

The Health Impacts of Mountaintop Removal Mining



*A Report to the National Commission on the
Health Impacts of Mountaintop Removal Mining*

A CALL FOR CONGRESSIONAL ACTION

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April 2013

Center for Health, Environment & Justice

Acknowledgements

Sponsored by the Center for Health, Environment & Justice (CHEJ)

With comments from the National Commission on the Health Impacts of Mountaintop Removal Mining

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CHEJ also wishes to acknowledge the people of Appalachia whose lives have been forever altered by mountaintop removal mining. Their stories serve as a vivid depiction of the impacts of MTR mining on human health and the quality of life.

About The Center for Health, Environment & Justice

CHEJ is a national organization that helps people build democratic, community based organizations to prevent harm from toxic chemical hazards. CHEJ works with the environmental health and justice movement to eliminate harmful toxic exposures in communities impacted by hazardous waste sites, chemical plants and other polluting industries, as well as eliminate unsafe products used in homes, schools and other facilities. CHEJ mentors and empowers community based groups to become effective in achieving their goals and build a national environmental health and justice movement where every community is safe to live, work, pray and play without toxic hazards. CHEJ has assisted more than 11,000 groups nationwide.

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Cover photo courtesy of OVEC - Maria Gunnoe walks along a gulley that used to be her yard--until flooding of the valley fill above her home washed part of her yard away.

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STATEMENT OF THE NATIONAL COMMISSION ON THE HEALTH IMPACTS OF MOUNTAINTOP REMOVAL MINING

April 2013

This report is sponsored by the Center for Health, Environment & Justice. We solicited environmental and health experts, as part of a National Commission on Health Impacts of Mountaintop Removal Mining, for their review and opinion on this report and for recommendations that will help to improve our understanding of the interactions between mountaintop removal mining, the environment, and human health. Their statement follows.

In 2011 a group of researchers from West Virginia University and Washington State University published a study on the association between exposure to mountaintop removal (MTR) mining and the increased rate of birth defects in Central Appalachia. Birth defect rates are considered a sensitive indicator of environmental exposures, and the study by Ahern and co-authors was a significant contribution to a growing body of scientific evidence linking MTR mining to human health disparities in Appalachia. This evidence includes increases in self-reported cancer rates and chronic cardiovascular mortality rates. Despite this growing body of evidence, little attention has been paid to the adverse health impacts of MTR mining or to strategies that could mitigate such impacts.

The following report, undertaken by the Center for Health, Environment & Justice summarizes some of the major scientific findings related to the human health effects due to MTR mining in order to identify actions necessary to mitigate and eventually eliminate such health disparities. Particular attention is paid to the individual level, medically-verified health outcomes reported by Ahern and co-authors.

The Center for Health, Environment & Justice asked this Commission to review the attached document. Having done so, the Commission strongly supports the findings in the report and, based on the evidence provided, we have developed recommendations that the Commission believes will advance our understanding of the interactions between mountaintop mining and human health. The Commission's recommendations are as follows:

- 1) Preventative action in the face of uncertainty is warranted. The findings in this report make clear that there is sufficient documentation of the hazards of MTR mining to place an immediate moratorium on MTR mining until such time as health studies have been conducted that provide a clearer understanding of the associations between adverse health impacts, notably adverse reproductive outcomes, and MTR mining. In addition, during the moratorium period, appropriate safeguards including remediation and engineering controls should be implemented to mitigate air and water pollution related to MTR mining activities.
- 2) The studies conducted by Ahern (2011), Hendryx (2011a and b), and Esch & Hendryx (2011) provide sufficient evidence to warrant follow-up studies to assess the specific health impacts of MTR mining. This research could include evaluating human exposure

to toxic chemicals related to MTR mining activities and their relationships with specific health impacts.

- 3) More information is needed on human exposure to pollutants in ambient air, groundwater and drinking water that result from MTR mining activities. Future studies should evaluate environmental samples (air, soil, surface water and groundwater) from MTR-area communities as well as the fate and transport of contaminants and uptake by humans.
- 4) It is important to examine health impacts of MTR mining. Birth defects may be one important factor, but other health outcomes as well as biomarkers of exposure need to be evaluated as well. It would also be valuable to evaluate the biological mechanisms by which contaminant by-products of MTR mining might lead to adverse health outcomes including birth defects. Case control studies using birth defect registry-ascertained cases with parental interviews should be considered to obtain additional risk factor information.
- 5) Corporations involved in MTR operations benefit financially from the coal that they extract. Therefore, they have a responsibility to fund the research on the health and environmental impacts of their process and activities. Other corporate sectors have funded independent organizations such as the Health Effects Institute (HEI), which is sponsored in part by the motor vehicle industry to conduct research on the health and environmental impacts of air pollution (HEI, 2010). Such organizations have been successful in funding high-quality, independent research that is ultimately accepted for publication in peer-reviewed journals. Thus, industries involved in MTR mining should develop a mechanism to fund research on the adverse health effects and exposure routes associated with MTR mining that includes a firewall to protect the research from industry influence which will damage the credibility of the research.

This Commission believes these recommendations are necessary actions to ensure the health and safety of the residents of Appalachia who are impacted by mountaintop removal mining.

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EXECUTIVE SUMMARY

This report was prepared to review the most significant studies on the human health impacts of mountaintop removal (MTR) mining. A group of experts on health and environment were commissioned to review this report and provide recommendations to improve our understanding of the interactions between MTR mining, the environment, and human health. The recommendations of the Commission are included as part of this report.

1. BACKGROUND

MTR mining is defined as removal of all or some portion of the mountain or ridge to access one or more coal seams. It results in significant large-scale impairment to local topography compared to other types of surface or underground mining, and is highly associated with environmental pollution and degraded soil, water, and air quality. MTR mining has become the primary method of coal mining in the Appalachian Mountains, where coalfields cover about 12 million acres of land in Kentucky, Tennessee, Virginia and West Virginia.

2. HEALTH IMPACTS OF MOUNTAINTOP REMOVAL MINING

Recent studies have revealed significant possible associations between MTR mining and health disparities in Central Appalachia. According to these studies, self-reported cancer rates and chronic cardiovascular mortality rates are significantly higher in areas where MTR mining occurs, even after controlling for covariates like respondent age, sex, smoking status, occupational history, or family history. One of the most pronounced health impacts associated with MTR mining is elevated rates of birth defects in Central Appalachia. Reproductive outcomes including birth defects are considered a sensitive indicator of toxic chemical exposures. Both MTR mining and poverty are independently associated with age-adjusted mortality rates, and the prevalence of mental health disorders and psychological distress is also elevated in MTR areas compared to national prevalence rates. Because MTR-exposed counties are associated with serious environmental degradation and elevated morbidity and mortality,

residents report significantly lower health-related quality of life than residents of non-MTR areas.

3. BIRTH DEFECTS IN COUNTIES WITH MOUNTAINTOP REMOVAL MINING

The Ahern (2011) study found birth defect rates to be 26% higher in MTR regions of Central Appalachia compared to non-mining areas. Furthermore, the prevalence of birth defects in Central Appalachia was positively correlated with MTR mining activity. Ahern (2011) utilized individual level, medically-verified health outcomes in the form of birth defects, and the Agency for Toxic Substances and Disease Registry (ATSDR) found that “the available published evidence is sufficiently strong to warrant further epidemiological research into the potential public health impacts of mountaintop removal activities.”

Study limitations include a lack of information on human exposure to MTR mining pollutants and the use of potentially inaccurate birth certificate data in the analysis of birth defects and covariates. However, while additional research is needed to definitively link MTR mining as an independent risk factor of birth defect disparities, this study is so far the most significant demonstration of how Appalachian health disparities are concentrated in MTR areas. An elevated rate of birth defects may result in higher levels of disability for future generations. Such disabilities may hinder economic productivity and societal prosperity in a region already struggling with poverty, low levels of education, and inadequate healthcare.

4. RECOMMENDATIONS OF THE COMMISSION

If the U.S. is to effectively eliminate MTR-related health disparities in Central Appalachia, investments must be made in research, regulations, and mitigation actions related to MTR mining operations. The recommendations below are offered to increase our understanding of the public health and environmental impacts of MTR mining. However, the residents of Central Appalachia should not have to continue to suffer from the impacts of MTR mining while this critical research is conducted.

- 1) Preventative action in the face of uncertainty is warranted. The findings in this report make

clear that there is sufficient documentation of the hazards of MTR mining to place an immediate moratorium on MTR mining until such time as health studies have been conducted that provide a clearer understanding of the associations between adverse health impacts, notably adverse reproductive outcomes, and MTR mining. In addition, during the moratorium period, appropriate safeguards including remediation and engineering controls should be implemented to mitigate air and water pollution related to MTR mining activities.

- 2) The studies conducted by Ahern (2011), Hendryx (2011a and 2011b), and Esch & Hendryx (2011) provide sufficient evidence to warrant follow-up studies to assess the specific health impacts of MTR mining. This research could include evaluating human exposure to toxic chemicals related to MTR mining activities and their relationships with specific health impacts.
- 3) More information is needed on human exposure to the pollutants in ambient air, groundwater and drinking water resulting from MTR mining activities. Future studies should evaluate environmental samples (air, soil, surface water and groundwater) from MTR-area communities as well as fate and transport of contaminants and uptake by humans.
- 4) It is important to examine health impacts of MTR mining. Birth defects may be one important factor, but other health outcomes as well as biomarkers of exposure need to be evaluated as well. It would also be valuable to evaluate the biological mechanisms by which contaminant by-products of MTR mining might lead to birth defects. Case control studies using birth defect ascertained cases with parental interviews should be considered to obtain additional risk factor information.
- 5) Corporations involved in MTR operations benefit financially from the coal that they extract. Therefore, they have a responsibility to fund the research on the health and environmental impacts of their process and activities. Other corporate sectors have funded independent organizations such as the Health Effects Institute (HEI), which is sponsored in

part by the motor vehicle industry to conduct research on the health and environmental impacts of air pollution (HEI, 2010). Such organizations have been successful in funding high-quality, independent research that is ultimately accepted for publication in peer-reviewed journals. Thus, industries involved in MTR mining should develop a mechanism to fund research on the adverse health effects and exposure routes associated with MTR mining that includes a firewall to protect the research from industry influence which will damage the credibility of the research.

The actions called for by the Commission are in line with recent government initiatives to protect the health of Appalachian communities. In February, 2013 Congressional Representatives re-introduced the Appalachian Communities Health Emergency (ACHE) Act. If passed this bill would require the Department of Health and Human Services to lead a federal investigation of the reported links between MTR mining and human health impacts. Until such an investigation is conducted, the ACHE Act would require a moratorium on all new MTR permits, as well as on any expansion of existing permits. Similarly, the 2012 Central Appalachian Women's Tribunal on Climate Justice, organized by the Loretto Community at the United Nations, the Ohio Valley Environmental Coalition, the Civil Society Institute and the Feminist Task Force of the Global Call to Action Against Poverty, called for immediate moratoriums on MTR mining as well as on the underground injection and surface impoundment of liquid coal sludge until a full investigation on environmental and human health impacts is undertaken.

INTRODUCTION

This report reviews the most significant studies on the human health impacts of mountaintop removal (MTR) mining. A group of experts on health and environment were commissioned to review this report and provide recommendations to improve our understanding of the interactions between MTR mining, the environment, and human health. The recommendations of the Commission are included in this report.

In the 1960s, large mining corporations began to use a new method of surface mining called mountaintop removal (MTR) mining which involved using explosives and heavy machinery to blast away mountain tops and expose valuable seams of coal (Copeland, 2004). Industry utilized this new technique because it was often faster, cheaper, and less labor intensive than more traditional underground mining (Holzman 2011). By the 1990s over 12 million acres throughout Appalachia were being actively mined with this method (Copeland, 2011).

MTR mining requires powerful blasting and deforestation that results in recontoured landscapes and permanent land use changes (Griffith, 2012). The process can crack the walls and foundations of nearby homes, cause dust, noise, and vibration from blasting, collapse drinking water wells, and force the relocation of entire communities (Copeland, 2011). Furthermore, because MTR mining is highly mechanized its use negatively impacts the employment rates and socioeconomic status of surrounding communities (Woods & Gordon, 2011). Such environmental, economic, and societal impacts of MTR mining are becoming increasingly controversial, and have provided incentive for scientific research. Current environmental data indicate that MTR mining results in permanent degradation in the quality and biodiversity of Appalachian forests and watersheds (Acton, 2011; Bernhardt, 2011; Eckstein, 2011; Griffith, 2012; Lindberg, 2011; Palmer, 2010; Petranka, 1998; Pond, 2008; Simmons, 2008; U.S. EPA, 2011). The importance of MTR mining as a determinant of human health outcomes has proven more difficult to establish due to a lack of data about exposures to the toxic substances involved in or released during the process of MTR mining, and

due to the lack of understanding about the impact of these toxic substances on human health.

Over 1.2 million people live in Central Appalachian counties where there is MTR mining (Hendryx, 2011b). These people have long been recognized as suffering health disparities (Zerhouni & Ruffin, 2002; Wood, 2005) and have been targeted by the U.S. government to address and eliminate these disparities (Zerhouni & Ruffin, 2002). Recent studies have examined the potential association between MTR mining and elevated rates of cancer, cardiovascular disease, mortality, and overall health-related quality of life (Hendryx, 2009, 2011a and 2011b; Halverson, 2004; Esch & Hendryx, 2011; Zullig & Hendryx, 2011; and Zhang, 2008). One study in particular is significant because it focuses on the association between MTR mining and birth defects (Ahern, 2011) which is considered a sensitive indicator of environmental exposures (Silbergeld, 2005; Stillerman, 2008). The authors of the study utilized individual-level health outcomes in the form of birth defects and found that the prevalence of birth defects in Central Appalachia was both elevated and positively correlated with MTR mining activity.

Despite these recent findings, little attention has been paid to the growing body of scientific evidence related to adverse health impacts of MTR mining (Palmer, 2010). The present report reviews this body of evidence by summarizing some of the major scientific findings related to the human health effects, with a particular focus on the recently published study by Ahern (2011) of disparities in birth defect rates. We conclude with recommendations to protect the residents of Central Appalachia from MTR mining and to improve our understanding of the relationships between MTR mining, the environment, and human health.

1. BACKGROUND

The Central Appalachian Region, which includes parts of Kentucky, Tennessee, Virginia and West Virginia, produced an estimated average of 12.82 million short tons of coal from March 2012 to February 2013 (U.S. EIA, 2013). An estimated 26 billion tons of coal still remain deposited in thin strips beneath the mountain ridges (Acton, 2011), and as deep coal deposits accessed through underground mines become depleted, the mining industry is shifting even more heavily to MTR mining (Palmer, 2010).

MTR mining is specifically designed for mountainous terrain and has enabled individual mines to expand considerably in size with less manual labor (Lindberg, 2011). This technique has become the primary method of coal mining in the Central Appalachian Mountains (Ferrari, 2009) where coal-producing areas cover about 12 million acres of land in Kentucky, Tennessee, Virginia and West Virginia (U.S. EPA, 2011). The U.S. Environmental Protection Agency (U.S. EPA) estimates that MTR mining will have impacted 6.8% of the Appalachian coalfields by the end of 2012 (U.S. EPA, 2011).

MTR mining is defined as the removal of all or some portion of the mountain or ridge to access one or more coal seams (U.S. EPA, 2011). It results in significant large-scale impairment to local topography compared to other types of surface or underground mining (Zullig & Hendryx, 2011), and it normally occurs in three stages. The first stage involves clearing the site of all vegetation and the uppermost layers of soil (Simmons, 2008). In the heavily forested Appalachian region this stage usually requires complete removal of trees, roots, and topsoil. The second stage requires blasting and removal of up to 984 vertical feet of mountain rock to expose the coal seams. The resulting waste material, also known as spoil or overburden, is then pushed into adjacent valleys (Lindberg, 2011) typically creating massive fills in the uppermost reaches of the valleys and burying mountain streams (Ahern, 2011). Finally, the coal is extracted and the site undergoes a reclamation process, which involves reconstruction to an “approximate” contour, grading with a topsoil substitute, and hydroseeding typically with non-native mixed grasses and legumes (Simmons, 2008). These post-mining sites

are often left as plateaus with non-natives grasses in primitive stages of natural development (Acton, 2011).

MTR operations are unique from all other forms of coal mining in that they result in permanent alterations in hydrogeology and regional land use (Griffith, 2012), creating a fundamentally recontoured landscape and significantly altered hydrology that negatively impacts the quality of local water, soil, and air (Acton, 2011; Ayers, 2007; Simmons, 2008).

According to the U.S. EPA, almost 1,200 miles of headwater streams have been completely buried under valley fills. West Virginia alone has suffered extensive loss of riparian, or riverbank, habitats (U.S. EPA, 2011). Many naturally occurring substances that are released by the extraction process including arsenic, manganese, aluminum and selenium are lethal to aquatic invertebrates. Selenium for example has been shown to bioaccumulate through aquatic food webs (Palmer, 2010) and is associated with death and deformities in fish and reduced hatching rates in birds throughout MTR-affected watersheds (U.S. EPA, 2011). Groundwater contamination also results from mining activities, as valley fills act as artificial aquifers that seep into migrating groundwater (Palmer, 2010).

A significant amount of anecdotal evidence in the region suggests that there is significant degradation of air quality from surface mine blasting associated with MTR mining operations. Surface explosives use significant amounts of ammonium nitrate and diesel fuel (Ayers, 2007) with blasts distributing coal dust, sulfuric flyrock, and fine metal particulates into the ambient air (Ayers, 2007; Ghose & Majee, 2007; Lockwood, 2009). Studies have also shown elevated levels of silica, sulfur compounds, benzene, carbon monoxide, and polycyclic aromatic hydrocarbons (PAH) in the air around surface mining operations (Hendryx, 2011b). The health implications are significant as coal mining particulates are respirable and thus hazardous to both wildlife and human health.

2. HEALTH IMPACTS OF MOUNTAINTOP REMOVAL MINING

According to the National Institutes of Health (NIH), Appalachia is a region with significant and persistent health disparities requiring focused research and attention (Zerhouni & Ruffin, 2002). Earlier studies addressing this issue focused on the rural setting, widespread poverty, and poor health infrastructure characteristic of the region. This led some to blame excess morbidity and mortality on unhealthy behaviors, lack of educational opportunities, lack of access to public health services, poor housing, and unsafe work places. Now scientists and public health officials are beginning to recognize other factors that lead to poor health in rural or socioeconomic distressed populations (Hendryx, 2011a).

Compared to other rural areas in the same states, Appalachian communities show several distinct health trends and conditions, suggesting the existence of additional factors specific to the region. MTR mining may be one of these factors, as it is a technique used in the Central Appalachian mountains and is highly associated with extensive physical disruption (Copeland, 2011; Palmer, 2010;), air and water pollution (EPA, 2011; Ahern, 2011; Lindberg, 2011), and overall environmental degradation (Acton, 2011; Palmer, 2010; Pond, 2008; Simmons, 2008).

Residents of Appalachian communities near MTR sites are concerned about impacts of mining associated with illnesses and diminished health. Concerns over air and water contamination are mounting, and psychological stress has been associated with flooding, landslides, and flyrock on or near MTR sites. There is also concern that the invasive mining is systematically destroying the natural heritage of Appalachia (Hendryx, 2011b), which may have serious impacts on mental health and overall quality of life in MTR-exposed communities. Residents are particularly concerned with the potential public health consequences of dust from mining explosions that settle over homes and schools, and communities continue to push for scientific monitoring of well water thought to contain contaminants from mine site runoff and semi-permeable coal treatment settling ponds.

Recent published peer-reviewed scientific research has revealed significant possible associations between MTR mining and disparities in birth defects (Ahern, 2011), mortality (Hendryx, 2009; 2011a), cardiovascular disease (Esch & Hendryx, 2011), cancer (Hendryx, 2011b), mental health (Zhang, 2008), and overall health-related quality of life (Zullig & Hendryx, 2011), further suggesting that MTR mining is a contributing factor to poor health outcomes.

In response to these studies, Congressional representatives introduced the Appalachian Communities Health Emergency (ACHE) Act initially in June, 2012 and more recently in February 2013. This historic bill acknowledges the significance of peer-reviewed research on the association of MTR mining exposure with health effects like cardiovascular disease, cancer, and elevated birth defect risk. If passed, this bill would require a federal investigation led by the Department of Health and Human Services into the reported health impacts of MTR mining (ACHE, 2013). The ACHE Act calls for a moratorium on all new MTR permits, as well as on any expansion of existing permits. It also requires all existing MTR projects to conduct continuous monitoring for water, air, soil, and noise pollution. Each MTR project would have to pay a one-time fee to cover said monitoring, and results would be posted in an online database accessible to the public (ACHE, 2013).

The health impacts of MTR mining were further defined at 2012 Central Appalachian Women's Tribunal on Climate Justice. This Tribunal was organized by the Loretto Community at the United Nations, the Ohio Valley Environmental Coalition, The Civil Society Institute, and the Feminist Task Force of the Global Call to Action Against Poverty to give grassroots women the opportunity to testify to the injustices they have faced as a result of MTR mining. Tribunal findings included human rights violations due to drinking water contamination associated with MTR operations. The key recommendations of the Tribunal call for immediate moratoriums on MTR mining and the underground injection and surface impoundment of liquid coal sludge until a full investigation on environmental and human health impacts is undertaken. The recommendations also include increasing access to potable safe water for bathing,

pets, and livestock in MTR-affected communities (Loretto Community at the UN, 2012).

2.1 Cancer Rates and Cancer Mortality

Many of the chemicals and byproducts of MTR mining are known or suspected carcinogens. Arsenic, a common impurity in coal, is associated with skin, bladder, lung, liver, and kidney cancers (U.S. EPA, 1998). The diesel fuel used in mining operations¹ emits particulate matter identified as a major contributor to cancer risk (U.S. EPA, 2002).

Hendryx (2011b) analyzed the cancer rates in the MTR-exposed Coal River region of West Virginia and compared them to rates in the non-mining communities of rural Pocahontas County. The study used a community-based participatory research approach, meaning data was gathered door-to-door from surveys at a personal level in small geographic communities directly impacted by MTR mining. This research method is superior to using county-level exposure data or aggregate statistics (Hendryx, 2011b). The study found that self-reported cancer rates were significantly higher in mining versus non-mining areas, even after controlling for covariates like respondent age, sex, smoking status, occupational history, or family cancer history. There was a 5% higher rate of cancer in the MTR-exposed Coal River communities, which, if representative of the entire Central Appalachian region, translates to an additional 60,000 mining county residents with cancer (Hendryx, 2011b). The odds for reporting cancer among Coal River study respondents were twice as high as in Pocahontas County in ways not explained by the covariates. Multiple types of cancer were reported, including breast, ovarian, skin, and urinary cancers. This study had limited information on covariates such as obesity or healthcare access that may impact cancer rates; however, the overall findings demonstrate that Appalachian disparities in cancer rates are specifically concentrated in MTR mining areas.

The more recent findings of Hendryx (2012) provide further evidence of the impacts of environmental pollution on cancer mortality. Specifically, the authors conducted an exploratory study to establish whether associations exist between EPA-permitted water pollution discharges

and cancer and non-cancer mortality. Results suggest that surface water chemical discharges are related to population mortality, and chemicals not currently recognized as carcinogens may play a role in contributing to cancer mortality risk. Hendryx (2012) did not look specifically at water pollution in MTR areas to come to this conclusion, but rather, analyzed the association between water pollution and cancer risk for all urban-rural areas across the U.S.

2.2 Chronic Cardiovascular Disease Mortality

Chronic cardiovascular disease (CVD) is the leading cause of death in the U.S. (CDC, 2011). In Central Appalachia, CVD mortality rates are higher than the national average (Halverson, 2004). While smoking, diet, and physical activity affect CVD risk, exposure to environmental pollution like that associated with MTR mining has been shown to be significantly related to increased CVD risk as well (Esch and Hendryx, 2011). Exposure to particulate air pollutants less than 10 micrometers (μm) in diameter is associated with fatal coronary heart disease (Puett, 2008), and such particulate matter is produced during MTR blasting and coal seam extraction processes (Ahern, 2011). Arsenic, a common contaminant of surface water and groundwater resulting from MTR mining (ATSDR, 2011a; Shiber, 2005), is associated with increased blood pressure (Kwok, 2007), atherosclerosis (Wu, 2006), and the risk of myocardial infarction (Yuan, 2007). Arsenic-contaminated well water has been detected through parts of Central Appalachia (Shiber, 2005).

Esch and Hendryx (2011) have revealed that even after adjusting for factors such as poverty rate, percent with college education or higher, obesity, smoking, and access to primary care physicians, chronic CVD mortality rates are significantly higher in counties with active MTR mining than in counties exposed to other types of mining or no mining at all. These mortality rates seem to increase as a function of greater levels of surface mining. These findings indicate that residents of MTR mining areas have significant cardiovascular health disadvantages (Esch & Hendryx, 2011).

¹ Diesel fuel is used in MTR mining operations to power heavy mining machinery and is also mixed with ammonium nitrate to create an explosive used to blast away the mountains.

2.3 General Mortality Disparities and Health-Related Quality of Life

Hendryx (2011a) investigated the associations between poverty rates, MTR mining, and age-adjusted total mortality rates to determine if populations in areas with MTR operations have higher death rates compared to people in other areas (Hendryx, 2011a). This analysis occurred at the county level and controlled for variables that can affect mortality like education, ethnicity, and smoking. The results of the study showed both poverty and MTR mining to be independently associated with age-adjusted mortality rates, and the health impacts of MTR-derived environmental contamination are likely compounded by those of poor socioeconomic conditions. While county-level analyses only estimate effects of individual risk factors under certain assumptions, and the exposures that may cause increased mortality are unknown, the results of this study are consistent with previous findings that MTR-exposed communities experience elevated mortality from cancer, CVD, and other respiratory diseases (Hendryx, 2009). Such results are suggestive of environmental contributions from MTR pollutants and byproducts to elevated rates of overall mortality.

Because MTR-exposed counties are associated with serious environmental degradation and elevated morbidity and mortality, health-related quality of life (HRQOL) is greatly reduced among area residents (Zullig & Hendryx, 2011). Using data from the 2006 national Behavioral Risk Factor Surveillance System, Zullig & Hendryx (2011) conducted a retrospective analysis that confirmed residents of MTR counties experienced significantly more days of poor physical, mental, and self-rated health and more frequent activity limitation than residents of non-MTR or non-mining counties. These disparities still existed even after researchers controlled for socioeconomic factors, suggesting once again that the environmental impacts of MTR operations may negatively impact public health.

The prevalence of mental health disorders in the Appalachian region is also elevated compared to national rates, as more Appalachian adults report serious psychological distress and major depressive disorders. The highest rates of psychological stress and depression have been detected in Central Appalachia, which is also the

region with the highest rates of MTR mining (Zhang, 2008).

Although the Appalachian region has been traditionally identified as one experiencing a high burden of adverse health outcomes compared to the rest of the nation (Zerhouni & Ruffin, 2002), recent health studies indicate that not all areas of Appalachia experience the same health disparities. In fact, the poorest health outcomes are concentrated in the portion of Appalachia where MTR mining occurs most heavily (Hendryx, 2011a). These studies indicate that birth defect and cancer rates, overall mortality, cardiovascular disease mortality, and mental health programs are all elevated and that poor overall health-related quality of life has been identified.

2.4 Respirable Air Pollution

MTR surface mining also has significant impact on local air quality. The explosive blasts required to flatten mountain ridges and expose coal seams release coal dust, silica, sulfuric flyrock, and fine metal and nitrogen dioxide particulates into the ambient air (Ayers, 2007). Hendryx (2011b) has also shown elevated levels of particulate ammonium nitrate, silica, sulfur compounds, benzene, carbon monoxide, and PAH in the air around surface mining operations. Research has shown the ambient air in the work zone and adjacent to mine sites to be polluted with dust alarmingly high in respirable particulates, which is dangerous to human health. Ghose and Majee (2007) urge implementation of more stringent air quality standards to mitigate potential environmental and social costs.

3. THE ASSOCIATION BETWEEN MOUNTAINTOP REMOVAL MINING AND BIRTH DEFECTS

Congenital birth anomalies occur in about 1 in 33 births and are the leading cause of infant mortality in the U.S. (CDC, 2010). While maternal factors like pre-pregnancy obesity, diabetes, age, and behaviors like smoking and drug use all pose risks to fetal development, the majority of birth defects are thought to be caused by a combination of genetic and environmental factors (Brent, 2004). Reproductive outcomes including birth defects are considered a sensitive indicator of toxic chemical exposures (Stillerman, 2008; Silbergeld, 2005). The most significant environmental factors include exposure to contaminated drinking water (Brent, 2004), ambient particulate matter and gaseous air pollutants which have been associated with fetal development problems, congenital anomaly risks, heritable gene mutations, and fetal mutations (Ahern, 2011). Recent findings in the Netherlands suggest that maternal exposure to ambient particulate matter (aerodynamic diameter < 10 μm) is inversely associated with fetal growth during the second and third trimesters and with birth weight (van den Hooven, 2012).

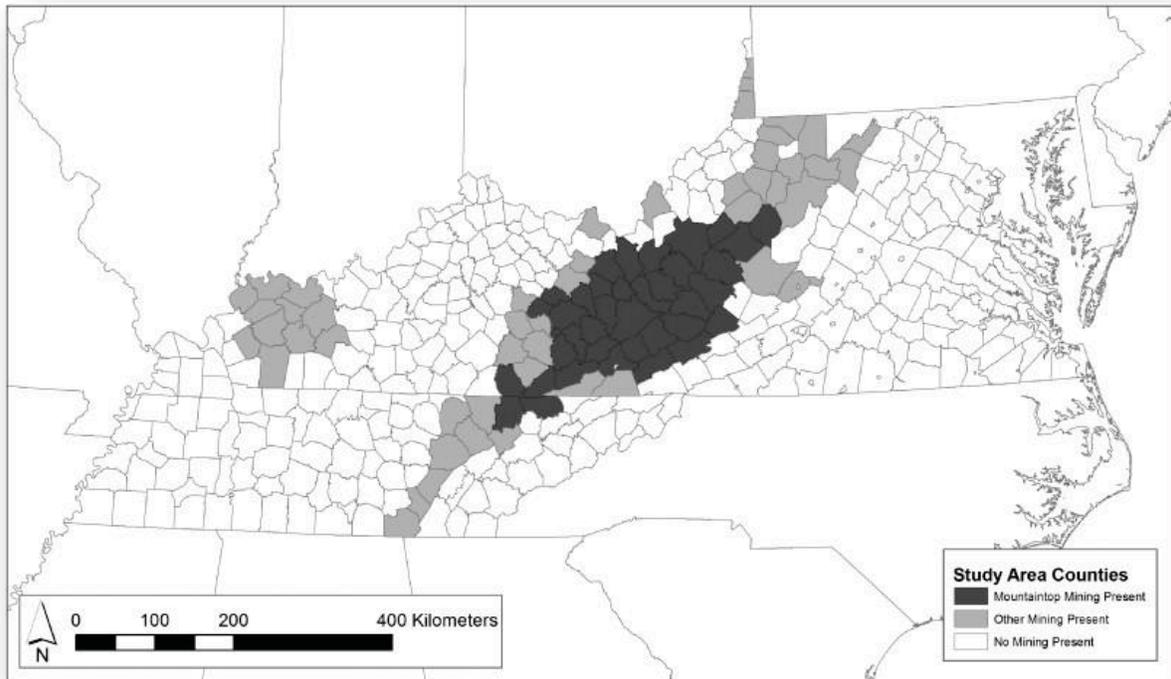
The blasting and recontouring required for MTR mining produces ambient coal dust (Lockwood, 2009) and many of the fine particulates and gaseous emissions that have been associated with fetal development problems (Dejmek, 2000; Maisonet, 2004). These contaminants include arsenic, manganese, and lead. When ingested by a pregnant woman, arsenic can cross the placenta and directly affect the fetus (U.S. EPA, 2000). Lead is also known to readily cross the placenta, adversely affecting fetus viability and increasing the risk of reduced birth weight even at low levels (ATSDR, 2007). Recent studies indicate that high manganese-lead coexposure is associated with neurodevelopment deficiencies in early childhood (Henn, 2012). Some researchers believe that the negative impacts of all types of mining on groundwater are well documented, and that slurry can and does migrate from the underground mines in which it is stored (Holzman, 2011).

3.1 Study Design

The Ahern (2011) study was a retrospective, ecological analysis that took place across four Central Appalachian states – Kentucky, Tennessee, Virginia, and West Virginia. The purpose of this study was to determine whether maternal residence in counties with MTR activities is associated with elevated rates of congenital anomalies at birth compared to residence in non-MTR mining counties or non-mining counties, both before and after controlling for mother's age, race, smoking, alcohol consumption, level of education, and prenatal care (See Figure 1). Approximately 1,900,000 live births were analyzed by researchers at Washington State University (WSU) and West Virginia University (WVU), using individual-level data from the National Center for Health Statistics (NCHS) natality data files for live births occurring between 1996 and 2003. Mining data were obtained from the Energy Information Administration (EIA) for the same time period, as well as from satellite imagery maps. Twenty-two types of congenital anomalies were considered individually and grouped by major affected organ system (See Table 1).

Researchers used inferential statistical analyses to determine the prevalence rate ratios (PRR) of congenital anomalies in the three county categories, with non-mining counties as the referent, both before and after controlling for covariates (Ahern, 2011). To account for the potential that environmental impacts of MTR activity accumulate over time, the researchers examined PRRs both for the entire period 1996-2003 and separately for earlier years (1996-1999) and later years (2000-2003). Environmental risk factors like contaminated water or air pollutants can cross county borders, thus sometimes impacting counties not directly exposed to MTR mining (Ahern, 2011). This means a pregnant woman in a non-MTR mining county who lives near a mine site in the adjacent county could experience similar exposures as residents of the MTR mining county. Furthermore, exposure to MTR mining in one county can be compounded by exposure in surrounding counties. To account for this diffusion of exposure, the authors conducted analyses to quantify spatial autocorrelation, which is a statistical measure that reflects the intensity of geographic relationships and identifies spatial patterns.

Figure 1: Study Area - Counties in Kentucky, Tennessee, Virginia and West Virginia showing type of mining activity for the years 1996 to 2003.



Source: Ahern (2011)

3.2 Findings

On average, mothers in MTR mining areas had less education, smoked more, had less access to prenatal care, and consumed alcohol during pregnancy less frequently than mothers in non-MTR and non-mining counties.

After controlling for these and other variables that can influence birth rates, the authors found birth defect rates to be 26% higher in MTR regions of Central Appalachia compared to non-mining areas. As seen in Table 2, five major bodily systems in particular—circulatory/respiratory, central nervous, gastrointestinal, urogenital, and musculoskeletal systems—were most affected by

these defects, with prevalence of circulatory and respiratory defects in MTR counties nearly double that of non-MTR counties. Rates for all types of anomalies were found to be around 235 per 10,000 live births in MTR areas, while non-mining areas experienced rates around 144 per 10,000 live births. In the comparison of PRRs from the early period (1996-1999) versus the late period (2000-2003), overall PRR was significant in both periods but was higher in the later period, supporting the supposition that birth defect rates increase as environmental impacts of MTR activity accumulate over time.

Table 1 - Number (and Prevalence per 10,000 live births) with a Congenital Anomaly by Presence and Type of Coal Mining in Kentucky, Tennessee, Virginia, and West Virginia 1996-2003.

Type of Anomaly	Non-mining (N=1,666,985 live births)	Mining in Non- Mountaintop Mining Area (N=112,771 live births)	Mountaintop Mining Area (N=109,315 live births)
Anencephaly	178 (1.1)	12 (1.1)	16 (1.5)
Meningomyelocele/spina bifida	378 (2.3)	24 (2.1)	43 (3.9)
Hydrocephalus	382 (2.3)	27 (2.4)	40 (3.7)
Microcephalus	82 (0.5)	13 (1.2)	9 (0.8)
Other central nervous system	246 (1.5)	32 (2.8)	53 (4.8)
All central nervous system ^a	1163 (7.0)	102 (9.0)	137 (12.5)
Heart malformations	1603 (9.6)	133 (11.8)	136 (12.4)
Other circulatory/respiratory	1028 (6.2)	104 (9.2)	317 (29.0)
All circulatory/respiratory ^a	2550 (15.3)	226 (20.0)	448 (41.0)
Rectal atresia/stenosis	107 (0.6)	11 (1.0)	20 (1.8)
Tracheo-esophageal fistula	167 (1.0)	16 (1.4)	19 (1.7)
Omphalocele/gastrochisis	494 (3.0)	47 (4.2)	53 (4.8)
Other gastrointestinal	487 (2.9)	40 (3.5)	80 (7.3)
All gastrointestinal ^a	1222 (7.3)	113 (10.0)	168 (15.4)
Malformed genitalia	687 (4.1)	71 (6.3)	66 (6.0)
Renal agenesis	155 (0.9)	17 (1.5)	14 (1.3)
Other urogenital	1808 (10.8)	228 (20.2)	266 (24.3)
All urogenital	2586 (15.5)	308 (27.3)	341 (31.2)
Cleft lip/palate	1496 (9.0)	135 (12.0)	133 (12.2)
Polydactyly/ syndactyly/ adactyly	1754 (10.5)	92 (8.2)	94 (8.6)
Club foot	1164 (7.0)	101 (9.0)	114 (10.4)
Diaphragmatic hernia	226 (1.4)	17 (1.5)	27 (2.5)
Other musculoskeletal	2469 (14.8)	227 (20.1)	402 (36.8)
All musculoskeletal ^a	6816 (40.9)	550 (48.8)	736 (67.3)
Down syndrome	781 (4.7)	52 (4.6)	53 (4.8)
Other chromosomal	578 (3.5)	40 (3.5)	43 (3.9)
All chromosomal ^a	1342 (8.1)	89 (7.9)	96 (8.8)
Other congenital anomaly	10,164 (61.0)	861 (76.4)	931 (85.2)
Any anomaly	24,065 (144.4)	2067 (183.3)	2569 (235.0)

^a The totals for each system are less than the numbers for specific anomalies due to cases with more than one specific anomaly.

Source: Reproduced from Ahern 2011

Table 2 - Adjusted^a Prevalence Rate Ratios (and 95% Confidence Limits) for Key Birth Defects by Mining Group Relative to Non-Mining Referent, 1996-2003 in Kentucky, Tennessee, Virginia, and West Virginia.

Anomaly Type	Mountaintop Mining Area	Other Coal Mining Areas
Circulatory/ respiratory	1.93 (1.73, 2.15)	1.08 (0.94, 1.24)
Central nervous system	1.36 (1.11, 1.67)	1.18 (0.95, 1.46)
Gastrointestinal	1.41 (1.17, 1.71)	1.02 (0.82, 1.28)
Urogenital	1.35 (1.19, 1.54)	1.32 (1.15, 1.51)
Musculoskeletal	1.30 (1.20, 1.41)	1.08 (0.99, 1.18)
Chromosomal	0.92 (0.72, 1.18)	0.85 (0.66, 1.09)
Other anomaly	1.13 (1.04, 1.23)	1.12 (1.03, 1.22)

^aCovariates include: mother's age ≥ 35 , years of education, smoking during pregnancy, drinking during pregnancy, African American race, Native American race, Hispanic ethnicity, infant sex, low prenatal care, diabetes co-morbidity, and residence in a metropolitan area.

Source: Reproduced from Ahern 2011

The percentage of birth defects within each county also exhibited strong spatial correlation, indicating a potentially strong relationship between a county's rate of birth defects and MTR mining activity in that county. This also suggests that the impacts of MTR mining extend beyond the immediate site of mining, and different communities may be impacted by different types of pollution and routes of exposure. Based on previous research, it is recognized that coal impurities like arsenic and chemicals used in and generated by MTR mining operations are possible agents in the etiology of birth defects, but because this study did not include specific exposure information, it could not identify exposure routes or biological mechanisms that could explain the relationship. Nor could it establish a causal relationship between the observed birth defects and specific MTR activities and exposures.

3.3 Significance of the Study

The study by Ahern (2011) is the only study that specifically set out to analyze potential associations between MTR mining and birth defects. Thus it is a significant contribution to public health research in Appalachia. Furthermore, while other studies have examined morbidity and mortality trends (Hendryx, 2009; 2011a), health-related quality of life (Zullig & Hendryx, 2011), and cancer rates (Hendryx, 2011b) in MTR mining areas, the Agency for Toxic Substances and Disease Registry (ATSDR) views the Ahern (2011) study as significant because the authors utilized individual level, medically-verified health

outcomes in the form of birth defects (ATSDR, 2011b). Additionally, ATSDR found that "the available published evidence is sufficiently strong to warrant further epidemiological research into the potential public health impacts of mountaintop removal activities" (ATSDR, 2011b).

A previous study by Ahern (2010) suggested that maternal residence in a coal-mining area was associated with low birth weight outcomes, but it did not differentiate between the types of mining to which different mothers were exposed. The birth defects study purposely distinguished maternal residence in counties exposed to MTR mining from residence in counties exposed to other types of surface mining, and findings revealed a significantly higher rate of birth defects in the MTR counties. This is the first study to make such a differentiation, and thus is especially significant to the scientific understanding of the health disparities characteristic of mining communities.

The findings in the current paper (Ahern 2011) found that the prevalence rate of defects in Central Appalachia was positively correlated with the rate of MTR mining activity, as the spread of MTR mining through Kentucky, Tennessee, Virginia and West Virginia between 1996 and 2003 was reflected by an increase in prevalence of birth defects. These findings build on previous research like the Ahern (2010) birth weight report. Thus far, the Ahern (2011) study is the most significant demonstration of how Appalachian health disparities are concentrated in MTR areas. An elevated rate of birth defects results in higher

levels of disability for future generations. Such disabilities may hinder economic productivity and societal prosperity in a region already struggling with poverty, low levels of education, and inadequate healthcare. The findings of Ahern (2011) add to a growing body of evidence that MTR mining negatively impacts human health.

3.4 Study Limitations

Ahern (2011) specifically identified and discussed the limitations of their study. These limitations include the lack of information on human exposure to MTR mining pollutants and the utilization of potentially inaccurate birth certificate data in the analysis of covariates.

The primary limitation is the classification of exposure to MTR mining pollutants according to county levels of MTR mining, which the authors chose to use based on a lack of availability of maternal or fetal exposure data for Central Appalachia. The authors felt that the best available proxy was to use the type of mining occurring in the county of maternal residence.

Another important limitation is the use of birth certificate data to evaluate birth defects in the region. The authors acknowledge that reporting of birth defects on birth certificates is incomplete and dependent on how easily anomalies are detected after birth and before data are completed on the birth registration. Many anomalies are not apparent at the time birth registration data are recorded. Even the more obvious defects such as clefts and neural tube defects are ascertained with a high degree of false positives and negatives. However, alternative sources of outcome data were limited for the region, and such inaccuracies are not likely differential by mining exposure status, meaning results were likely bias towards the null.

Some risk factors for birth defects were controlled for in this study based on self-reported birth certificate data. Some of these variables like mother's age, race, education, and quality of prenatal care can be reliably determined from self-reported birth certificate data, but two of the major risk factors, smoking and alcohol consumption while pregnant, are not considered to be reliable. These behaviors are commonly underestimated on birth certificates because the normative stigma associated with smoking and drinking while pregnant causes mothers to hesitate in reporting

such behaviors. More consistent figures would likely come from direct interviews with study subjects. Thus while the covariates used in the study were appropriate, the sources of data for those covariates were limited.

In addition, as previously discussed, one analysis conducted by Ahern (2011) (spatial autocorrelation) suggests that exposure to mining activity is not limited to the county where the mining occurs. Diffusion of mining-related air pollution and toxic substances can occur across county lines, and residents of counties adjacent to counties with MTR activity may be indirectly exposed to and affected by the pollution. Ahern and her co-authors acknowledged this condition and feel that the study results are conservative as a result.

3.5 The Response of the National Mining Association

The most controversial issue raised by Ahern (2011) is the extent to which MTR mining is a risk factor for poor health outcomes. The NMA response not just to the Ahern (2011) paper, but to the series of health outcome studies in relation to MTR mining conducted by researchers at WVU and WSU, was to commission a review of these studies. This review, conducted by researchers at Yale University, was designed to assess the risk factors including coal mining that might explain the disproportionately high mortality rates across Appalachia, as well as reanalyze the health outcome studies published by the research group at WVU and WSU (Borak, 2012). The Borak (2012) review concluded that "coal mining is not per se an independent risk factor for increased mortality in Appalachia," although the authors could not "rule out the possibility that mining contributes to the development of the social environments and cultural practices that adversely impact health." The authors continue, "This possibility seems most likely in those specific areas where mining is the principal industry. Likewise, our analysis does not rule out the possibility that some specific mining methods may have greater adverse effects than others on the physical environment" (Borak, 2012). These comments are not surprising as it would be extremely difficult, if not impossible, to tease out coal mining as an "independent risk factor" for mortality in Central Appalachia. Thus, the Borak (2012) study reaffirmed the earlier

findings of the WVU and WSU research group that socioeconomic and environmental risk factors are not mutually exclusive and that it is difficult to attribute health outcomes entirely to environmental exposures like MTR mining (Ahern, 2011; Esch & Hendryx, 2011; Hendryx, 2009, 2011a, 2011b; and Zullig & Hendryx, 2011). This is not new evidence nor at odds with the conclusions in Ahern (2011).

Critics have accurately stated that the study findings are not definitive enough to prove MTR mining to be an independent risk factor of existing birth defect disparities; however, it cannot be ruled out. According to an analysis of this study by ATSDR, this “review utilized individual level medically-verified health outcomes (birth defects) and was able to demonstrate impacts even after adjustment for a full set of individual-level

covariates relevant for this health outcome (e.g. mother’s age, years of education, smoking during pregnancy, drinking during pregnancy, race/ethnicity, infant sex, low prenatal care, and diabetes co-morbidity)” (ATSDR, 2011b).

Ahern and her co-authors made it clear that the mechanisms by which environmental exposures lead to birth defects are still imperfectly understood and that the ability to distinguish the impacts of socioeconomic and environmental risk factors on health outcomes is quite difficult. Because these limitations can serve to shape the focus of future research, this study is an important addition to the growing base of evidence that a causal association between MTR mining and poor health outcomes may in fact exist.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

MTR surface mining has been used for decades to extract coal from Central Appalachia. This activity has resulted in substantial alterations to mountain ecosystems, including destruction of streams and sediments within mine boundaries and regional degradation of entire watersheds. MTR mining has affected a significant portion of the Central Appalachian population and raised serious questions about the health impacts on these people.

The health studies described in this report address the quality of human health in the communities surrounding MTR sites. While the focus and design of each study varies, together they provide sufficient evidence that MTR mining has impacted the residents in the surrounding communities and that further research is needed to better understand the relationship between adverse health effects and MTR mining.

The association between MTR mining and human health is emerging. It is complicated by the fact that Appalachia is characterized by poor socioeconomic conditions. Poverty is a cause of poor diet, unsafe housing, lack of access to good schools or medical services, dangerous working conditions, and psychological stress. These factors contribute to increased susceptibility to chemical exposures, including those resulting from coal mining. Studies reviewed in this report show that MTR areas have higher rates of cancer, cardiovascular disease-related mortality, overall mortality, and birth defects, and that the residents of these areas report lower health-related quality of life than residents of any other part of Appalachia. The birth defects study by Ahern (2011) is the first study to distinguish maternal residence in counties exposed to MTR mining from residences in counties exposed to other types of surface mining, and thus is especially significant to the scientific understanding of the health disparities characteristic of mining communities. This study is particularly significant because the researchers utilized individual-level, medically-verified health outcomes in their analysis, and the covariate control is more advanced than in other studies.

4.2 Recommendations of the Commission

If the U.S. is to effectively eliminate MTR-related health disparities in Central Appalachia, investments must be made in research, regulations, and mitigation related to MTR operations. The recommendations below are offered to increase our understanding of the public health and environmental impacts of MTR mining. However, the residents of Central Appalachia should not have to continue to suffer from the impacts of MTR mining while this critical research is conducted.

- 1) Preventative action in the face of uncertainty is warranted. The findings in this report make clear that there is sufficient documentation of the hazards of MTR mining to place an immediate moratorium on MTR mining until such time as health studies have been conducted that provide a clearer understanding of the associations between adverse health impacts, notably adverse reproductive outcomes, and MTR mining. In addition, during the moratorium period, appropriate safeguards including remediation and engineering controls should be implemented to mitigate existing air and water pollution related to MTR mining activities.
- 2) The studies conducted by Ahern (2011), Hendryx (2011a and 2011b), and Esch & Hendryx (2011) provide sufficient evidence to warrant follow-up studies to assess the specific health impacts of MTR mining. This research could include evaluating human exposure to toxic related to MTR mining activities and their relationships with uptake by humans.
- 3) More information is needed on human exposure to the pollutants in ambient air, groundwater and drinking water resulting from MTR mining activities. Future studies should evaluate environmental samples (air, soil, surface water and groundwater) from MTR-area communities as well as fate and transport of contaminants and uptake by humans.

It is important to examine the health impacts of MTR mining. Birth defects may be one important factor, but other health outcomes as well as biomarkers of exposure need to be

evaluated as well. It would also be valuable to evaluate the biological mechanisms by which contaminant by-products of MTR mining might lead to birth defects. Case control studies using birth defect ascertained cases with parental interviews should be considered to obtain additional risk factor information.

- 4) Corporations involved in MTR operations benefit financially from the coal that they extract. Therefore, they have a responsibility to fund the research on the health and environmental impacts of their process and activities. Other corporate sectors have funded independent organizations such as the Health Effects Institute (HEI), which is sponsored in part by the motor vehicle industry to conduct research on the health and environmental impacts of air pollution (HEI, 2010). Such organizations have been successful in funding high-quality, independent research that is ultimately accepted for publication in peer-reviewed journals.

Thus, industries involved in MTR mining should develop a mechanism to fund research on the adverse health effects and exposure routes associated with MTR mining that includes a firewall to protect the research from industry influence which will damage the credibility of the research.

This report is not the first call for a moratorium on MTR mining. The Appalachian Communities Health Emergency Act calls for a moratorium on all new MTR permits, as well as on any expansion of existing permits, while a federal investigation is conducted on the reported links between MTR mining and human health effects (ACHE, 2013). Similarly, the 2012 Central Appalachian Women's Tribunal on Climate Justice, organized by the Loretto Community at the United Nations, the Ohio Valley Environmental Coalition, the Civil Society Institute, and the Feminist Task Force of the Global Call to Action Against Poverty called for immediate moratoriums on MTR mining as well as on the underground injection and surface impoundment of liquid coal sludge until a full investigation on environmental and human health impacts is undertaken (Loretto Community at the UN, 2012).

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