tome, REHS/RS

Donald T. Torres, RS

Tara N. Tradd

Charles Treser

Mary G. Trometter

Brian Turner

Douglas E. Turner, REHS

*u*

Cynthia L. Ulch, RS

Gerald T. Ulleberg, REHS

*v*

Robert Vaccarella, RS

Lawrence G. Van Dyck

Steve Van Stockum

A.F. VanNostrand

Laura L. Vasile, MPH, RS

Leon F. Vinci, DHA, RS

Janice Viola

Daniel R. Voss

*w*

Richard Michael Walton, REHS/RS

Steven Joseph Ward

Michael D. Warren, RS

Robert B. Washam, RS, MPH

Norman L. Weiss

Michael M. Welch

Susan L. Welch, CIH, CSP, RS

Daniel M. Wellington, REHS, CP-FS

April L. Wendling, MPA, MS, PhD, RS

Betty L. Wernette-Babian, RS

Richard H. Whelan

James F. White, RS

James M. White, Jr., RS/REHS

Chris J. Wiant, PhD

Christopher E. Wicker

Douglas A. Wigle, Jr.

Donald B. Williams, Jr.

Karen E. Williams

James S. Williamson

Keith M. Willingham, RS

Edward F. Wirtanen

Linden E. Witherell, PE

Dana Wiyninger, REHS

Joe J. Wolfe, CSP

John D. Wollstein, RS

Aura C. Wong

*y*

Dale Yamnik, REHS, CP-FS

Larry D. Yates, REHS

Bruce C. York, REHS

C.L. Young, MEd

George G. Young, REHS

Melinda A. Young

Webster Young, Jr.

*z*

George Zameska, REHS/RS, CP-FS

Brian J. Zamora, MPH, REHS

Patrick Zurick

# NEHA **NEWS**

## Call for Nominations

NEHA is governed by a corporate board of directors that oversees the affairs of the association. There will be four board positions up for election in 2017:

- Region 1 vice-president (represents Alaska, Idaho, Oregon, and Washington; 3-year term);
- Region 5 vice-president (represents Arkansas, Kansas, Louisiana, Missouri, New Mexico, Oklahoma, and Texas; 3-year term);
- Region 7 vice-president (represents Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina, and Tennessee; 3-year term);
- second vice-president (national officer; 5-year term that progresses through the national offices and will serve as NEHA president in 2020–2021).

We seek diversity on the board in terms of gender, ethnicity, and a balance between regulatory officials, academia, and industry. Most importantly, we want people who will help us develop a new strategic vision, have experience managing diverse organizations, and can open doors for NEHA in building relationships with industry, academia, federal and state agencies, foundations, and other associations.

Requirements to serve on the board include

- membership with NEHA (individual or life) for three consecutive years prior to assuming office on July 13, 2017;
- not simultaneously holding a voting position on the board of a NEHA affiliate;
- endorsement by at least five voting NEHA members (from members residing in the region for regional vice-president candidates and from members residing in at least three different regions for second vice-president candidates); and
- willingness to commit the time necessary to actively serve on the board.

If you are interested in serving on our board of directors, please visit www.neha.org/about-neha/elections for information on the nomination and election process. You can also contact NEHA Past-President Bob Custard, chairman of NEHA's Nominations Committee, at BobCustard@comcast.net. The deadline to submit a nomination is **December 1, 2016**.

## NEHA Staff Profile

As part of tradition, NEHA features new staff members in the *Journal* around the time of their 1-year anniversary. These profiles give you an opportunity to get to know the NEHA staff better and to learn more about the great programs and activities going on in your association. Contact information for all NEHA staff can be found on page 49.

**Nancy Finney**

I joined NEHA's Entrepreneurial Zone (EZ) in November 2015. After a few years in finance, I was excited to get back to my passion, which is the art of language. As EZ's technical editor, I have the unique challenge of editing learning materials for disciplines such as food science, manufacturing, law, microbiology, and public policy. I enjoy learning from scientists, authors, and subject matter experts and creating quality trainings. One of the most meaningful moments I've had at NEHA was when I discovered that my favorite president, Abraham Lincoln, created the U.S. Department of Agriculture.

I received my master's degree in public administration from Grand Valley State University, and my bachelor's degree is in professional writing. My career experiences are diverse; I've been employed as an education analyst, activity leader for at-risk youth, and managed marketing and public relations for political campaigns. After completing a research position with the Provost's Office at my alma mater, I embarked on an adventure to the Rocky Mountains of Colorado. While living in the mountains, I mentored inner-city students on a horse, llama, and alpaca ranch. I later moved to Denver to be a fiscal administrator for nonprofit groups and political action committees.

Outside of the office l compose and record music, play piano, read poetry, ride my bicycle, and hula hoop with friends at the park. Over the years my writing has received many accolades. My master's thesis is published in an academic journal, several articles and short creative pieces have appeared in magazines, and my poetry was featured twice on the radio. In the future I plan to help NEHA's publications and courses reach larger audiences and look forward to creating additional content that meets NEHA's high standards for the profession.

## Recruiting Health Department Internship Hosts

NEHA is excited to announce another year of the National Environmental Public Health Internship Program (NEPHIP) and is accepting applications from state, local, and tribal environmental health departments to host interns. Interns will complete a 10-week internship during summer 2017 and will be sponsored through a stipend from the Centers for Disease Control and Prevention.

"This is a great opportunity for small, local health departments that may not have existing resources to support qualified interns," said Dr. David Dyjack, NEHA executive director. "City, county, and tribal health departments serving rural, frontier, or underserved communities are especially encouraged to apply to this capacity building program as they often feel the impact of limited budgets more acutely."

A major benefit of hosting an intern is the assistance they will provide to environmental health program at no cost to the health department. In addition to having students eager to gain experience in the field and contribute to the important mission of the environmental health practice, participation also contributes to the recruitment of highly trained professionals into the environmental public health workforce.

**2016 Intern Activities**

This summer, 19 students completed their internships at environmental health departments throughout the U.S. These interns were involved in a wide range of activities such as studying contaminant levels in surface water and groundwater; helping to build upon tracking initiatives by presenting pesticide exposures and illness information; performing food, pool, and campground inspections; and much more (see photo above). Visit www.neha.org/nephip-success-stories to read a few success stories from the 2016 interns.

**To Apply**

Health departments can apply to host an environmental health intern by submitting a simple, one-page application by **December 1, 2016**. Visit www.neha.org/internships to apply.

*Emily Cunis, a 2016 NEPHIP intern, tests for fluoride levels in water during her internship. She completed her internship at the Tanana Chiefs Conference's Office of Environmental Health in Fairbanks, Alaska. Photo courtesy of Emily Cunis.*

## 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. 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!

**DirecTalk**
*continued from page 58*

- Local health departments (LHDs) don't have resources to analyze data and create meaningful information that can be marketed to the end user and be used for performance improvement and public health promotion.
- Vocabulary differs across agencies for the same data elements.
- Cooperative or unified standards for data collection and reporting are lacking.
- It is difficult for LHDs to report up to federal and state agencies.
- LHDs often aren't looped back in by federal agencies once their data have been uploaded regarding how or if they are being used.
- LHDs lack centralized IT systems and similar software among other LHDs and state and federal agencies.

2. **What are the knowledge, skills, and abilities environmental health departments need to solve the problem?**
   - Knowledge of existing models to utilize as a guide for their own adoption of informatics.
   - Better understanding of how the public receives and uses environmental public health data.
   - Knowledge of software capabilities and analysis tools.
   - Understanding of what local environmental health professionals need in order to develop tools for informatics.
   - Understanding of how to turn data into information—not just how to collect data, but how to quickly analyze that data.
   - Securing resources (i.e., time and money) to complete data analysis and publish scientific literature as data collection is usually funded, but analysis and sharing are not.
   - Ability to work with federal agencies around data use, collection, analysis, etc.
3. **What is NEHA's role in solving the problem?**
   - Make environmental health data meaningful to local agencies to promote and protect public health.
   - Facilitate value and ease of informatics adoption by LHDs through the provision of models and toolkits.
   - Conduct a needs assessment and gap analysis around collection and use of environmental public health data.
   - Facilitate and act as a steward of the development of data standards for the environmental health community.
   - Market to LHDs to make them aware of opportunities and to promote data sharing and analysis.
   - Advocate for LHD funding to upgrade technology and data analysis abilities.
   - Facilitate conversations at the federal level around environmental public health data to encourage the incorporation of local data into federal level data in a meaningful way.

I suggest we create a NEHA Community of Solutions to tackle the issues identified above. The de Beaumont Foundation workshop participants recommended that as we move forward, NEHA should continue the conversation around environmental health and informatics, as well as position itself as a resource for environmental health departments as they transition from data collection systems to informatics systems. What do you think?

Our profession should be the grand public health reducing agent. Let's consider collecting, packaging, and giving away our environmental health data in a manner that creates value for philosophically aligned agencies, sectors, and data users. Healthcare systems, health officials, and citizens at large would love to have access to our retail food inspection data, recreational water data, septic system data, vector data, prison inspection data, body art data, air quality data, and all the other data we collect. In the process, our value and contributions to population health becomes easier to understand and our workforce is more likely to achieve long-term stability and growth. That's a balanced redox equation I can live with.

ddyjack@neha.org
Twitter: @DTDyjack



**DirecTalk** MUSINGS FROM THE 10TH FLOOR

David Dyjack, DrPH, CIH

# Data: The Grand Simplifier

As I write this column it's August, it's unseasonably hot, I'm ensconced in Bethesda, and my head is about to explode! The general chemistry class I labored through at Saint Mary's College seems a lifetime ago. What was *that* definition? A reducing agent … a compound that loses an electron during a chemical reaction, thus becoming something else in the process. Strong reducing agents easily lose control of their valence electrons, leaving a simpler, more stable atom in its place.

For the last eight hours I've participated in an energetic discussion with a handful of the country's preeminent public health talent. They represent state and local health departments, national membership organizations, academia, and key players in the training and education of the governmental workforce. Who brought us together? The de Beaumont Foundation (www.debeaumont.org). Why? To explore opportunities to advance the use of data, informatics, and other surveillance systems in support of informed decision making.

Interest in population health data has grown exponentially of late, in large measure to the 2010 Patient Protection and Affordable Care Act, more commonly referred to as the Affordable Care Act or Obamacare. Among other things, healthcare providers are increasingly motivated to keep people healthy with less financial remuneration for treating illness. I reluctantly accept that healthcare is the 800-pound gorilla in the health world, which drives my cortisol levels skyward. On the other hand, there is very good news—common interests in prevention. Data are a universal language that creates fertile conditions for collaboration and shared understanding with the clinical side of the house.

> *Data are a universal language that creates fertile conditions for collaboration and shared understanding.*

The de Beaumont Foundation workshop began its efforts through exploration of the challenges to the public health workforce's efficient and effective use of data, of which the environmental health profession is awash. Participants identified many common workforce development challenges in the current public health informatics environment. A few key challenges that bubbled to the top were:

- lack of agreement on standards of practice,
- lack of tools and guidance documents related to defining requirements and selecting health information systems, and
- balancing innovation with the need to replicate best practices.

Over the last five years I have listened to the frustrations voiced in the environmental health field around issues such as software systems being expensive to customize or amend, uncertainty regarding what to purchase, and a lack of common social space for us to exchange health information systems experiences and recommendations. I grieve over these conditions. Ironically, while many of the de Beaumont Foundation workshop participants suggested that resources to purchase an informatics system were a major limiting factor, I pointed out that our constituents often have these resources, but lack a road map to follow to make informed purchasing decisions.

The state of environmental informatics is puzzling. So, earlier this year I charged our Program and Partnerships Development team to assist me in conceptualizing what NEHA's role in informatics should be. Two of our staff, Christl Tate and Solly Poprish, hosted an excellent day-long forum in Denver that brought together experts representing the fields of private information technology (IT), state and local environmental health departments, and federal agencies. We struggled to answer three basic questions, which I outline below, along with some preliminary conclusions.

1. **What environmental heath informatics problem is NEHA trying to solve?**
   - Local data are not routinely utilized by the majority of federal databases, which affects the timeliness of data availability.

*continued on page 56*

# TEST WITH THE BEST!

**LEARN ABOUT ITS' WATER QUALITY PRODUCTS FOR TESTING; THE PREMIER CHOICE OF HEALTH INSPECTORS**


ECONOMICAL
DIGITAL
PHOTOMETETERS

HARNESS THE POWER OF THE SMARTPHONE AND UPGRADE THE WAY YOU TEST WATER


USEPA
HEALTH DEPT
COMPLIANT
FOR FREE & TOTAL
CHLORINE
CHLORINE DIOXIDE

waterproof IP67

INCLUDES LANGELIER
LSI
AUTO CALCULATIONS


VISUAL TESTS
FOR OVER
100 PARAMETERS


Industrial Test Systems, Inc.
Innovators of Water Quality Testing

**(800) 861-9712 SENSAFE.COM**
SENSAFE ITSSENSAFE


MADE IN THE USA

# In the office...
# and out in the field


...our mobile inspection platform gives you the efficiency and flexibility professionals need.

**HEALTHSPACE.com**

Call 1.866.860.4224 for Your DEMO.

INTERNATIONAL PERSPECTIVES

# Association Between Keeping Pet Animals and Allergic Rhinitis: A Case-Control Study Among Japanese University Students

Mitsuo Uchida, MD, PhD
Minoru Kaneko, MD, PhD
Shigeyuki Kawa, MD, PhD
*Center for Health, Safety, and Environmental Management Shinshu University*

**Abstract** **Keeping pet animals might enhance allergic diseases, although studies have yielded inconsistent results. This case-control study investigated whether previously keeping pets was associated with the development of allergic rhinitis. A questionnaire was distributed to first-year university students in 2012 and 2013, and responses were obtained from 3,061 individuals. Matching of demographic factors, including age, sex, family history, hometown region, number of siblings, daycare center attendance, and the type of fuel used for heating yielded 570 case-control pairs.**

**Previous experience keeping pets, including cats and indoor or outdoor dogs, was evaluated at all ages from 0 to 18 years continuously. The odds ratios for developing allergic rhinitis of keeping a dog inside or outside the home and of keeping a cat at age 0 were 2.50, 1.26, and 1.64, respectively. These odds ratios decreased with increasing age, however, falling below 1.0 at ages 10, 4, and 11 years, respectively. This study could facilitate further understanding of the effects of pets on allergic diseases.**

## Introduction

Environmental factors are believed to affect the development of allergic diseases (Asher et al., 2006; Strachan, 1989). Pet ownership, especially keeping a dog (Bergroth et al., 2012; Chen et al., 2008) or cat (Celedon et al., 2002; Polk et al., 2004), has been associated with respiratory allergic diseases. Although these associations have been discussed in several review articles (Chen, Tischer, Schnappinger, & Heinrich, 2010; Lodge, Allen, et al., 2012; Takkouche, Gonzalez-Barcala, Etminan, & Fitzgerald, 2008), data regarding the effects of these animals, usually expressed as "risk" or "protection," have been inconsistent. These inconsistencies are thought to be due to the differences in subject age (Holt & Sly, 2009), geographical effects (Asher et al., 2006), avoidance of animals by high-risk subjects (Bertelsen et al., 2010), and study methods used (Chen et al., 2010). Therefore, further studies are required to clarify the association between keeping pets and allergic diseases.

Allergic rhinitis is a major respiratory allergic disease, the prevalence of which is increasing in the general population (Strachan et al., 1997). As allergic rhinitis affects a patient's quality of life (Greiner, Hellings, Rotiroti, & Scadding, 2011) and has significant socioeconomic impact (Hellgren, Cervin, Nordling, Bergman, & Cardell, 2010), methods are required for prevention, as well as for determination of the association between its pathogenesis and environmental factors, including pet animals.

While several comprehensive cohort studies show that early exposure to a pet has protective effects for allergic sensitization (Almqvist et al., 2010; Lodrup Carlsen et al., 2012; Ownby, Johnson, & Peterson, 2002; Wegienka et al., 2011; Wegienka, Johnson, Havstad, Ownby, & Zoratti, 2010), the effects of pets on allergic rhinitis are still unclear (Lodrup Carlsen et al., 2012). This uncertainty might be due in part to the many studies that have evaluated subject exposure to animals over short periods of time only, such as at birth or in early childhood (Bergroth et al., 2012; Chen et al., 2008; Lodge, Lowe, et al., 2012).

Additional studies are therefore necessary to evaluate exposure at later times, especially because allergic rhinitis frequently has an onset at older ages than other allergic diseases. Thus, evidence is needed to determine whether previous experience of keeping pets, from birth to adolescence, is related to the development of allergic rhinitis.

This study evaluated the association between past experience of keeping pets and consequent development of allergic rhinitis using a retrospective epidemiological method. This study focused on allergic rhinitis because of its high worldwide prevalence and the long-term effects of environmental factors on this condition.

## Methods

### Study Subjects

We recruited first-year students at Shinshu University in central Japan, including 2,164 who enrolled in 2012 and 2,133 who enrolled in 2013. Almost one third of these first-year students lived in the same prefecture as the university, with the remainder coming from other areas. A questionnaire was distributed to all 4,297 first-year students at lectures held by the authors, with 3,614 (84.1%) providing responses. To maintain the age homogeneity of the study population, first-year students over 20 years of age were excluded. In addition, incomplete answers were excluded. In total, 3,061 first-year students ages 18 to 20 years, or 71.2% of all first-year students, were included in the study. The study design and protocol were reviewed and approved by the Committee for Medical Ethics of Shinshu University (approval number 1709).

### Questionnaire

The self-administered anonymous survey questionnaire included questions regarding a diagnosis of allergic rhinitis: "Have you ever been diagnosed with allergic rhinitis by a doctor? If yes, please state your age at diagnosis." To make the baseline appearance of allergic rhinitis uniform, the questionnaire asked about the first diagnosis at a medical facility.

The experience of keeping a dog or cat was investigated. In Japan, dogs may be kept inside or outside the home, resulting in a different frequency of exposure for children. Dogs kept inside the home (mostly small-sized dogs) spend their entire time inside the home, except when being walked for toileting and recreation. Dogs kept outside the home rarely enter the home. Cats in Japan are usually kept inside the home. In the present study, keeping a pet was therefore sorted into three categories: dogs inside the home, dogs outside the home, and cats. In addition, the questionnaire included age at first exposure to a pet.

The survey also included demographic factors, including age (number of years), sex (male or female), and family history of allergic rhinitis (yes or no). Participants were also asked about past habits or background factors that have been reported to show associations with allergic rhinitis. For example, differences in air pollution or pollen count between rural and urban districts are thought to affect the development of allergies (Nicolai, 1997; Uchida, Kaneko, & Kawa, 2013); therefore, location of previous hometown region (prefecture) was included in the questionnaire. We asked about number of siblings because large number of siblings is associated with a decrease in allergic diseases (Strachan, 1989). The age of enrollment in daycare also affects the development of allergic diseases (Svanes et al., 2002). Although many children in Japan attend daycare, those who do not attend daycare usually go to kindergarten. To assess the effects of daycare on allergic rhinitis, daycare center attendance (yes or no) was investigated. As the type of fuel used for heating has also been shown to affect allergic diseases (Burr et al., 1999), the questionnaire asked about heating of their homes, whether by coal, oil, or other fuels.

TABLE **1**

**Characteristics of Case and Control Subjects in First-Year University Students**

| Factor | Case | | Control | | *p*-Value* |
|---|---|---|---|---|---|
| | (*n* = 570) | (%) | (*n* = 570) | (%) | |
| Onset age | | | | | |
| 0–4 | 72 | 12.6 | | | |
| 5–9 | 183 | 32.1 | | | |
| 10–14 | 232 | 40.7 | | | |
| 15–18 | 83 | 14.6 | | | |
| Sex | | | | | |
| Male | 385 | 67.5 | 385 | 67.5 | 1.00 |
| Female | 185 | 32.5 | 185 | 32.5 | |
| Sibling number | | | | | |
| 1 | 43 | 7.5 | 43 | 7.5 | 1.00 |
| 2 | 322 | 56.5 | 322 | 56.5 | |
| 3 | 186 | 32.6 | 186 | 32.6 | |
| 4 or more | 19 | 3.3 | 19 | 3.3 | |
| Experience of daycare center | | | | | |
| Yes | 290 | 50.9 | 290 | 50.9 | 1.00 |
| No | 280 | 49.1 | 280 | 49.1 | |
| Family history of allergic rhinitis | | | | | |
| Yes | 74 | 13.0 | 74 | 13.0 | 1.00 |
| No | 496 | 87.0 | 496 | 87.0 | |
| Habitual heating | | | | | |
| Fuels or coal | 440 | 77.2 | 440 | 77.2 | 1.00 |
| Others | 130 | 22.8 | 130 | 22.8 | |
| Dog inside the home | | | | | |
| Yes | 47 | 8.2 | 96 | 16.8 | <.01 |
| No | 523 | 91.8 | 474 | 83.2 | |
| Dog outside the home | | | | | |
| Yes | 112 | 19.6 | 127 | 22.3 | .28 |
| No | 458 | 80.4 | 443 | 77.7 | |
| Cat | | | | | |
| Yes | 72 | 12.6 | 95 | 16.7 | .05 |
| No | 498 | 87.4 | 475 | 83.3 | |

*Chi square test was used for categorical data.

### Statistical Analysis

Of the 3,061 students, 761 (24.9%) had been diagnosed with allergic rhinitis and 2,300 (75.1%) had not. To control for background factors (described below) and also to compare effects of pet exposure by age, a case-control design was used in this study. Case and control subjects were matched by six background factors: sex, hometown region, number of siblings, daycare experience, type of fuel used for heating, and family history.

Age was not matched because the study population was uniform, with all subjects 18 to 20 years. Age at onset of allergic rhinitis was assessed by two matching methods: whole

TABLE **2**

**Association Between Past Experience of Keeping Pet Animals and Allergic Rhinitis at Several Ages in Whole Matching Group (*N* = 1,140, 570 Control and 570 Matched Case Subjects)**

| Age | Dog Inside the Home | | | | Dog Outside the Home | | | | Cat | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Case | Control | *OR* | 95% *CI* | Case | Control | *OR* | 95% *CI* | Case | Control | *OR* | 95% *CI* |
| 0 | 10 | 4 | 2.50 | 0.72, 10.92 | 30 | 24 | 1.26 | 0.70, 2.28 | 18 | 11 | 1.64 | 0.73, 3.83 |
| 1 | 10 | 4 | 2.50 | 0.72, 10.92 | 34 | 25 | 1.38 | 0.79, 2.43 | 21 | 12 | 1.75 | 0.82, 3.90 |
| 2 | 11 | 5 | 2.20 | 0.70, 8.08 | 36 | 33 | 1.10 | 0.65, 1.87 | 22 | 15 | 1.50 | 0.73, 3.19 |
| 3 | 12 | 5 | 2.40 | 0.79, 8.70 | 40 | 37 | 1.09 | 0.66, 1.79 | 28 | 16 | 1.86 | 0.93, 3.84 |
| 4 | 14 | 5 | 2.80 | 0.95, 9.93 | 43 | 45 | 0.95 | 0.60, 1.50 | 31 | 18 | 1.81 | 0.95, 3.57 |
| 5 | 16 | 8 | 2.00 | 0.81, 5.40 | 51 | 50 | 0.98 | 0.64, 1.50 | 33 | 21 | 1.63 | 0.89, 3.06 |
| 6 | 24 | 15 | 1.60 | 0.81, 3.28 | 53 | 63 | 0.83 | 0.56, 1.23 | 36 | 23 | 1.62 | 0.91, 2.94 |
| 7 | 27 | 22 | 1.23 | 0.67, 2.26 | 61 | 75 | 0.79 | 0.54, 1.15 | 40 | 25 | 1.65 | 0.96, 2.90 |
| 8 | 32 | 30 | 1.07 | 0.62, 1.84 | 70 | 83 | 0.81 | 0.56, 1.17 | 41 | 28 | 1.52 | 0.89, 2.63 |
| 9 | 36 | 32 | 1.13 | 0.68, 1.89 | 73 | 89 | 0.78 | 0.54, 1.12 | 44 | 33 | 1.38 | 0.83, 2.30 |
| 10 | 40 | 42 | 0.95 | 0.60, 1.51 | 80 | 100 | 0.75 | 0.53, 1.06 | 47 | 41 | 1.17 | 0.73, 1.87 |
| 11 | 40 | 45 | 0.89 | 0.56, 1.40 | 82 | 106 | 0.72 | 0.51, 1.01 | 47 | 49 | 0.95 | 0.61, 1.49 |
| 12 | 41 | 54 | 0.75 | 0.48, 1.16 | 84 | 112 | 0.70 | 0.50, 0.97 | 47 | 55 | 0.84 | 0.54, 1.29 |
| 13 | 43 | 60 | 0.71 | 0.46, 1.07 | 84 | 115 | 0.67 | 0.48, 0.93 | 47 | 58 | 0.79 | 0.52, 1.21 |
| 14 | 44 | 70 | 0.61 | 0.40, 0.91 | 84 | 119 | 0.64 | 0.46, 0.89 | 50 | 65 | 0.75 | 0.50, 1.12 |
| 15 | 45 | 77 | 0.56 | 0.37, 0.83 | 85 | 122 | 0.63 | 0.46, 0.88 | 50 | 71 | 0.68 | 0.46, 1.01 |
| 16 | 46 | 86 | 0.49 | 0.33, 0.73 | 85 | 125 | 0.61 | 0.44, 0.84 | 51 | 80 | 0.61 | 0.41, 0.89 |
| 17 | 47 | 92 | 0.46 | 0.31, 0.69 | 85 | 126 | 0.61 | 0.44, 0.84 | 51 | 92 | 0.52 | 0.36, 0.76 |
| 18 | 47 | 96 | 0.44 | 0.30, 0.65 | 85 | 127 | 0.60 | 0.43, 0.83 | 51 | 95 | 0.51 | 0.35, 0.73 |

*OR* = odds ratio; *CI* = confidence interval.

matching and onset age-stratified matching. In whole matching, case and control groups each consisted of 570 subjects. As allergic rhinitis first appeared over a wide age range, environmental exposure may have different effects according to age at onset. Therefore, not only age at first animal exposure, but age at onset of allergic rhinitis should be considered. In onset age-stratified matching, subjects were divided into four groups according to age at onset of allergic rhinitis (0–4, 5–9, 10–14, and ≥15 years).

The age stratified matching was conducted independently from the all-study subjects to avoid using any control subject twice in the study. The four age-stratified groups included 62, 155, 204, and 79 subject pairs, respectively. Finally, both of the matching groups were used for analysis in this study.

The association between previously keeping pet animals and a diagnosis of allergic rhinitis was analyzed statistically. In the whole matched pairs, the number of subjects who began keeping a pet animal was assessed by yearly age, from 0 to 18 years. The proportions of subjects in each age group who kept a pet were compared using the McNemar's test, odds ratio (*OR*), and 95% confidence interval (95% *CI*).

In subjects stratified by age at onset, a similar calculation was performed up to the onset age. Thus, subjects who had a pet were placed in the same category, regardless of whether or not they subsequently kept the pet.

In the case group, subjects who brought home a pet after the onset of allergic rhinitis were not counted as keeping a pet. This allocation was based on the hypothesis that previous pet keeping affects the consequent onset of allergic rhinitis. Stata13 software was used for all statistical analyses with $p < .05$ deemed statistically significant.

## Results

The demographic and clinical characteristics of the case and control subjects are shown in Table 1. Age at onset of allergic rhinitis was most frequently 10–14 years, accounting for 40.7% of subjects with allergic rhinitis. Factors were compared among case and control groups. The rates of keeping a dog inside the home, outside the home, and keeping a cat were 8.2%, 19.6%, 12.6%, and 16.8%, 22.3%, 16.7% in case and control groups, respectively.

The effects of previously keeping a pet on the development of allergic rhinitis were determined. The *OR*s (95% *CI*s) for allergic rhinitis of keeping a dog inside the home, a dog outside the home, and a cat at age 0 were 2.50 (0.75–10.92), 1.26 (0.70–2.28), and 1.64 (0.73–3.83), respectively, by whole matching (Table 2), although these differences were not statistically significant. The *OR*s, however, decreased with increasing subject age. At age 18 years, the *OR*s (95% *CI*s) for allergic rhinitis of keeping a dog inside the home, a dog outside the home, and a cat

TABLE **3**

**Association Between Past Experience of Keeping a Dog Inside the Home and Allergic Rhinitis in Onset Age Stratified Group**

| Age | 0–4 Years Onset Group | | | | 5–9 Years Onset Group | | | |
|---|---|---|---|---|---|---|---|---|
| | Case | Control | *OR* | 95% *CI* | Case | Control | *OR* | 95% *CI* |
| | *n* = 62 | *n* = 62 | | | *n* = 155 | *n* = 155 | | |
| 0 | 0 | 0 | NA | | 4 | 1 | 4.00 | 0.40, 197.0 |
| 1 | 0 | 0 | NA | | 4 | 1 | 4.00 | 0.40, 197.0 |
| 2 | 0 | 0 | NA | | 4 | 1 | 4.00 | 0.40, 197.0 |
| 3 | 0 | 0 | NA | | 4 | 1 | 4.00 | 0.40, 197.0 |
| 4 | 0 | 0 | NA | | 5 | 1 | 5.00 | 0.56, 236.5 |
| 5 | | | | | 5 | 2 | 2.50 | 0.41, 26.25 |
| 6 | | | | | 8 | 2 | 4.00 | 0.80, 38.67 |
| 7 | | | | | 9 | 2 | 4.50 | 0.93, 42.80 |
| 8 | | | | | 10 | 4 | 2.50 | 0.72, 10.92 |
| 9 | | | | | 11 | 4 | 2.75 | 0.81, 11.84 |

| Age | 10–14 Years Onset Group | | | | 15–18 Years Onset Group | | | |
|---|---|---|---|---|---|---|---|---|
| | Case | Control | *OR* | 95% *CI* | Case | Control | *OR* | 95% *CI* |
| | *n* = 204 | *n* = 204 | | | *n* = 79 | *n* = 79 | | |
| 0 | 3 | 2 | 1.50 | 0.17, 18.00 | 3 | 1 | 3.00 | 0.24, 157.5 |
| 1 | 3 | 2 | 1.50 | 0.17, 18.00 | 3 | 1 | 3.00 | 0.24, 157.5 |
| 2 | 3 | 2 | 1.50 | 0.17, 18.00 | 3 | 1 | 3.00 | 0.24, 157.5 |
| 3 | 4 | 2 | 2.00 | 0.29, 22.10 | 3 | 1 | 3.00 | 0.24, 157.5 |
| 4 | 4 | 2 | 2.00 | 0.29, 22.10 | 4 | 1 | 4.00 | 0.40, 197.0 |
| 5 | 5 | 2 | 2.50 | 0.41, 26.25 | 5 | 1 | 5.00 | 0.56, 236.5 |
| 6 | 9 | 5 | 1.80 | 0.54, 6.84 | 6 | 1 | 6.00 | 0.73, 276.0 |
| 7 | 11 | 7 | 1.57 | 0.56, 4.78 | 6 | 4 | 1.50 | 0.36, 7.23 |
| 8 | 14 | 9 | 1.56 | 0.63, 4.07 | 6 | 4 | 1.50 | 0.36, 7.23 |
| 9 | 16 | 9 | 1.78 | 0.74, 4.56 | 7 | 4 | 1.75 | 0.44, 8.15 |
| 10 | 18 | 11 | 1.70 | 0.74, 4.15 | 8 | 4 | 2.00 | 0.54, 9.08 |
| 11 | 18 | 11 | 1.70 | 0.74, 4.15 | 8 | 4 | 2.00 | 0.54, 9.08 |
| 12 | 18 | 14 | 1.31 | 0.60, 2.93 | 9 | 4 | 2.25 | 0.63, 10.00 |
| 13 | 19 | 15 | 1.31 | 0.60, 2.93 | 10 | 5 | 2.25 | 0.63, 10.00 |
| 14 | 20 | 20 | 1.00 | 0.49, 2.04 | 10 | 5 | 2.25 | 0.63, 10.00 |
| 15 | | | | | 11 | 7 | 1.67 | 0.55, 5.58 |
| 16 | | | | | 12 | 7 | 1.83 | 0.62, 6.04 |
| 17 | | | | | 13 | 7 | 2.00 | 0.69, 6.49 |
| 18 | | | | | 13 | 8 | 1.71 | 0.62, 5.14 |

NA = not applicable; *OR* = odds ratio; *CI* = confidence interval.

were 0.44 (0.30–0.65), 0.60 (0.43–0.83), and 0.51 (0.35–0.73), respectively.

To examine differences in age at onset, *OR*s were evaluated in the age-stratified matching groups. Among families of subjects diagnosed with allergic rhinitis at 0–4 years old, none had kept a pet dog inside the home. The same was true of control subjects matched for age. Therefore, we could not analyze *OR*s among these groups. Although the *OR*s ranged widely and some were not below 1.0 at later periods, the *OR*s for allergic rhinitis of keeping all three categories of pets showed a similar tendency as that of the whole matching group, of decreasing with age (Tables 3–5).

The estimated *OR*s and 95% *CI*s for allergic rhinitis of keeping all three types of animals are shown in Figure 1A–C. At age 0 years, the *OR*s for allergic rhinitis of keeping a dog inside the home, a dog outside the home, and a cat were >1.0, but decreased with increasing age. The *OR*s for keeping a dog inside the home, a dog outside the home, and a cat fell below 1.0 at ages 10, 4, and 11 years, respectively. Keeping a pet of all three types at around age 0 years was found to be a risk factor for the later development of allergic rhinitis, but in time changed to a protective effect with increasing age.

## Discussion

In general, allergic diseases might be caused by both genetic and environmental factors (Portelli, Hodge, & Sayers, 2015). Allergic rhinitis is a fairly common disease that is often associated with other comorbidities, including asthma, which also has a high first year of life diagnosis. Environmental factors that affect the prognosis of allergic diseases have long been studied (Strachan, 1989). To tease apart the associations between and among genetic and environmental factors and allergic diseases is difficult; therefore longitudinal epidemiologic studies are necessary. Under these circumstances, in the present study, we focused only on examining the association between allergic rhinitis and pets.

This study evaluated the association between previous experience of keeping a pet and a diagnosis of allergic rhinitis among first-year university students. To minimize sampling bias and to evaluate the effect of animal exposure from birth to adolescence, case-control matching was performed. At age 0 years, the *OR*s for allergic rhinitis of keeping a dog or cat were all >1.0, with these *OR*s decreasing with increasing subject age, falling below 1.0 in the entire matching group for all three classes of pet animals. Thus, the effects of previous experience of keeping a pet animal on the development of allergic rhinitis were different soon after birth and at later times.

Cohort studies have reported that keeping pets can protect against the development of allergic rhinitis. For example, the *OR* for

TABLE **4**

**Association Between Past Experience of Keeping a Dog Outside the Home and Allergic Rhinitis in Onset Age Stratified Group**

| Age | 0–4 Years Onset Group | | | | 5–9 Years Onset Group | | | |
|---|---|---|---|---|---|---|---|---|
| | Case | Control | *OR* | 95% *CI* | Case | Control | *OR* | 95% *CI* |
| | *n* = 62 | *n* = 62 | | | *n* = 155 | *n* = 155 | | |
| 0 | 1 | 1 | 1.00 | 0.01, 78.50 | 7 | 4 | 1.75 | 0.44, 8.15 |
| 1 | 1 | 1 | 1.00 | 0.01, 78.50 | 8 | 5 | 1.60 | 0.46, 6.21 |
| 2 | 1 | 2 | 0.50 | 0.01, 9.60 | 8 | 7 | 1.14 | 0.36, 3.70 |
| 3 | 1 | 2 | 0.50 | 0.01, 9.60 | 11 | 10 | 1.10 | 0.42, 2.89 |
| 4 | 1 | 2 | 0.50 | 0.01, 9.60 | 11 | 12 | 0.92 | 0.37, 2.27 |
| 5 | | | | | 12 | 14 | 0.86 | 0.36, 2.00 |
| 6 | | | | | 13 | 19 | 0.68 | 0.31, 1.46 |
| 7 | | | | | 15 | 20 | 0.74 | 0.34, 1.55 |
| 8 | | | | | 16 | 21 | 0.75 | 0.36, 1.54 |
| 9 | | | | | 16 | 23 | 0.67 | 0.31, 1.37 |

| Age | 10–14 Years Onset Group | | | | 15–18 Years Onset Group | | | |
|---|---|---|---|---|---|---|---|---|
| | Case | Control | *OR* | 95% *CI* | Case | Control | *OR* | 95% *CI* |
| | *n* = 204 | *n* = 204 | | | *n* = 79 | *n* = 79 | | |
| 0 | 12 | 12 | 1.00 | 0.37, 2.68 | 4 | 2 | 2.00 | 0.29, 22.11 |
| 1 | 15 | 13 | 1.18 | 0.49, 2.91 | 4 | 2 | 2.00 | 0.29, 22.11 |
| 2 | 15 | 16 | 0.93 | 0.40, 2.13 | 5 | 4 | 1.25 | 0.27, 6.30 |
| 3 | 16 | 19 | 0.82 | 0.38, 1.78 | 5 | 7 | 0.67 | 0.14, 2.81 |
| 4 | 18 | 21 | 0.84 | 0.41, 1.73 | 5 | 8 | 0.50 | 0.08, 2.34 |
| 5 | 23 | 23 | 1.00 | 0.52, 1.92 | 7 | 8 | 0.83 | 0.20, 3.28 |
| 6 | 23 | 29 | 0.78 | 0.42, 1.43 | 8 | 9 | 0.86 | 0.24, 2.98 |
| 7 | 26 | 34 | 0.72 | 0.39, 1.31 | 9 | 11 | 0.78 | 0.25, 2.35 |
| 8 | 30 | 37 | 0.77 | 0.43, 1.37 | 13 | 12 | 1.13 | 0.39, 3.35 |
| 9 | 32 | 40 | 0.76 | 0.43, 1.31 | 14 | 12 | 1.25 | 0.44, 3.64 |
| 10 | 35 | 42 | 0.79 | 0.46, 1.36 | 18 | 12 | 1.75 | 0.69, 4.81 |
| 11 | 36 | 43 | 0.79 | 0.46, 1.36 | 19 | 12 | 1.88 | 0.75, 5.11 |
| 12 | 38 | 43 | 0.85 | 0.50, 1.44 | 19 | 12 | 1.88 | 0.75, 5.10 |
| 13 | 38 | 44 | 0.82 | 0.49, 1.40 | 19 | 12 | 1.88 | 0.75, 5.10 |
| 14 | 38 | 46 | 0.78 | 0.46, 1.31 | 19 | 12 | 1.88 | 0.75, 5.10 |
| 15 | | | | | 20 | 12 | 2.00 | 0.80, 5.40 |
| 16 | | | | | 20 | 13 | 1.78 | 0.74, 4.56 |
| 17 | | | | | 20 | 13 | 1.78 | 0.74, 4.56 |
| 18 | | | | | 20 | 14 | 1.60 | 0.68, 3.94 |

*OR* = odds ratio; *CI* = confidence interval.

allergic rhinitis at 4 years in subjects exposed to pets at birth was 0.6 (Nafstad, Magnus, Gaarder, & Jaakkola, 2001), and previous cat ownership was associated with a reduced risk of current allergic rhinitis (*OR* = 0.41) at age 5 years (Perzanowski et al., 2008). In these studies, however, subjects were evaluated at 4 or 5 years of age, which is below the age at which symptoms of allergic rhinitis are usually first noted. Therefore, these *OR*s might change if evaluated longitudinally.

Evaluation of older subjects showed that keeping a cat in the home during the first year of life increased the risk of allergic rhinitis (*OR* = 2.21) in children ages 6–12 (Tamay et al., 2007). A collaborative European cohort study found no significant association between early animal exposure and allergic rhinitis among school-aged children (Lodrup Carlsen et al., 2012). Thus, the effects of pet exposure after birth might differ in subjects evaluated during early childhood and in those evaluated at a later period.

The effects of current pet exposure on allergic rhinitis have also been found to differ. For example, current exposure to a cat or dog did not have a significant effect on allergic rhinitis (*OR* = 1.0) in children ages 7–10 (Wickens et al., 2002). The risk ratios for allergic rhinitis were found to be 0.71 in children age 6 years with a current pet (Kurosaka et al., 2006), and 0.6 in children ages 10–11 who currently had a cat (Braback, Kjellman, Sandin, & Bjorksten, 2001).

Therefore, keeping a pet in later childhood may have a protective effect against allergic rhinitis. Thus, these results indicated that the effects of a pet on allergic rhinitis vary according to the timing of animal exposure or the age at which subjects are evaluated. Although pets have been regarded as increasing or reducing the risk of development of allergic rhinitis, our finding, that the effects of pets change, might explain the discrepancies in previous studies.

Although the effects on allergic rhinitis across the three pet categories were mostly consistent, some slight differences were seen. This study evaluated two categories of keeping a dog (i.e., indoor or outdoor). Keeping a dog inside the home showed a slightly higher *OR* for allergic rhinitis, similar to that for keeping a cat. As exposure to dander or dust mites is greater inside than outside the home, allergic diseases can more easily develop in subjects who have pets inside the home. This observation is similar to the observation that house dust is a general risk factor for several allergic diseases (Nurmatov, van Schayck, Hurwitz, & Sheikh, 2012). Thus, it may be necessary to consider environmental factors when investigating the effects of pet animals on allergic diseases.

This study had several limitations. First, because this study was based on a self-administered questionnaire survey, recall bias could not be excluded. This bias might be especially true in the cases where recall was of memories of early childhood. Moreover,

TABLE **5**

**Association Between Past Experience of Keeping a Cat and Allergic Rhinitis in Onset Age Stratified Group**

| Age | 0–4 Years Onset Group | | | | 5–9 Years Onset Group | | | |
|---|---|---|---|---|---|---|---|---|
| | Case | Control | *OR* | 95% *CI* | Case | Control | *OR* | 95% *CI* |
| | *n* = 62 | *n* = 62 | | | *n* = 155 | *n* = 155 | | |
| 0 | 0 | 3 | 0 | 0.00, 2.42 | 6 | 2 | 3.00 | 0.54, 30.39 |
| 1 | 0 | 3 | 0 | 0.00, 2.42 | 8 | 2 | 4.00 | 0.80, 38.67 |
| 2 | 0 | 3 | 0 | 0.00, 2.42 | 8 | 3 | 2.67 | 0.64, 15.60 |
| 3 | 0 | 3 | 0 | 0.00, 2.42 | 13 | 3 | 4.33 | 1.19, 23.70 |
| 4 | 0 | 3 | 0 | 0.00, 2.42 | 14 | 4 | 3.50 | 1.10, 14.60 |
| 5 | | | | | 15 | 5 | 3.00 | 1.04, 10.55 |
| 6 | | | | | 16 | 5 | 3.20 | 1.12, 11.17 |
| 7 | | | | | 16 | 5 | 3.20 | 1.12, 11.17 |
| 8 | | | | | 16 | 7 | 2.29 | 0.89, 6.57 |
| 9 | | | | | 16 | 9 | 1.78 | 0.74, 4.56 |

| Age | 10–14 Years Onset Group | | | | 15–18 Years Onset Group | | | |
|---|---|---|---|---|---|---|---|---|
| | Case | Control | *OR* | 95% *CI* | Case | Control | *OR* | 95% *CI* |
| | *n* = 204 | *n* = 204 | | | *n* = 79 | *n* = 79 | | |
| 0 | 9 | 6 | 1.50 | 0.48, 5.12 | 1 | 1 | 1.00 | 0.01, 78.50 |
| 1 | 9 | 6 | 1.50 | 0.48, 5.12 | 2 | 2 | 1.00 | 0.07, 13.80 |
| 2 | 10 | 8 | 1.29 | 0.43, 4.06 | 2 | 2 | 1.00 | 0.07, 13.80 |
| 3 | 11 | 8 | 1.43 | 0.49, 4.42 | 2 | 3 | 0.67 | 0.06, 5.82 |
| 4 | 13 | 8 | 1.71 | 0.62, 5.14 | 2 | 3 | 0.67 | 0.06, 5.82 |
| 5 | 14 | 10 | 1.44 | 0.57, 3.83 | 2 | 3 | 0.67 | 0.06, 5.82 |
| 6 | 14 | 10 | 1.44 | 0.57, 3.83 | 2 | 3 | 0.67 | 0.06, 5.82 |
| 7 | 16 | 12 | 1.36 | 0.59, 3.28 | 3 | 3 | 1.00 | 0.13, 7.47 |
| 8 | 17 | 14 | 1.23 | 0.56, 2.78 | 3 | 4 | 0.75 | 1.10, 4.43 |
| 9 | 19 | 16 | 1.21 | 0.56, 2.66 | 4 | 6 | 0.67 | 1.38, 2.81 |
| 10 | 21 | 19 | 1.11 | 0.55, 2.29 | 4 | 8 | 0.50 | 0.11, 1.87 |
| 11 | 21 | 22 | 0.95 | 0.48, 1.88 | 4 | 12 | 0.33 | 0.08, 1.10 |
| 12 | 21 | 24 | 0.86 | 0.44, 1.67 | 4 | 13 | 0.31 | 0.07, 1.00 |
| 13 | 21 | 24 | 0.86 | 0.44, 1.67 | 4 | 13 | 0.31 | 0.07, 1.00 |
| 14 | 22 | 27 | 0.80 | 0.42, 1.50 | 5 | 14 | 0.36 | 0.10, 1.05 |
| 15 | | | | | 5 | 14 | 0.36 | 0.10, 1.05 |
| 16 | | | | | 6 | 15 | 0.40 | 0.13, 1.09 |
| 17 | | | | | 6 | 16 | 0.38 | 0.12, 1.01 |
| 18 | | | | | 6 | 16 | 0.38 | 0.12, 1.01 |

*OR* = odds ratio; *CI* = confidence interval.

laboratory data, including intensity of allergen exposure and serum IgE concentration, could not be determined. These limitations might have resulted in an overestimation of the association between pets and allergic rhinitis. As the effect curves were similar for the three pet classifications, however, the results probably are reliable.

Second, duration of pet animal exposure might vary between matched pairs. We only hypothesized that previous pet keeping was associated with the consequent onset of allergic rhinitis, so we did not control for duration of pet animal exposure. Indeed it is probably impossible to find enough subjects in a population to completely eliminate this confounding variable. By using age-stratified matching, however, we could adjust and control for this variable as much as possible in our data set. This difference might cause an increase in the odds ratio between case and control groups. For exposure duration to be equivalent and analyzed in detail, a prospective and large sample cohort study is necessary.

Third, the study did not adjust for several environmental factors. Passive smoking, for example, may affect the development of allergic rhinitis (Biagini et al., 2006). Moreover, underlying allergic diseases that might affect the subsequent avoidance of pets (Bertelsen et al., 2010) was not determined. Moreover, allergic diseases often show higher prevalence in urban areas compared to rural areas (Nicolai, 1997). We matched subjects for previous hometown prefecture to avoid the district effect in this study; however, the effect might remain because prefectures are relatively large. Thus, the possibility of confounding factors could not be ruled out.

Fourth, although keeping pet cats and dogs was evaluated separately, this study did not assess the simultaneous keeping of multiple pets, thereby overestimating the effects of pet animals on allergic rhinitis. Fifty-two (4.4%) of the 1,194 individuals with pets, however, began keeping multiple animals simultaneously for the first time, suggesting that the effect of multiple pets was small.

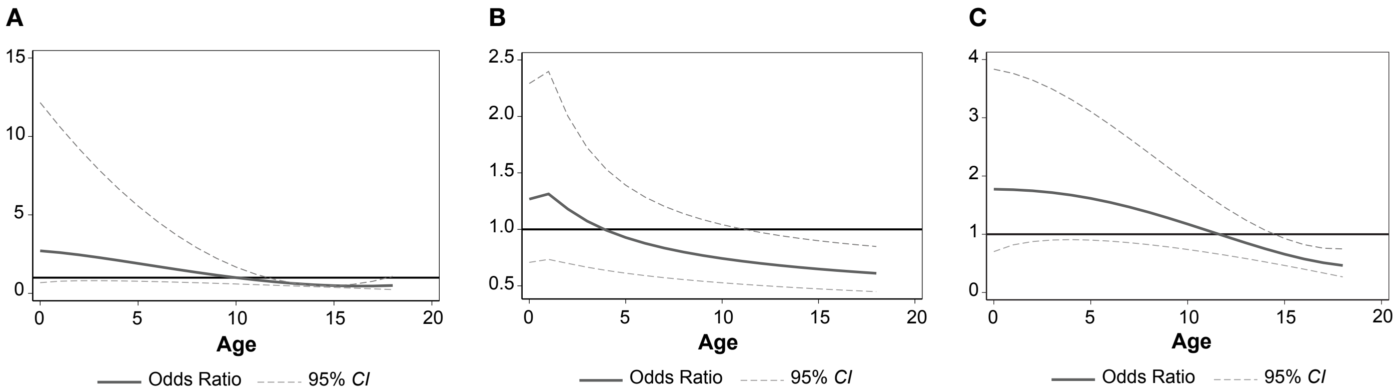
Fifth, this study assessed only the association between pet animals and allergic rhinitis. Therefore, the pathogenesis of allergic rhinitis was not clarified. Moreover, the study population consisted only of university students, limiting the generalization of these study results to other populations.

## Conclusions

The data from this study suggested that keeping a dog or cat soon after birth increases the risk of the child subsequently developing allergic rhinitis. This effect, however, was likely to be reduced when pets were introduced later in childhood, with keeping pets even showing a protective effect against allergic rhinitis. This study may contribute to a

FIGURE **1**

**Association Between Previous Experience of Keeping Pet Animals and Allergic Rhinitis**




*CI* = confidence interval.

*Note:* Associations between A) keeping a dog inside the home, B) keeping a dog outside the home, and C) keeping a cat and a subsequent diagnosis of allergic rhinitis, expressed by curve estimation in the whole matching group.

greater understanding of the inconsistencies in previous studies on the effects of pet animals and allergic diseases. Further studies are warranted to clarify the effects of pet animals on allergic diseases.

*Acknowledgement:* We acknowledge Tomoko Fujimura, Hiroko Hayashi, Naomi Yuzawa, Kiyomi Tanaka, Yoshinobu Shinkai, Kyoko Inuura, Kazuki Nagai, Yoko Watanabe, and Koichi Asawa for their assistance in the collection and analysis of data.

*Corresponding Author:* Mitsuo Uchida, Center for Health, Safety, and Environmental Management, Shinshu University, 3-1-1 Asahi, Matsumoto 390-8621, Japan.
E-mail: uchida01@shinshu-u.ac.jp.

## References

Almqvist, C., Garden, F., Kemp, A.S., Li, Q., Crisafulli, D., Tovey, E.R., . . . CAPS Investigators. (2010). Effects of early cat or dog ownership on sensitisation and asthma in a high-risk cohort without disease-related modification of exposure. *Paediatric and Perinatal Epidemiology, 24*(2), 171–178.

Asher, M.I., Montefort, S., Bjorksten, B., Lai, C.K., Strachan, D.P., Weiland, S.K., . . . ISAAC Phase Three Study Group. (2006). Worldwide time trends in the prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and eczema in childhood: ISAAC Phases One and Three repeat multicountry cross-sectional surveys. *Lancet, 368*(9537), 733–743.

Bergroth, E., Remes, S., Pekkanen, J., Kauppila, T., Buchele, G., & Keski-Nisula, L. (2012). Respiratory tract illnesses during the first year of life: Effect of dog and cat contacts. *Pediatrics, 130*(2), 211–220.

Bertelsen, R.J., Carlsen, K.C., Granum, B., Carlsen, K.H., Haland, G., Devulapalli, C.S., . . . Lovik, M. (2010). Do allergic families avoid keeping furry pets? *Indoor Air, 20*(3), 187–195.

Biagini, J.M., LeMasters, G.K., Ryan, P.H., Levin, L., Reponen, T., Bernstein, D.I., . . . Lockey, J. (2006). Environmental risk factors of rhinitis in early infancy. *Pediatric Allergy and Immunology, 17*(4), 278–284.

Braback, L., Kjellman, N.I., Sandin, A., & Bjorksten, B. (2001). Atopy among schoolchildren in northern and southern Sweden in relation to pet ownership and early life events. *Pediatric Allergy and Immunology, 12*(1), 4–10.

Burr, M.L., Anderson, H.R., Austin, J.B., Harkins, L.S., Kaur, B., Strachan, D.P., & Warner, J.O. (1999). Respiratory symptoms and home environment in children: A national survey. *Thorax, 54*(1), 27–32.

Celedon, J.C., Litonjua, A.A., Ryan, L., Platts-Mills, T., Weiss, S.T., & Gold, D.R. (2002). Exposure to cat allergen, maternal history of asthma, and wheezing in first 5 years of life. *Lancet, 360*(9335), 781–782.

Chen, C.M., Morgenstern, V., Bischof, W., Herbarth, O., Borte, M., Behrendt, H., . . . German Infant Nutrition Intervention Programme Study Group. (2008). Dog ownership and contact during childhood and later allergy development. *European Respiratory Journal, 31*(5), 963–973.

## References


Chen, C.M., Tischer, C., Schnappinger, M., & Heinrich, J. (2010). The role of cats and dogs in asthma and allergy: A systematic review. *International Journal of Hygiene and Environmental Health, 213*(1), 1–31.

Greiner, A.N., Hellings, P.W., Rotiroti, G., & Scadding, G.K. (2011). Allergic rhinitis. *Lancet, 378*(9809), 2112–2122.

Hellgren, J., Cervin, A., Nordling, S., Bergman, A., & Cardell, L.O. (2010). Allergic rhinitis and the common cold: High cost to society. *Allergy, 65*(6), 776–783.

Holt, P.G., & Sly, P.D. (2009). Non-atopic intrinsic asthma and the “family tree” of chronic respiratory disease syndromes. *Clinical and Experimental Allergy, 39*(6), 807–811.

Kurosaka, F., Nakatani, Y., Terada, T., Tanaka, A., Ikeuchi, H., Hayakawa, A., . . . Nishio, H. (2006). Current cat ownership may be associated with the lower prevalence of atopic dermatitis, allergic rhinitis, and Japanese cedar pollinosis in schoolchildren in Himeji, Japan. *Pediatric Allergy and Immunology, 17*(1), 22–28.

Lodge, C.J., Allen, K.J., Lowe, A.J., Hill, D.J., Hosking, C.S., Abramson, M.J., & Dharmage, S.C. (2012). Perinatal cat and dog exposure and the risk of asthma and allergy in the urban environment: A systematic review of longitudinal studies. *Clinical and Developmental Immunology, 2012*, 176484.

Lodge, C.J., Lowe, A.J., Gurrin, L.C., Matheson, M.C., Balloch, A., Axelrad, C., . . . Dharmage, S.C. (2012). Pets at birth do not increase allergic disease in at-risk children. *Clinical and Experimental Allergy, 42*(9), 1377–1385.

Lodrup Carlsen, K.C., Roll, S., Carlsen, K.H., Mowinckel, P., Wijga, A.H., Brunekreef, B., . . . Keil, T. (2012). Does pet ownership in infancy lead to asthma or allergy at school age? Pooled analysis of individual participant data from 11 European birth cohorts. *PLoS One, 7*(8), e43214.

Nafstad, P., Magnus, P., Gaarder, P.I., & Jaakkola, J.J. (2001). Exposure to pets and atopy-related diseases in the first 4 years of life. *Allergy, 56*(4), 307–312.

Nicolai, T. (1997). Epidemiology of pollution-induced airway disease: Urban/rural differences in East and West Germany. *Allergy, 52*(Suppl. 38), 26–29.

Nurmatov, U., van Schayck, C.P., Hurwitz, B., & Sheikh, A. (2012). House dust mite avoidance measures for perennial allergic rhinitis: An updated Cochrane systematic review. *Allergy, 67*(2), 158–165.

Ownby, D.R., Johnson, C.C., & Peterson, E.L. (2002). Exposure to dogs and cats in the first year of life and risk of allergic sensitization at 6 to 7 years of age. *The Journal of the American Medical Association, 288*(8), 963–972.

Perzanowski, M.S., Chew, G.L., Divjan, A., Johnson, A., Goldstein, I.F., Garfinkel, R.S., . . . Miller, R.L. (2008). Cat ownership is a risk factor for the development of anti-cat IgE but not current wheeze at age 5 years in an inner-city cohort. *The Journal of Allergy and Clinical Immunology, 121*(4), 1047–1052.

Polk, S., Sunyer, J., Munoz-Ortiz, L., Barnes, M., Torrent, M., Figueroa, C., . . . Cullinan, P. (2004). A prospective study of Fel d1 and Der p1 exposure in infancy and childhood wheezing. *American Journal of Respiratory and Critical Care Medicine, 170*(3), 273–278.

Portelli, M.A., Hodge, E., & Sayers, I. (2015). Genetic risk factors for the development of allergic disease identified by genome-wide association. *Clinical and Experimental Allergy, 45*(1), 21–31.

Strachan, D.P. (1989). Hay fever, hygiene, and household size. *BMJ, 299*(6710), 1259–1260.

Strachan, D., Sibbald, B., Weiland, S., Ait-Khaled, N., Anabwani, G., Anderson, H.R., . . . Williams, H. (1997). Worldwide variations in prevalence of symptoms of allergic rhinoconjunctivitis in children: The International Study of Asthma and Allergies in Childhood (ISAAC). *Pediatric Allergy and Immunology, 8*(4), 161–176.

Svanes, C., Jarvis, D., Chinn, S., Omenaas, E., Gulsvik, A., & Burney, P. (2002). Early exposure to children in family and day care as related to adult asthma and hay fever: Results from the European Community Respiratory Health Survey. *Thorax, 57*(11), 945–950.

Takkouche, B., Gonzalez-Barcala, F.J., Etminan, M., & Fitzgerald, M. (2008). Exposure to furry pets and the risk of asthma and allergic rhinitis: A meta-analysis. *Allergy, 63*(7), 857–864.

Tamay, Z., Akcay, A., Ones, U., Guler, N., Kilic, G., & Zencir, M. (2007). Prevalence and risk factors for allergic rhinitis in primary school children. *International Journal of Pediatric Otorhinolaryngology, 71*(3), 463–471.

Uchida, M., Kaneko, M., & Kawa, S. (2013). Does change of residence affect pollinosis? A study of Japanese university students. *International Journal of Environmental Health Research, 23*(5), 380–391.

Wegienka, G., Johnson, C.C., Havstad, S., Ownby, D.R., Nicholas, C., & Zoratti, E.M. (2011). Lifetime dog and cat exposure and dog- and cat-specific sensitization at age 18 years. *Clinical and Experimental Allergy, 41*(7), 979–986.

Wegienka, G., Johnson, C.C., Havstad, S., Ownby, D.R., & Zoratti, E.M. (2010). Indoor pet exposure and the outcomes of total IgE and sensitization at age 18 years. *The Journal of Allergy and Clinical Immunology, 126*(2), 274–279.

Wickens, K., Lane, J.M., Fitzharris, P., Siebers, R., Riley, G., Douwes, J., . . . Crane, J. (2002). Farm residence and exposures and the risk of allergic diseases in New Zealand children. *Allergy, 57*(12), 1171–1179.