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DRAFT CONCEPT FOR LITERATURE-BASED ANALYSIS OF

MOUNTAINTOP REMOVAL MINING: IMPACTS ON HEALTH IN THE SURROUNDING COMMUNITY

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Summary: OHAT is proposing to conduct an evaluation to identify potential impacts of mountaintop removal (MTR) mining on the health of people living in the surrounding communities and identify key research needs. Depending on the extent and nature of the literature available, level of evidence conclusions for hazard identification may be reached.

BACKGROUND AND RATIONALE

Since its introduction in the 1960s, mountaintop removal (MTR) mining is a major method of coal mining in and around Central Appalachia (including parts of Kentucky, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia) because it is typically faster, cheaper, and less labor intensive than underground mining (Holzman 2011). This mining method involves clearing the area of trees and topsoil and using explosives to blast apart the mountain rock to access coal seams (Palmer *et al.* 2010). The excess rock (i.e. mine spoil) is often pushed into adjacent streams (i.e. valley fill). The air, water, and soil in the surrounding area are impacted by these mining practices and have the potential to adversely impact human health and the environment (Simmons *et al.* 2008, Palmer *et al.* 2010, Acton *et al.* 2011). These exposures include particulate matter, polycyclic aromatic hydrocarbons, metals, and other potentially harmful substances (Palmer *et al.* 2010).

Several recent peer-reviewed papers have investigated rates of birth defects (Ahern *et al.* 2011, Lamm *et al.* 2015), cancer (Hendryx *et al.* 2012), cardiovascular disease (Esch and Hendryx 2011), hospitalization (Brink *et al.* 2014, Talbott *et al.* 2015), general quality of health (Zullig and Hendryx 2011, Woolley *et al.* 2015b), and mortality (Hendryx 2009, Woolley *et al.* 2015a) in communities affected by MTR mining – with varied results.

Overall Objective

The overall objective of this evaluation is to understand the human health impacts of MTR mining by conducting a systematic review of published studies of MTR mining and community health, occupational studies of MTR mining, and any available animal and in vitro experimental studies of exposures to MTR mining-related mixtures.

Considerations for Literature-Based Analyses

- There are few studies of community health effects of MTR mining and those available are predominantly of limited size and scope. Thus, utilizing a comprehensive literature search including other types of data may inform interpretation of the community health studies. For example, recognizing issues such as differences in exposure, evaluating consistency of health outcomes identified in occupational studies with those identified in community studies might assist in assessing plausibility of causation.

- Observational epidemiology studies must properly account for all potential sources of confounding. Lower socioeconomic status, smoking, and reduced access to health care are all factors they may be associated with both the observed health effects and living near MTR mining. A systematic review including a transparent evaluation of confounding and other aspects of internal validity (risk of bias) will help document the relative strengths and weaknesses of each study's design and conduct as well as identify areas for improvement in future research in this area.

- Experimental studies allow for a controlled exposure to mining-related mixtures to test biological hypotheses generated by human observational studies. When available, experimental animal and *in vitro* studies provide context for interpreting the human literature.

- Unlike relatively contained underground coal mining, MTR mining can expose the surrounding community to hazardous materials, particularly air particulate matter. Such complex mixture exposure scenarios include metals with other components of air particulate matter and selenium with other water pollutants (Palmer *et al.* 2010). Identifying risks from specific sources and their individual components is extremely difficult in observational epidemiological studies of communities. Most currently available studies consider residence near mining activities as a proxy for exposure. Studies that characterize exposures related to MTR mining (i.e. environmental monitoring) will be identified by the systematic review and summarized to provide context for the observed human health studies. Toxicity studies of individual components will not be included in the systematic review, but considered as relevant background material.

Utility of the Systematic Review

- A comprehensive approach will collect all published literature relevant to community health effects of mountaintop removal mining

- Critical appraisal of the risk of bias in these studies will identify ways to strengthen the design and conduct of future studies

- Integration across multiple evidence streams can help prioritize areas for future research

PROPOSED LITERATURE-BASED ANALYSIS

Systematic review of community health effects of mountaintop removal (MTR) mining

1. Identify literature reporting the effects of exposure to MTR or other coal mining practices in Appalachia, including other forms of surface mining, in human, experimental animal, and in vitro model systems[1] (see Appendix I literature search strategy).
2. Extract data on potential health effects from relevant studies.
3. Assess the internal validity (risk of bias) of individual studies.
4. Summarize the extent and types of evidence available.

The following steps will depend on the extent and nature of the available evidence (i.e., number and similarity of studies):

5. Synthesize the evidence, including meta-analyses if appropriate, considering limitations on data integrating such as study design heterogeneity. Conduct sensitivity analyses to consider variation in community/occupational, MTR/unspecified mining, and pre-1980/post-1990 effect estimates.
6. Rate confidence in the body of evidence for human and animal studies separately according to one of four statements: High, Moderate, Low, or Very Low/No Evidence Available.
7. Translate confidence ratings into level of evidence of health effects for human and animal studies separately according to one of four statements: High, Moderate, Low, or Inadequate.
8. Combine the level of evidence ratings for human and animal data and consider the degree of support from mechanistic data to reach one of five possible hazard identification conclusions: Known, Presumed, Suspected, Not classifiable, or Not identified to be a hazard to humans.

A protocol for these steps using the OHAT Approach for Systematic Review and Evidence Integration will be developed based on the Handbook for Conducting Literature-Based Health Assessments (Rooney *et al.* 2014, NTP 2015).

[1] Limited to experimental studies of mountaintop removal mining-related mixtures, not individual components.

To address our overall objective we developed PECO (Population, Exposure, Comparators and Outcomes) statements. The PECO statement is used as an aid to develop the specific research questions, search terms, and inclusion/exclusion criteria for the systematic review (Higgins and Green 2011).

Table 1. PECO (Population, Exposure, Comparator and Outcome) Statement	
PECO Element	**Evidence**
Population	Humans without restriction based on age, sex, or lifestage at exposure or outcome assessment; experimental animal and in vitro systems that are used as models of human health.
Exposure	Exposure to mountaintop removal mining activities including residential proximity or occupational exposure, environmental measures (e.g., air, water levels), or experimental exposure to a MTR mining-related mixture (not single components)
Comparators	A comparison population exposed to lower levels (e.g. greater distance of residence from exposure or no exposure/exposure below detection levels) or vehicle-only treatment controls in experimental studies
Outcomes	Any health-related effect or change in physiological or cellular response

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Talbott EO, Sharma RK, Buchanich J, Stacy SL. 2015. Is there an association of circulatory hospitalizations independent of mining employment in coal-mining and non-coal-mining counties in west virginia? *Journal of occupational and environmental medicine / American College of Occupational and Environmental Medicine* 57(4): e30-36.

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Zullig KJ, Hendryx M. 2011. Health-related quality of life among central Appalachian residents in mountaintop mining counties. *American journal of public health* 101(5): 848-853.

APPENDIX I. MOUNTAINTOP REMOVAL MINING SEARCH TERMS

	Mountaintop Mining	Appalachia Coal Mining	Total
Embase	(mountaintop OR 'mountain top'):ab,ti AND (anthracite OR bituminous OR coal OR mine OR mines OR mining OR removal):ab,ti = 47	((Appalachian Region OR Appalachia* OR Kentucky OR Ohio OR Pennsylvania OR Tennessee OR Virginia OR "West Virginia"):ti,ab AND coal mining/exp) OR ((Appalachia*:ti,ab OR Kentucky:ti,ab OR Ohio:ti,ab OR Pennsylvania:ti,ab OR Tennessee:ti,ab OR Virginia:ti,ab OR "West Virginia":ti,ab) AND (anthracite:ti,ab OR bituminous:ti,ab OR coal/exp OR coal:ti,ab) AND (mining/exp OR mine:ti,ab OR mines:ti,ab OR mining:ti,ab)) = 310	357
PsycINFO	(mountaintop OR "mountain top") AND (anthracite OR bituminous OR coal OR mine OR mines OR mining OR removal) =12	(Appalachia* OR Kentucky OR Ohio OR Pennsylvania OR Tennessee OR Virginia OR "West Virginia") AND (anthracite OR bituminous OR coal) AND (mine OR mines OR mining) =59	71
PubMed	((mountaintop OR "mountain top") AND (anthracite OR bituminous OR coal OR mine OR mines OR mining OR removal)) = 39	((Appalachian Region[mh] OR Appalachia*[tiab] OR Kentucky[tiab] OR Ohio[tiab] OR Pennsylvania[tiab] OR Tennessee[tiab] OR Virginia[tiab] OR "West Virginia"[tiab]) AND coal mining[mh]) OR ((Appalachian Region[mh] OR Appalachia*[tiab] OR Kentucky[tiab] OR Ohio[tiab] OR Pennsylvania[tiab] OR Tennessee[tiab] OR Virginia[tiab] OR "West Virginia"[tiab]) AND (anthracite[tiab] OR bituminous[tiab] OR coal[mh] OR coal[tiab]) AND (mining[mh] OR mine[tiab] OR mines[tiab] OR mining[tiab])) =319	329
Scopus	TITLE-ABS((mountaintop OR "mountain top") W/6 (anthracite OR bituminous OR coal OR mine OR mines OR mining OR removal)) =178	TITLE-ABS((Appalachia* OR Kentucky OR Ohio OR Pennsylvania OR Tennessee OR Virginia OR "West Virginia") AND (anthracite OR bituminous OR coal) AND (mine OR mines OR mining)) =1646	1824
Toxline	(mountaintop OR "mountain top") AND (anthracite OR bituminous OR coal OR mine OR mines OR mining OR removal) =9 (excl. PubMed records)	((Appalachia* OR Kentucky OR Ohio OR Pennsylvania OR Tennessee OR Virginia OR "West Virginia") AND (anthracite OR bituminous OR coal) AND (mine OR mines OR mining)) = 742 (excl. PubMed records)	751
Web of Science	TS=((mountaintop OR "mountain top") NEAR/6 (anthracite OR	TS= ((Appalachia* OR Kentucky OR Ohio OR Pennsylvania OR Tennessee	953

	Mountaintop Mining	**Appalachia Coal Mining**	**Total**
	bituminous OR coal OR mine OR mines OR mining OR removal)) =134	OR Virginia OR "West Virginia") AND (anthracite OR bituminous OR coal) AND (mine OR mines OR mining)) =819	
SUBTOTAL REFS			**4285**
DUPLICATES			**(1302)**
TOTAL REFS			**2983**

- "Mountaintop" terms identified studies that specified mountaintop removal within the citation. Because MTR mining is currently the predominant form of coal mining in the Appalachian Region of the US, the addition of "Appalachia" terms was necessary to capture studies that did not specify mountaintop mining.

- Terms for other "open" mining practices (e.g. strip mining) were also considered to identify potentially relevant studies, but these results predominantly included coal mining in regions where MTR mining is not allowed and mining of things other than coal. Due to a significant increase in the number of references retrieved and limited utility of the majority of these studies, these terms are not included in the proposed literature search strategy.

- When the systematic review is conducted, the reference lists of included studies and relevant reviews will be searched for additional relevant publications.

- The list of included (and excluded) studies will also be posted on the OHAT website prior to release of a draft report as an additional strategy to identify potentially relevant studies that may have been missed during the literature search.