REPRODUCTIVE AND DEVELOPMENTAL TOXICITY OF HYDRAULIC FRACTURING CHEMICALS

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OUTLINE

Background on unconventional natural gas development

- Challenges in exposure assessments

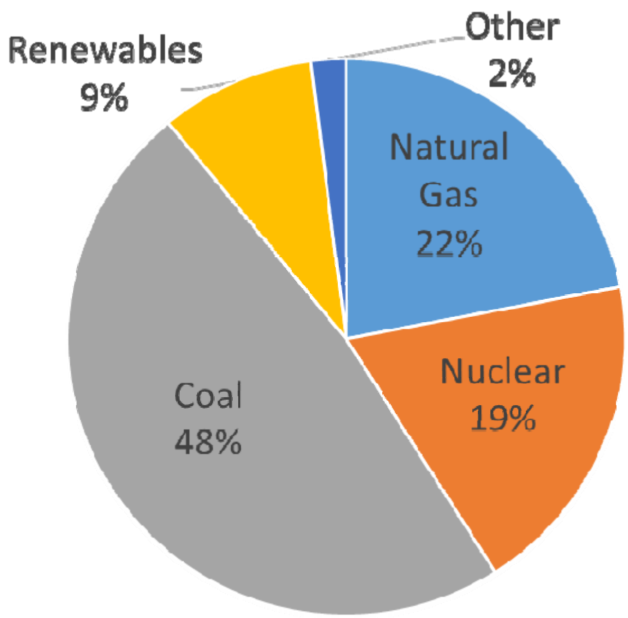
Research Objective & Approach

Results

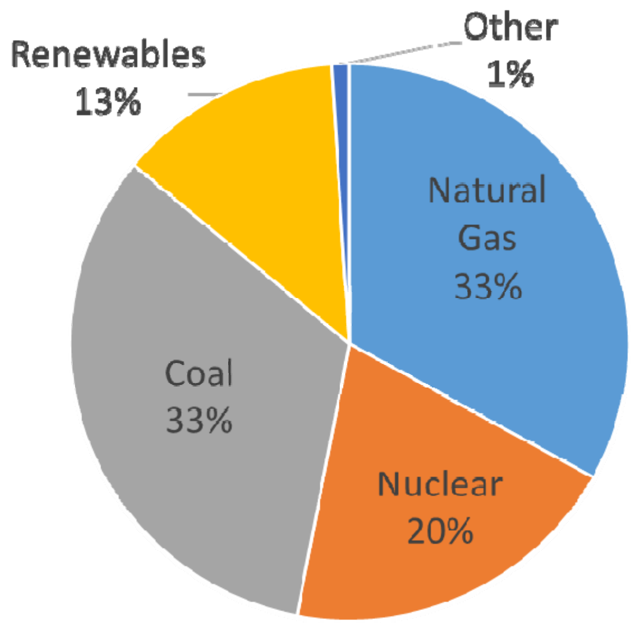
Conclusions

U.S. SOURCES OF ELECTRICITY GENERATION

2007

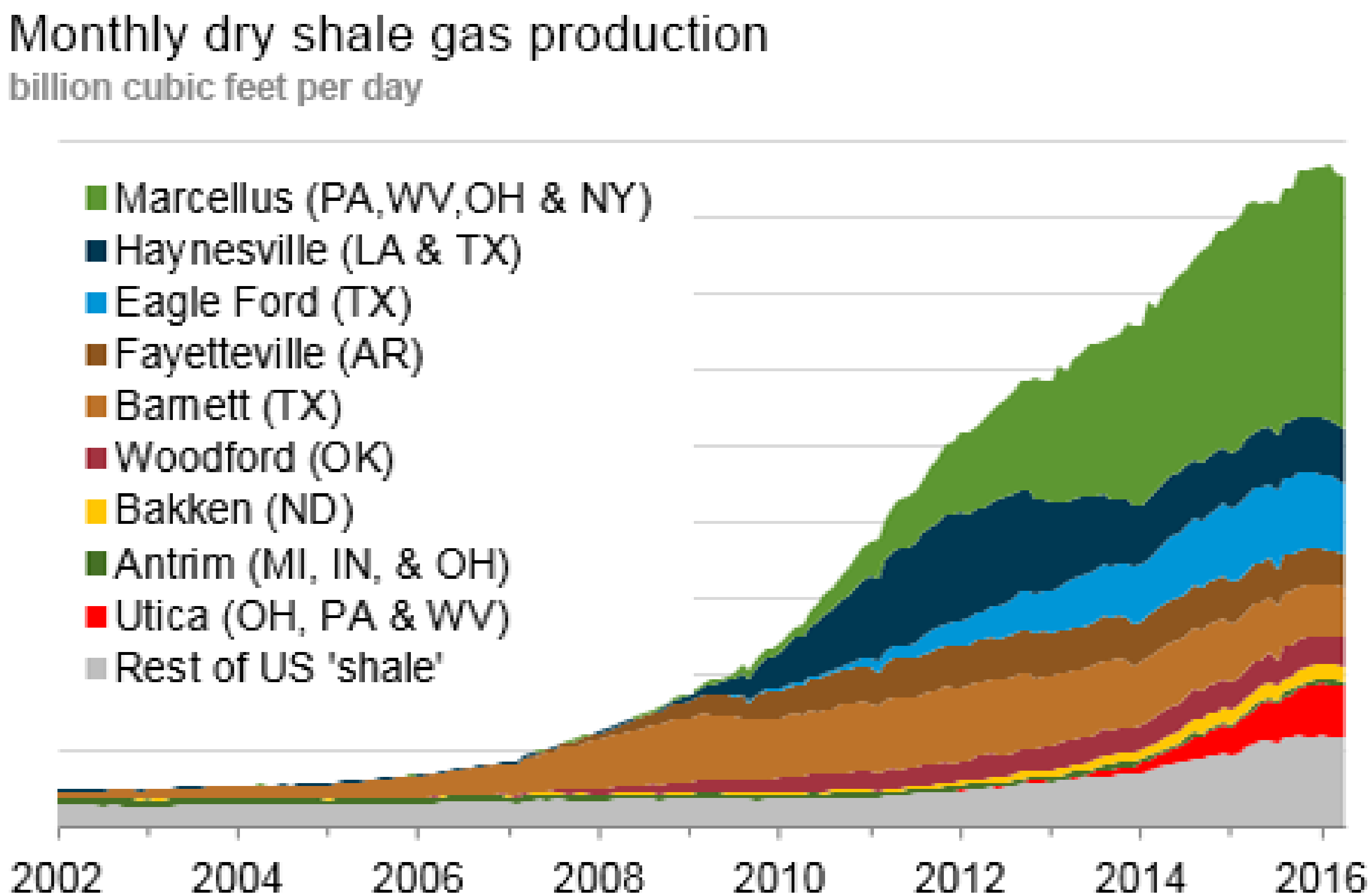


2015



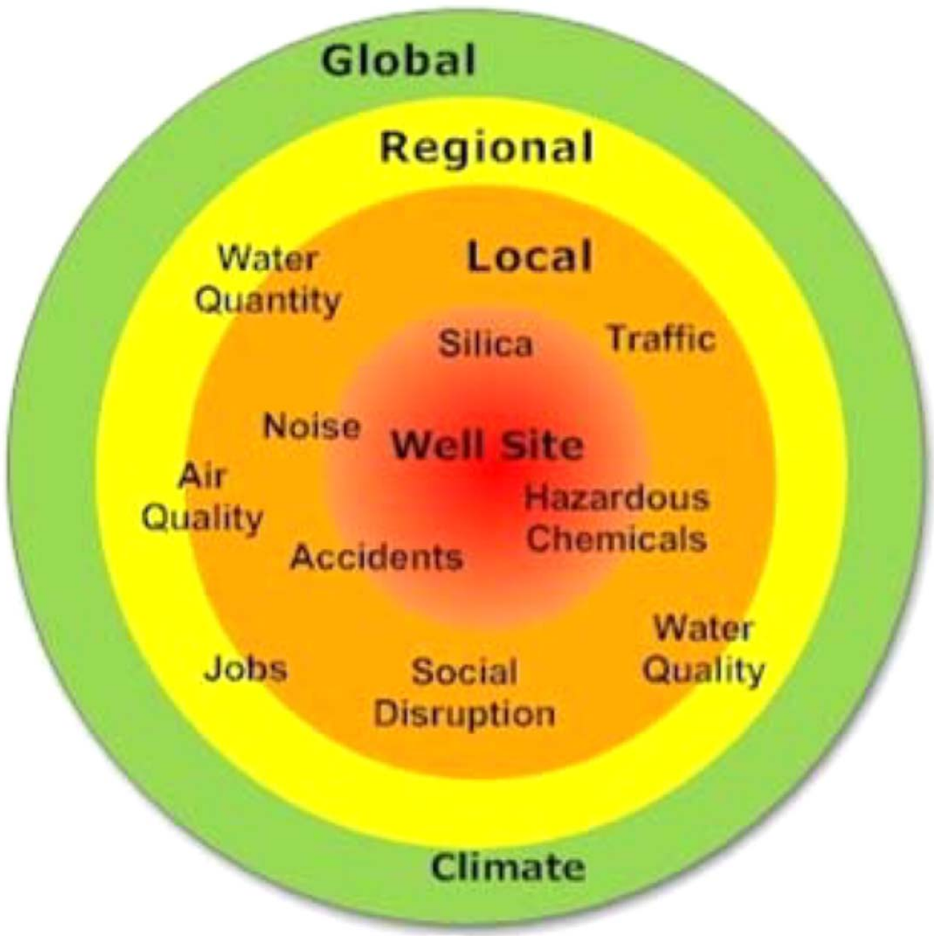
Monthly Energy Review, FAQs
https://www.eia.gov/tools/faqs/

UNCONVENTIONAL NATURAL GAS (UNG) PRODUCTION



http://www.eia.gov/naturalgas/weekly/

POTENTIAL ENVIRONMENTAL HEALTH HAZARDS



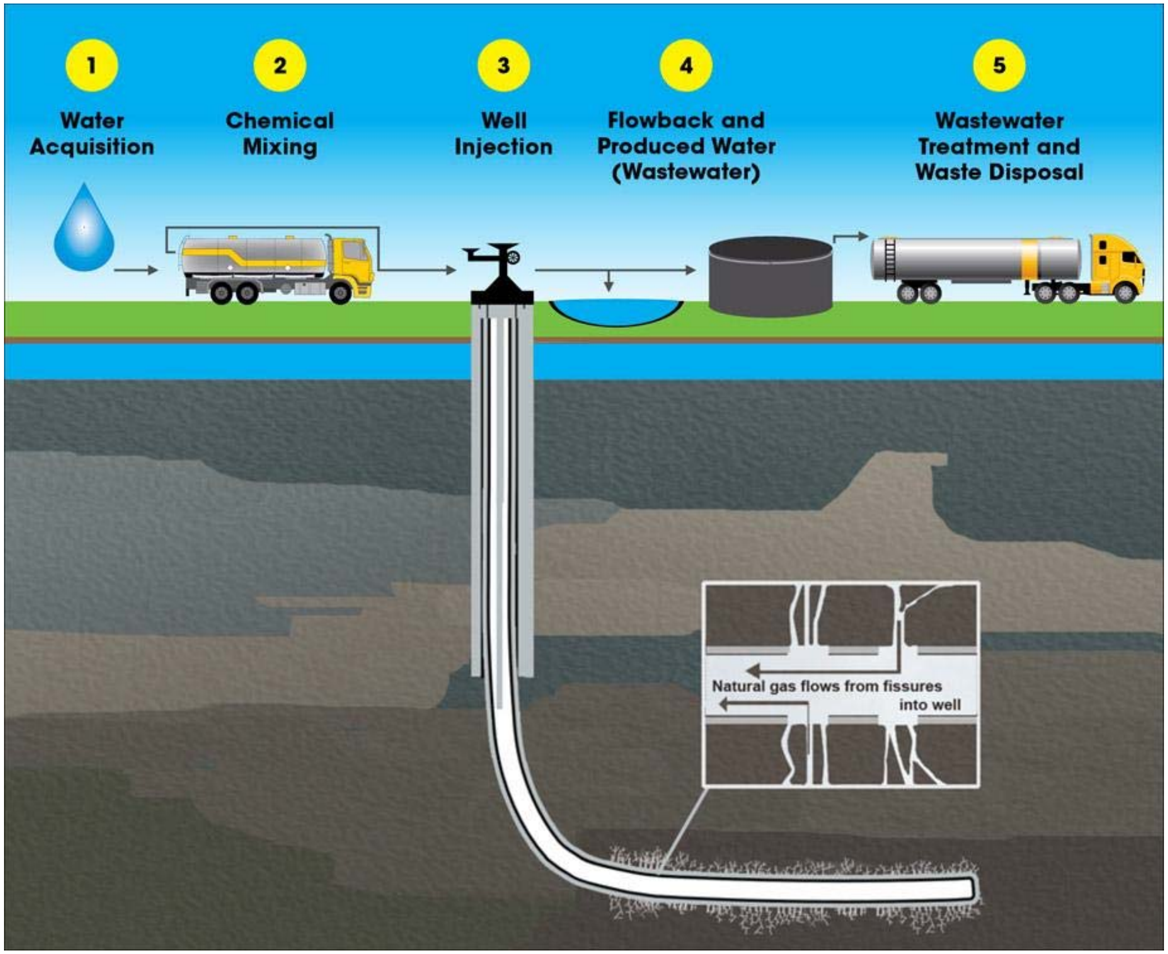
Adgate et al. 2014

POTENTIAL ENVIRONMENTAL HEALTH HAZARDS

Possible sources of endocrine disrupting chemicals (EDCs)

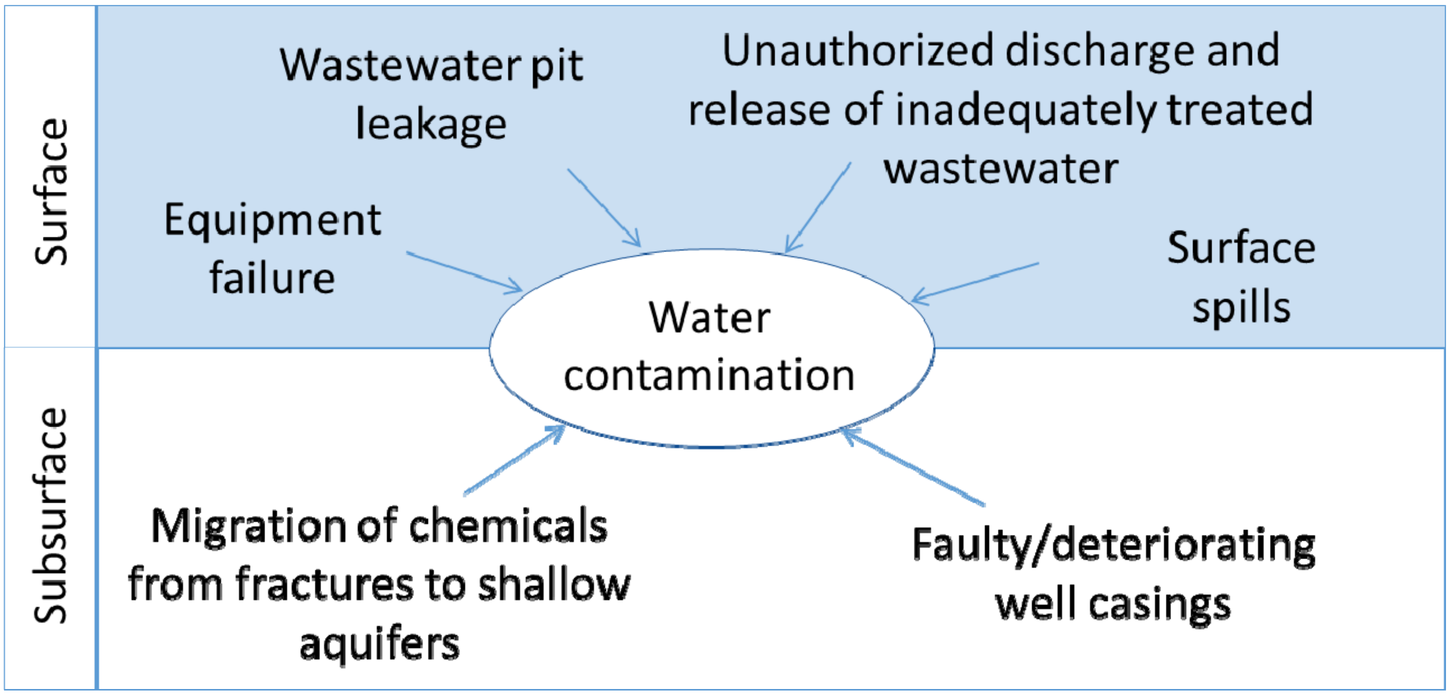
Adgate et al. 2014

OVERVIEW OF UNG DEVELOPMENT

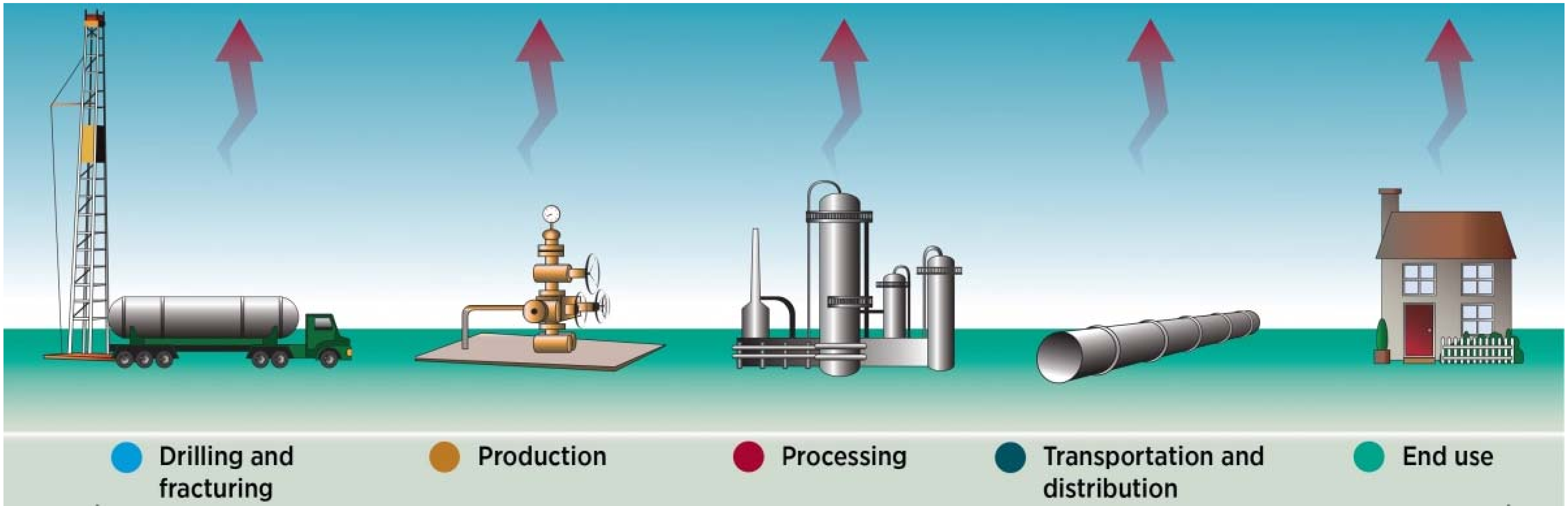


Source: www.epa.gov/hfstudy/hydraulic-fracturing-water-cycle

POTENTIAL PATHWAYS OF WATER CONTAMINATION



POTENTIAL PATHWAYS OF AIR EMISSIONS



Adapted from Brandt et al. 2014

DRILLING SITE IN OHIO

Source: E. Elliott

LIMITED EPIDEMIOLOGIC STUDIES

Childhood leukemia (null) *(Fryzek et al. 2013)*

Self-reported dermal and respiratory irritation
(Rabinowitz et al. 2014)

Hospitalizations *(Jemielita et al. 2015)*

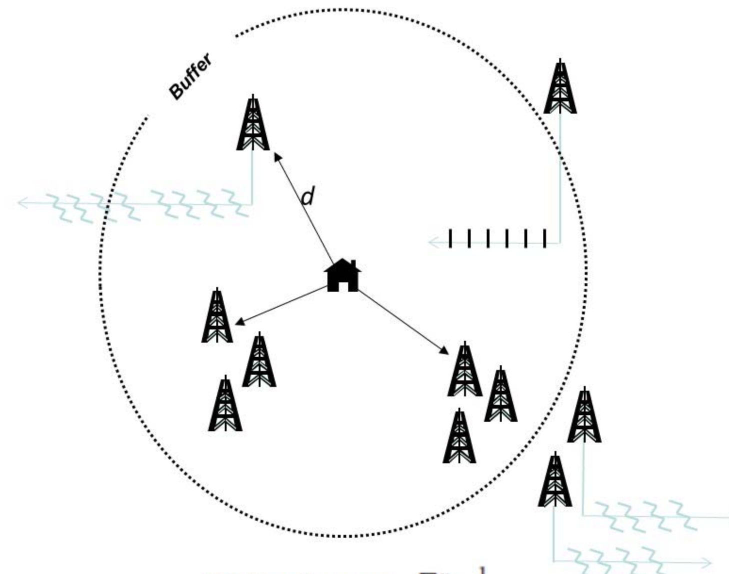
Perinatal outcomes
(McKenzie et al. 2014, Stacy et al. 2015, Casey et al. 2015)

EXPOSURE ASSESSMENT METHODS

\# wells per zip code *(Jemielita 2015)* or county *(Fryzek et al. 2013)*

Inverse distance weighted metric (*McKenzie et al. 2014, Stacy et al. 2015*)

Inverse distance-squared weighted phase-specific intensity model (*Casey et al. 2016*)



IDW well count = $\Sigma_{i=1}^{n} \frac{1}{d_i}$

$$Mother \quad j \quad metric = \sum_{i=1}^{n} \sum_{k=1}^{l} m\left(I_A(k)\right) / {d_{ij}}^2$$

CHALLENGES IN EXPOSURE ASSESSMENTS

Wells treated as collective sources

>1000 potential water/air pollutants

Wide range in physicochemical properties

Incomplete disclosure of agents

Emerging, but limited, measurements of health-relevant chemicals

Other facilities may also be significant sources

RESEARCH OBJECTIVES

Use a screening-level approach to prioritize agents for measurement in exposure and health studies

Systematically evaluate >1000 potential water contaminants for reproductive and developmental toxicity

Determine which chemicals linked to reproductive or developmental toxicity had water quality standards or guidelines

APPROACH

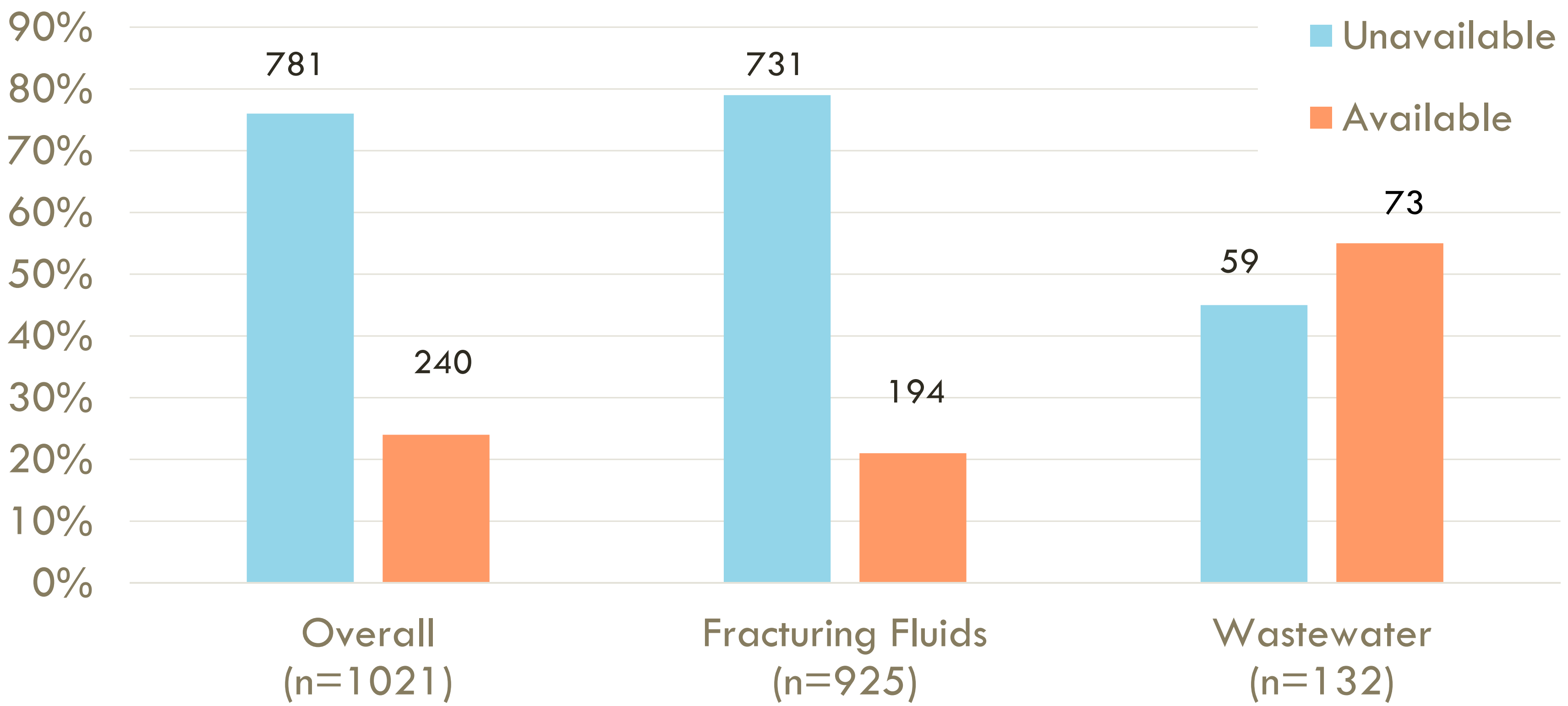
Obtained names and Chemical Abstract Service Registry Numbers for 1,021 chemicals from EPA Progress Report on the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources (2012)

Searched the REPROTOX information system for reproductive and developmental toxicity data and evaluated evidence available from animal and human data

For chemicals potentially linked to repro/developmental toxicity, determined whether they had drinking water standards or guidelines

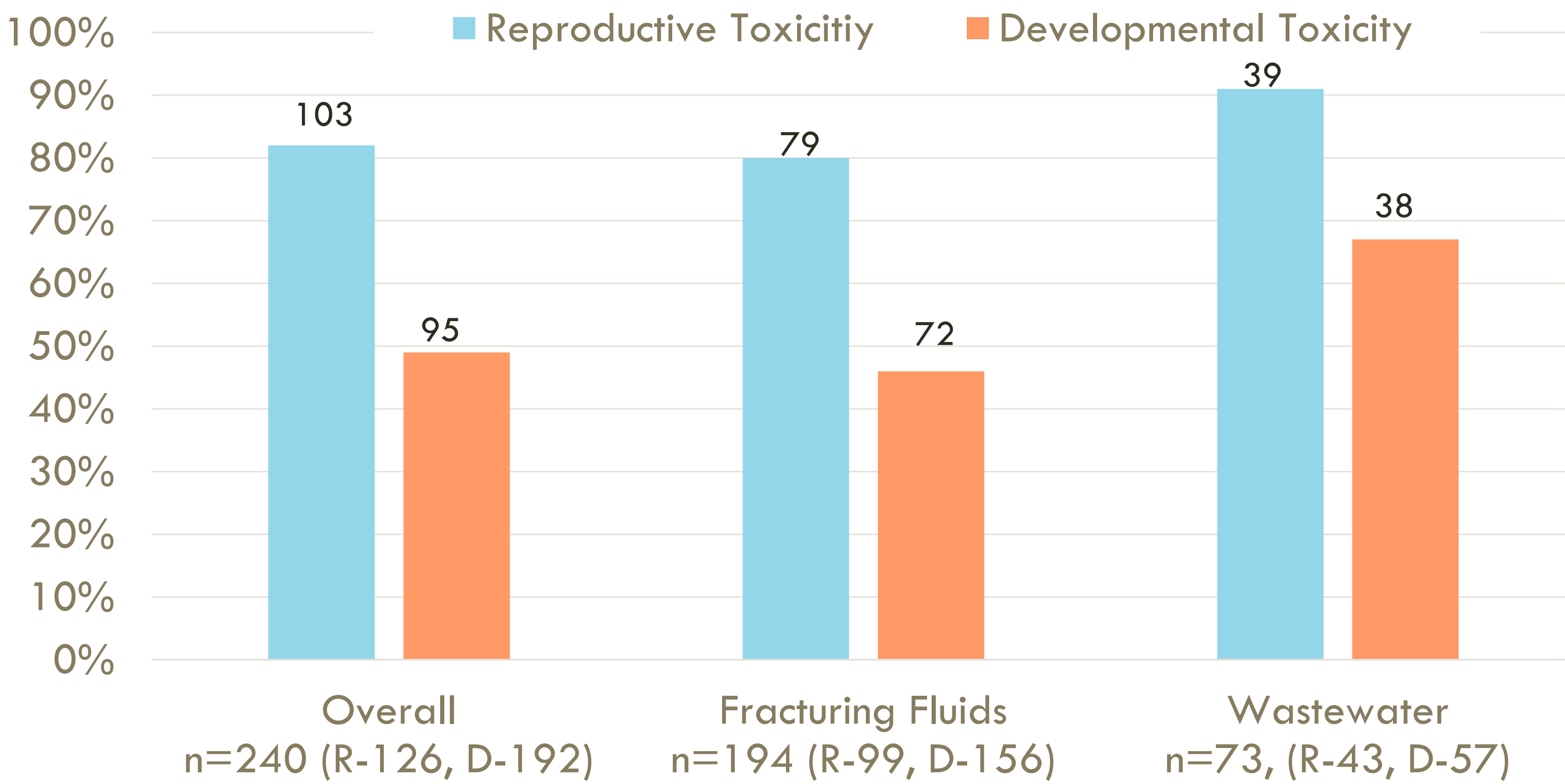
- EPA Maximum Contaminant Level (MCL) or MCL Goal (MCLG), or Oral Reference Dose (RfD), or were on Contaminant Candidate Lists (CCL)

AVAILABILITY OF REPRODUCTIVE/DEVELOPMENTAL TOXICITY INFORMATION



Elliott et al. 2016

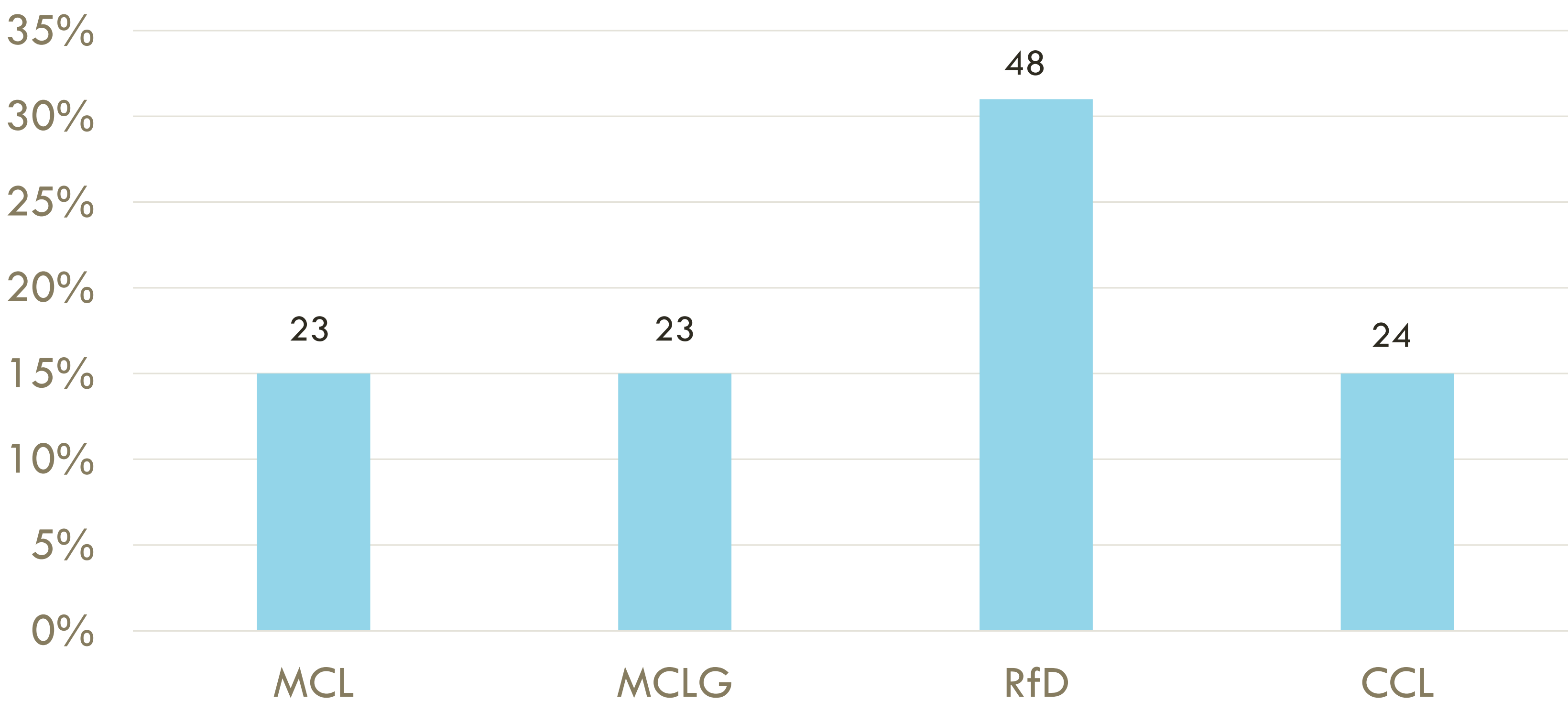
POSSIBLE ASSOCIATIONS WITH REPRODUCTIVE AND DEVELOPMENTAL TOXICITY (N=240)



157 unique chemicals associated with at least one endpoint

Elliott et al. 2016

STANDARDS OR GUIDELINES FOR CHEMICALS WITH POSSIBLE TOXICITY (N=157)



67 unique chemicals possibly associated with reproductive/developmental toxicity have water quality standard or guideline

EXAMPLE CHEMICALS

Examples from fracturing fluids:

1,2-propanediol, acrolein, bisphenol-A, and chlorine dioxide

Examples from wastewater:

metals (e.g., arsenic, cadmium, lead, and mercury)

polycyclic aromatic hydrocarbons (e.g., benzo(a)pyrene)

volatile organic compounds (e.g., benzene and toluene)

other organics (e.g., di(2-ethylhexyl) phthalate and dibutyl phthalate)

LIMITATIONS

Reliance on one publically available database

More inclusive screening approach, not a formal risk assessment

Presence of chemicals alone does not indicate potential for exposure or risk

As more measurement studies become available, results need to be placed into context

Focused only on water

CONCLUSIONS

Constituents of fracturing fluids and waste water linked to reproductive and developmental toxicity

Limited toxicity information available for many substances

Carefully designed, rigorous exposure and epidemiologic studies are urgently needed

The 67 chemicals possibly associated with reproductive or developmental toxicity with a current or proposed drinking water standard or health-based guideline represent a feasible starting point for evaluation in future drinking water exposure studies or human health studies particularly with respect to these outcomes

Further prioritization could be achieved with inclusion of environmental measurements from specific geographic regions of interest, as those data become available, and information on physicochemical properties and toxicologic potency

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