

ISES 2020 Virtual Meeting
September 22, 2020

Unconventional Oil and Natural Gas Development: Improving the Integration of Exposure and Health Research

Donna Vorhees, ScD
Health Effects Institute-Energy
Boston, MA

Overview of presentation

- Brief introduction to HEI-Energy
- Research about UOGD's potential human exposures and health effects – progress and complexities
- Future exposure research and its application to epidemiology and risk assessment

Brief introduction to HEI-Energy

HEI-Energy: a new national research program

Delivering *research useful to communities, policy makers, and others* on:

- Human exposures associated with onshore development of oil and natural gas from shale and other unconventional resources (UOGD) across the United States
- As feasible and appropriate based on findings from the exposure studies, targeted efforts to assess the potential health effects that might result from exposures

HEI-Energy Sponsors:

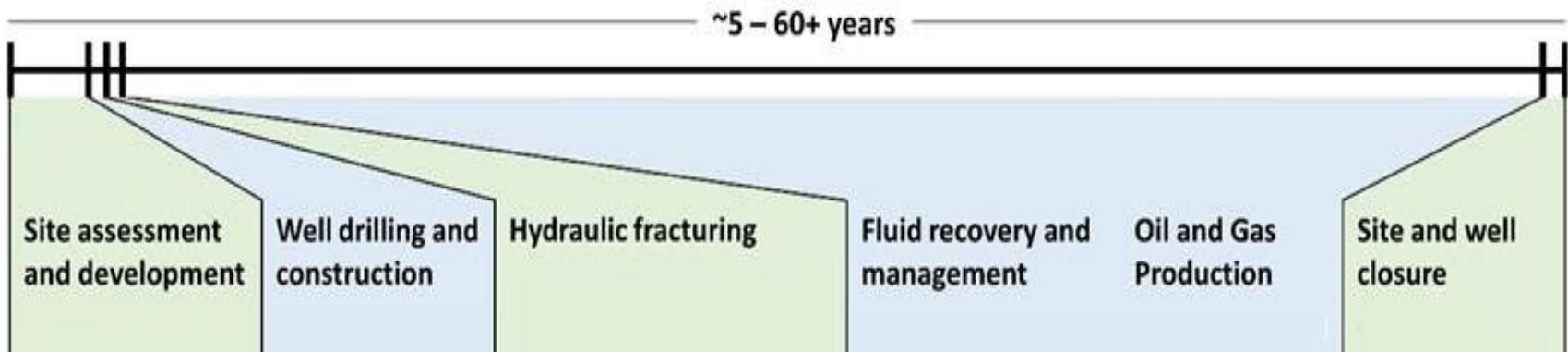
- Funded jointly by government and the oil and natural gas industry
- All research is selected, conducted, overseen, and reviewed independently of HEI-Energy's sponsors

Unconventional oil and natural gas development (UOGD)

- Development and production of oil and natural gas as practiced starting around the beginning of the 21st century through multistage hydraulic fracturing in horizontal wells.
- Processes occur on and off the well pad.



UOGD phases



Graphic modified from: USEPA. 2016

Ensuring the quality of HEI-Energy's work

HEI Energy Research Committee



George Hornberger, Chair
Vanderbilt University
Nashville, TN



Shari Dunn-Norman
Missouri University
Rollo, MO



Stefanie Ebelt
Emory University
Atlanta, GA



Howard Hu
University of Washington
Seattle, WA



Judy S. LaKind
LaKind Associates and University
of Maryland
Baltimore City, MD



Bhramar Mukherjee
University of Michigan
Ann Arbor, MI



Armistead (Ted) G. Russell
Georgia Institute of Technology
Atlanta, GA



Peter S. Thorne
University of Iowa
Iowa City, IA

HEI-Energy staff work with the Energy Research Committee on:

- Workshops with Stakeholders
- Literature Reviews
- Defining research needs in Requests for Applications (RFAs)
- Scientific oversight of research funded by HEI-Energy

Research about UOGD's potential human exposures and health effects – progress and complexities



> Publications

Providing Credible Science

Publications

- > All results from projects funded by HEI-Energy can be found here. Results will also be made available through annual conferences, workshops, and presentations to legislative bodies, public agencies, community organizations, and other interested groups.

Potential Human Health Effects Associated with Unconventional Oil and Gas Development: A Systematic Review of the Epidemiology Literature (FINAL REPORT)

HEI-Energy Research Committee

September 2019

This report reviews the epidemiology research that assesses whether exposure to unconventional oil and natural gas development (UOGD) might lead to adverse health effects.

Human Exposure to Unconventional Oil and Gas Development: A Literature Survey for Research Planning (FINAL COMMUNICATION)

HEI-Energy Research Committee

June 2020

Communication 1 surveys the literature about environmental exposures associated with unconventional oil and natural gas development (UOGD). The Energy Research Committee conducted the survey as part of a larger effort to understand the current state of the science on UOGD exposures and their potential health effects.

Strategic Research Agenda on the Potential Impacts of 21st Century Oil and Natural Gas Development in the Appalachian Region and Beyond (Published 2015)

HEI-Energy Reports

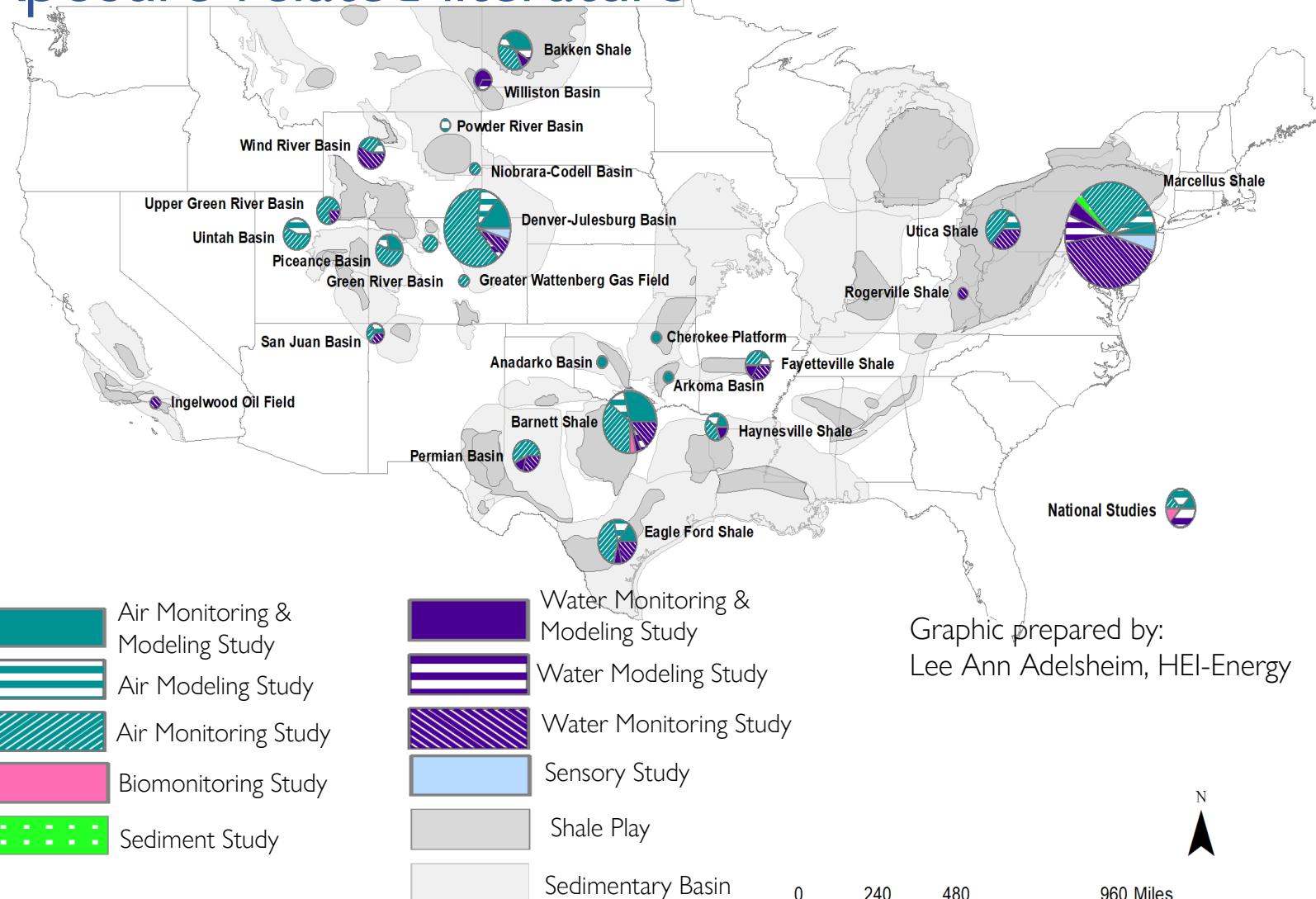
Reports:

<https://hei-energy.org/publications>

Online database of citations:

<https://hei-energy.org/resources>

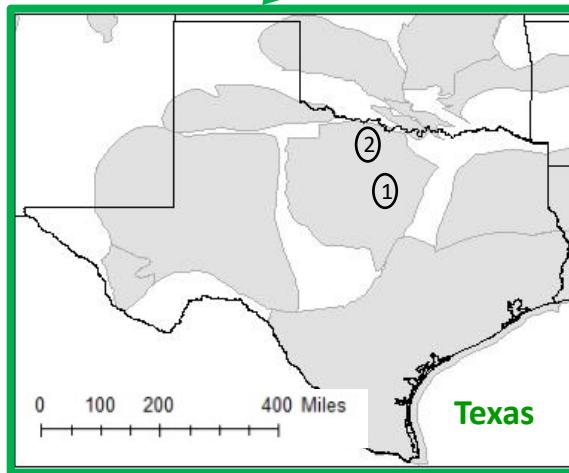
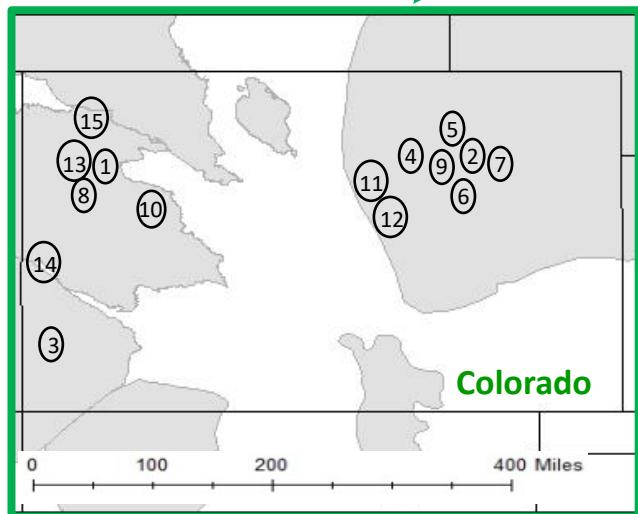
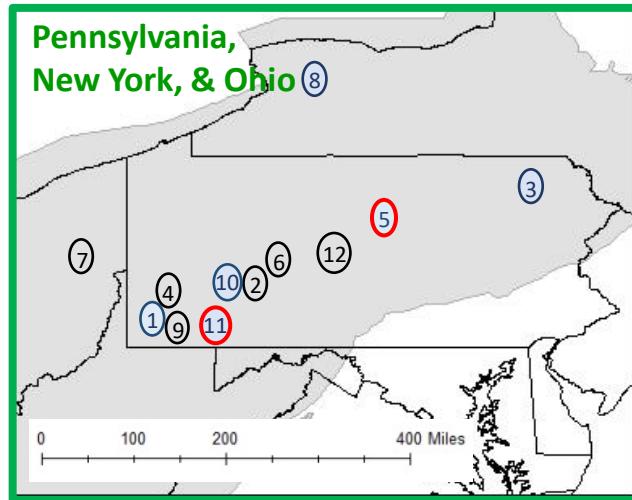
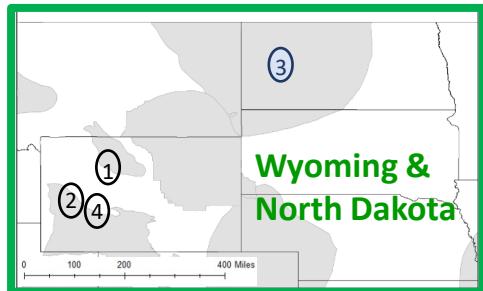
HEI-Energy 2019 survey of UOGD exposure-related literature



Graphic prepared by:
Lee Ann Adelsheim, HEI-Energy

UOGD Human Health Risk Assessments

- Community drinking water
- Community air
- Occupational

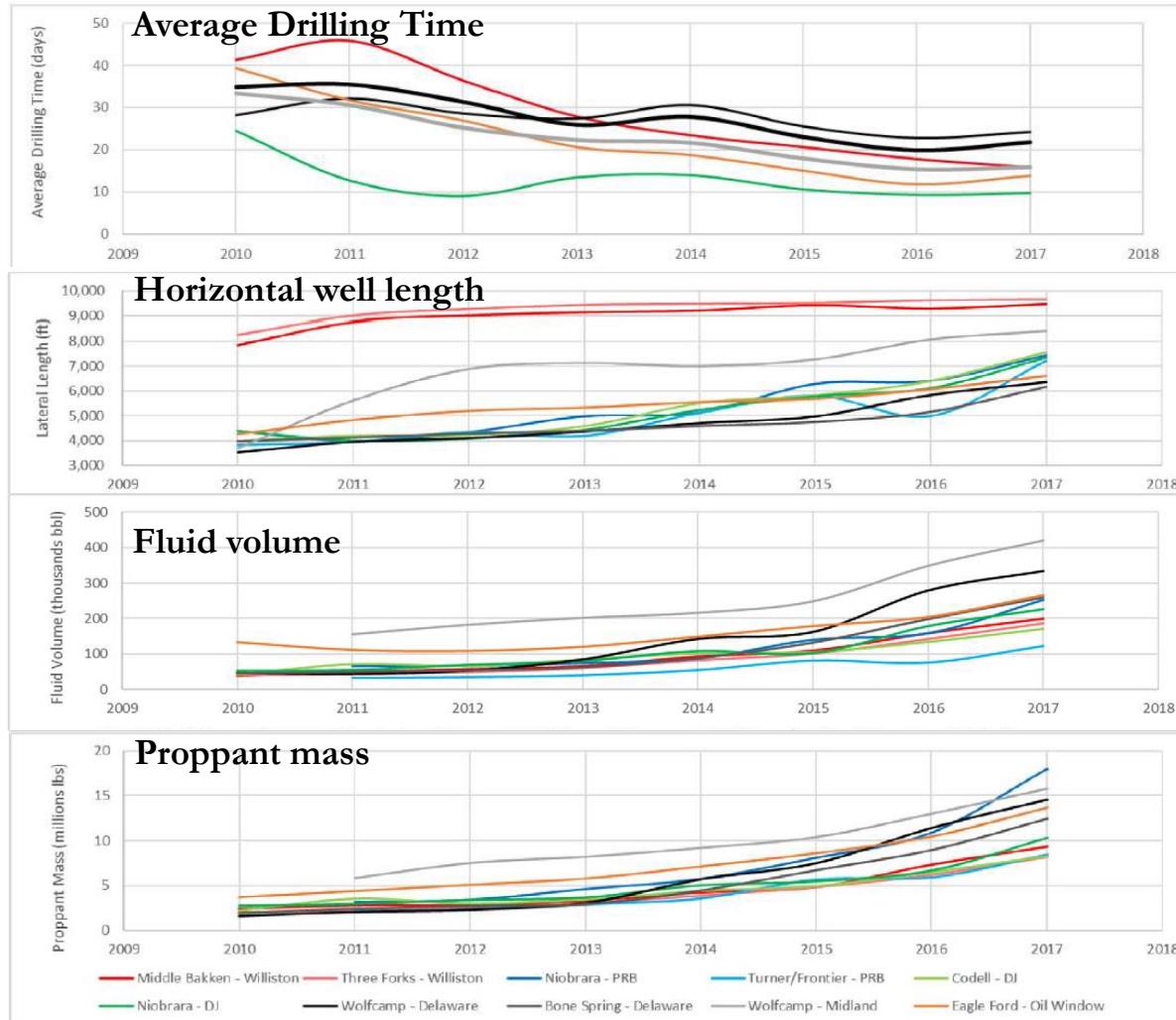


*Plus several others that are either national in scope or focus on operations outside the U.S.

Overview of UOGD exposure-related literature, including risk assessments

- **Regional variability:** Conducted in many of the major oil- and natural gas-producing regions of the United States; unknown how representative of all regions over time.
- **Chemical agent and non-chemical agent levels in environmental media:** Sampling and analytical methods are usually documented clearly.
- **UOGD source:** Some studies linked environmental concentrations to UOGD-related sources, but very often no detail on phases or scale of operations or other possible sources (e.g., conventional oil and gas development) in the study area.
- **Exposure pathway:** Often describe portions of a pathway well, but not an entire exposure pathway linking a UOGD process to an exposed population.
- **Generalizability:** Unclear how well the body of literature represents acute and chronic exposure conditions that can occur across regions, operations, and population over time. Two examples to illustrate why....

Temporal variability – changes in UOGD processes



Source: Weijers et al. 2019.
Trends in the North American
Frac Industry: Invention
through the Shale Revolution.
SPE-194345-MS

Temporal variability – fluctuating levels of development

Crude oil production

- EIA expects U.S. crude oil production to fall from an average of 12.2 million b/d in 2019 to 11.4 million b/d in 2020 and 11.1 million b/d in 2021.

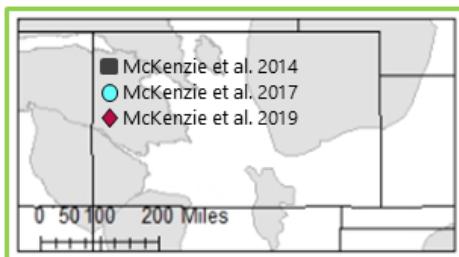
Natural gas production

- EIA forecasts U.S. dry natural gas production will average 89.9 Bcf/d in 2020 and decline to an average of 86.6 Bcf/d in 2021.
 - Production declines the most in the Permian region of Texas, where low crude oil prices can reduce associated natural gas output from oil-directed rigs.
 - EIA expects production to begin rising in the second quarter of 2021 in response to higher natural gas and crude oil prices.

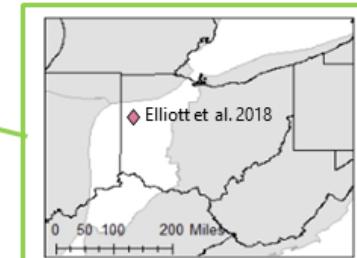
Source: USEIA Short-Term Energy Outlook, September 9, 2020 (<https://www.eia.gov/outlooks/steo/>)

HEI-Energy 2019 review of UOGD environmental epidemiology literature

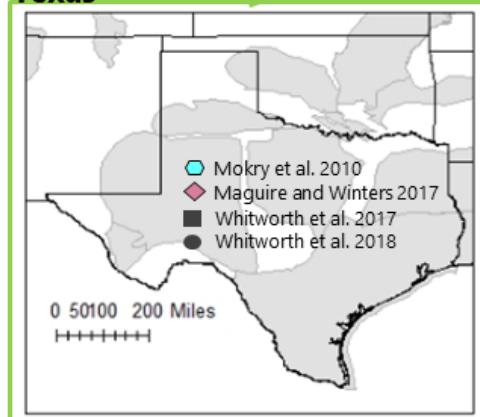
Colorado



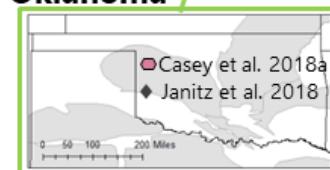
Ohio



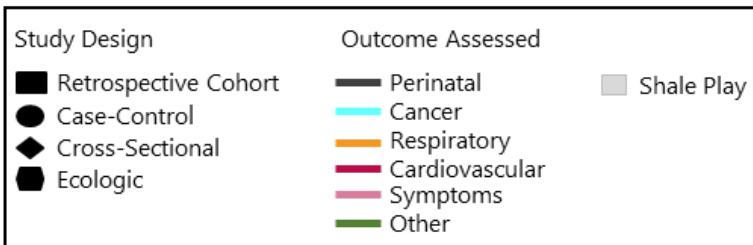
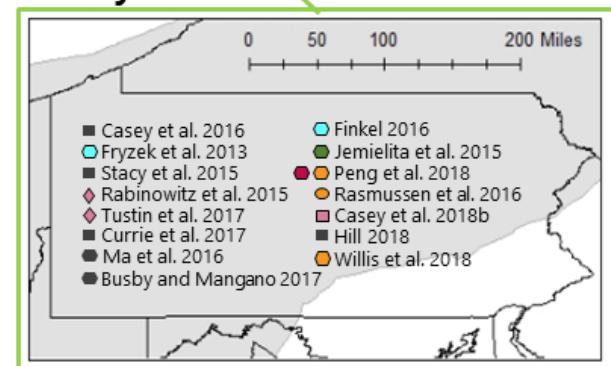
Texas



Oklahoma



Pennsylvania



UOGD epidemiology literature and the “matrix”

Matrix of priority “asks” of epidemiologic studies for each risk assessment step.			
Risk assessment step	Priority “asks” for risk assessment		
Hazard ID	Confirm outcome.	Confirm exposure.	Report methods fully and transparently.
Dose response	Include information on shape of the curve.	Evaluate concordance with previous results.	Describe direction and magnitude of error.
Exposure assessment	Describe source-to-intake pathways.	Describe complete exposure data.	Describe direction and magnitude of error.

Source: Burns et al. 2019

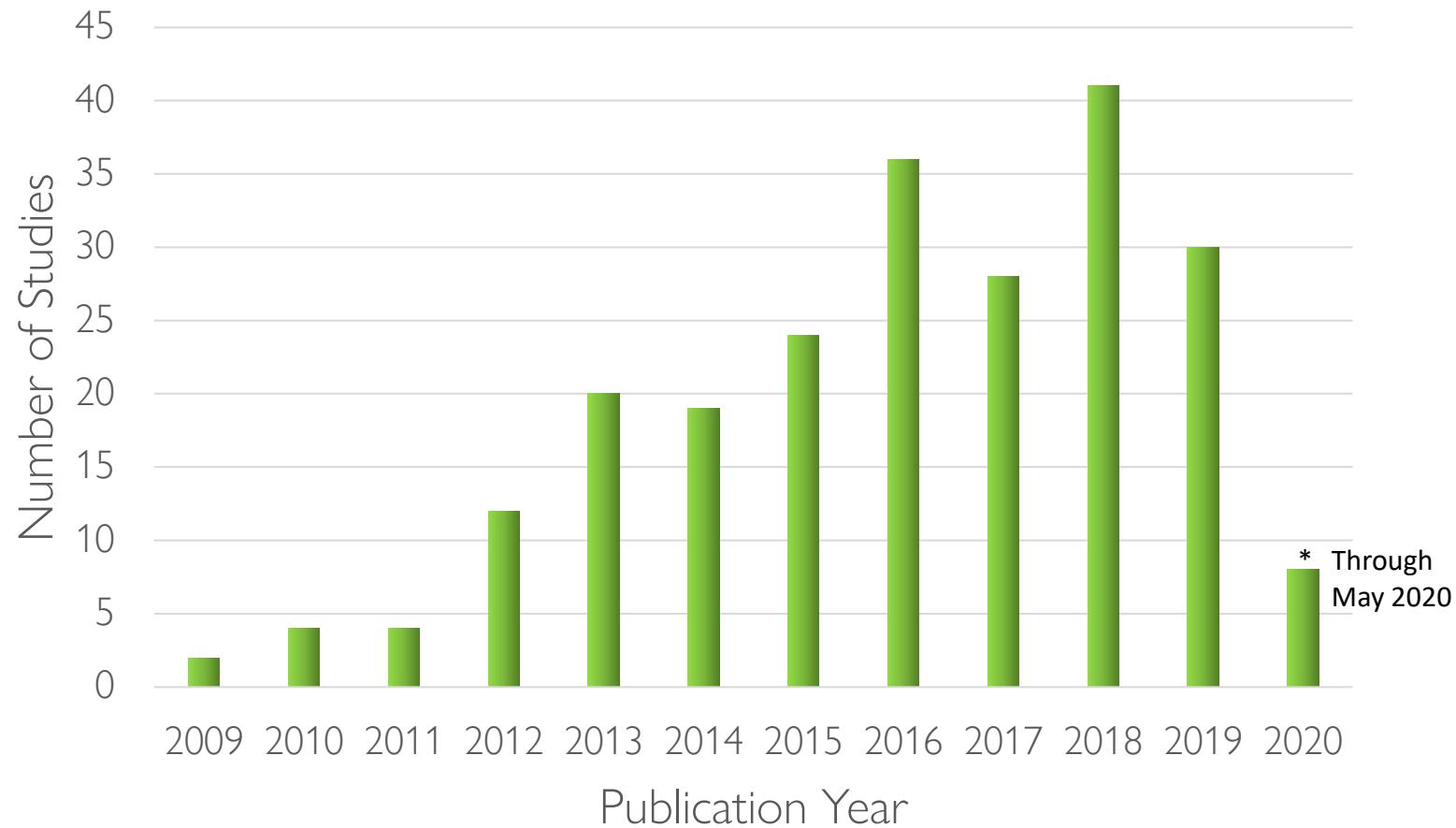
- A tall order to deliver all “asks;” but many studies contribute substantially to some of them
- The HEI Energy Research Committee’s review addresses these matrix topics in some detail, as do other recent literature reviews
- Given our brief time together today, let’s focus on the exposure assessment components of the UOGD epidemiology studies...

Surrogate measures of exposure in epidemiology research

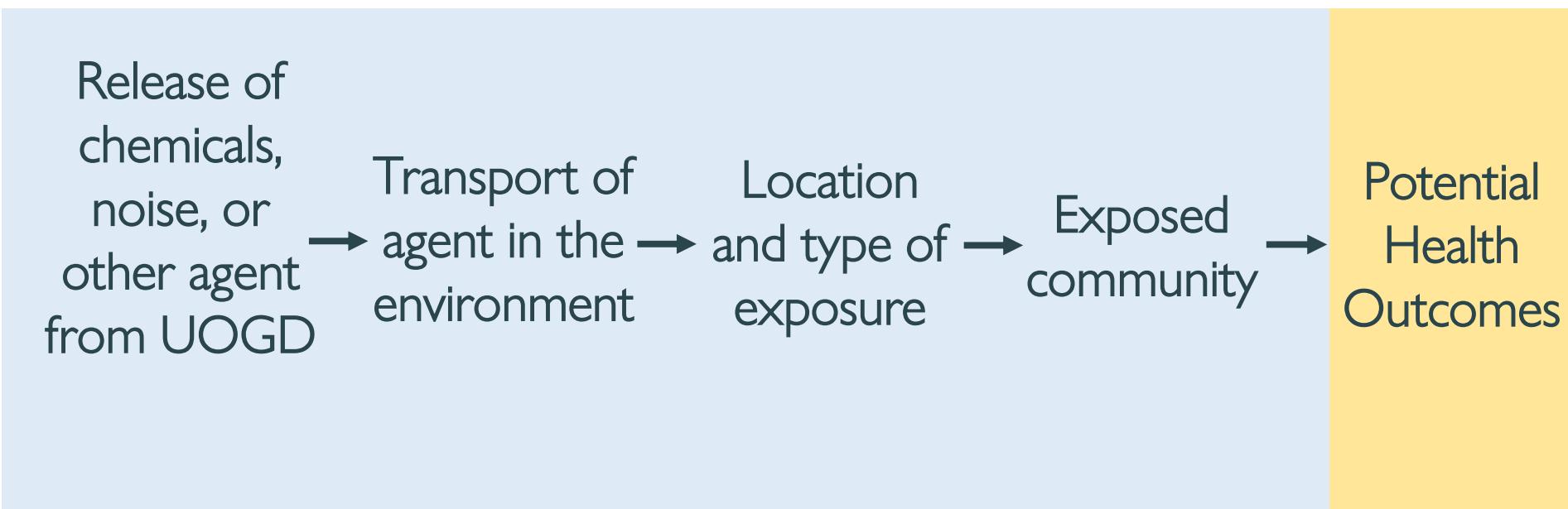
Metric Type	Description
Distance	Distance between household and closest well
Earthquakes	USGS-recorded earthquakes ≥ 4 in magnitude
Emissions	Annual tons of pollutants emitted by zip code
Inverse Distance Weighting	$\text{IDW}_a = \sum_{i=1}^n \frac{1}{d_i}$ $\text{IDW}_a = \sum_{i=1}^n \frac{1}{d_i^2}$ $\text{IDW for separate UOGD phases: Patient } j = \sum_{i=1}^n \frac{X}{d_{ij}^2}$
Spatiotemporal Activity Model	Score incorporating location, number of wells, activity phase, use of green completion, production volume, number of tanks on well pad, and estimated emission rates of select VOCs by phase.
Spud date with time-series component	Product vector with indicator for spud date and proximity indicator
Time-Period	Effect estimates compared between time periods (years; before or after spud date)
Well density or count	Number of ever-spudded wells; number of newly-spudded wells; number of wells ever drilled; number of active wells per km^2 within zip code

Future exposure research and its application to epidemiology and risk assessment

UOGD exposure-related research continues...how can we make it useful for assessing risk to human health?



Reflecting on the matrix...here's what we would like to know to about UOGD exposure pathways to assess health risk





HEI-Energy released Requests for Applications for research in multiple U.S. regions *(Preliminary applications due September 24, 2020)*

Key criteria for exposure research design:

- Be able to document one or more complete exposure pathways, should they exist, between UOGD processes and communities potentially exposed to one or more UOGD agents. In so doing, to distinguish between agents released from UOGD and non-UOGD sources.
- Improve understanding of exposure conditions over temporal and spatial scales relevant for decision making by communities, policy makers, industry, and other stakeholders.
- Maximize the applicability, or generalizability, of research to regions, operations, and communities beyond the study location.
- Collect data or analyze existing data (or establish practical exposure assessment methodologies) useful for assessing the potential for human health effects at resolutions relevant for application in an epidemiology study or risk assessment.



Thank you

U.S. Shale Plays

For more information:

Our website: hei-energy.org

Contact: energy@healtheffects.org