TRADE UNIONS FOR ENERGY DEMOCRACY

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AN ILLNESS TO ONE IS THE CONCERN OF ALL

The Health Impacts of Rising Fossil Fuel Use

CUNY The Murphy Institute

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TRADE UNIONS FOR ENERGY DEMOCRACY

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Trade Unions for Energy Democracy (TUED) is a global, multi-sector initiative to advance democratic direction and control of energy in a way that promotes solutions to the climate crisis, energy poverty, the degradation of both land and people, and responds to the attacks on workers' rights and protections.

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TRADE UNIONS FOR ENERGY DEMOCRACY

An Illness to One is the Concern of All

The Health Impacts of Rising Fossil Fuel Use

A global health emergency is rapidly unfolding. The volume of health-related research dealing with fossil fuel use and climate change has grown exponentially in recent years, as evidenced by the work compiled and assessed by the Intergovernmental Panel on Climate Change (IPCC), the World Health Organization (WHO), and numerous research centers and universities. A 2016 report released by the United Nations Development Program (UNDP), in partnership with the International Trade Union Confederation (ITUC) and Union Network International (UNI), focused on how a warming world could seriously impact occupational health, particularly for those working outdoors in agriculture or construction or in factories without air conditioning.

Recent research on the direct and indirect health impacts of fossil fuel use indicates a dual crisis: the alarming implications for human health caused by pollution and by climate change, both of which are being made worse by the growing use of coal, oil, and gas.[1]

An Issue for Unions in All Sectors

This paper has been written to help unions representing workers *in all sectors* get a clear sense of what is presently happening in terms of the health impact of fossil fuel use and what could also happen if present patterns in energy use continue into the future. The data are presented in a way that unions can use to more effectively advocate both for their members and the broader public.

Unions in health care can play—indeed are playing—an important role in addressing both the climate-related and the pollution-related dimensions of the unfolding health crisis, as can health and safety personnel working with or for unions in different sectors. But the health-related impacts of rising pollution levels and climate change are expected to affect the lives of workers across a range of occupations. Unions representing workers in emergency services, workers in transport systems, or workers who must work outdoors in agriculture or construction also have a particularly important role to play. The situation requires as unified a response as possible.

One of the striking features of fossil fuel use today is how much it reflects and reinforces class inequalities. It is well known that rich countries consume far more energy per person than poorer ones, but within both rich and poor countries there is often a huge gulf between the energy consumed by the rich and the energy consumed by the poor and working class.[2] The same is true of emissions. A December 2015 study released by Oxfam calculated that the poorest half of the global population are responsible for only around 10% of global emissions yet live overwhelmingly in the countries most vulnerable to climate change while the richest 10% of people in the world are responsible for around 50% of global emissions.[3]

Trade unions with the capacity to play more of an active role in resisting the expansion of fossil fuel use can be confident of the fact that they will be intersecting with a rising global movement that is confronting fossil fuel extraction, including “unconventional fuels” like shale gas and shale oil. The concerns that drive this movement are numerous. Along with cli-

mate and air quality concerns, struggles have been built around questions of water scarcity and contamination and the fight to defend land and livelihoods from "extractivist" energy companies.

Two Trends

Recent studies suggest that the steady rise in the use of coal, oil, and gas is damaging the health—and claiming or shortening the lives—of millions of people every year. Taken together, these studies point to two major trends. Firstly, the number of people whose health is being harmed due to rising pollution levels is growing (and has, for some time, been underestimated). Extracting, transporting, and burning coal, oil, and gas are associated with a range of health conditions, such as respiratory illness, heart disease, and cancer. These are established and well known facts. But what is less well known, especially in the Global North, is the extent to which the problem has become more severe in recent decades. Secondly, rising fossil fuel use is contributing to warmer temperatures and climate instability—disruptions that are already affecting human health. Today, more is known about climate-related impacts on health than was known a decade ago, and the overall results of this research have raised concerns among health care-related NGOs, social movements, and a growing number of unions.

After Paris

The future health of the world's people and the ecosystems that sustain life will depend in large part on how energy is generated and used in the coming decades. The Paris Climate Agreement was adopted on December 12, 2015, and nations were invited to ratify on April 22, 2016. The agreement has been hailed as "historic" because it acknowledges the need to restrict global warming to "well below 2 degrees Celsius" and to pursue efforts to "limit the temperature increase to 1.5 degrees Celsius above pre-industrial levels."[4] Reaching these targets is contingent upon phasing out fossil fuels altogether, and if this were to occur the positive outcomes in terms of public health would be immense—at least when compared to the do-nothing or "business-as-usual" scenario.

However, the Intended Nationally Determined Contributions (INDCs) situated at the core of the Paris Agreement are presently not sufficient to meet either the 2 degrees or 1.5 degrees targets. The INDCs point to around 2.7 degrees Celsius of warming by the end of the century.[5] Together the INDCs are expected to reduce warming by a maximum 0.9 degrees Celsius based on business-as-usual projections that point to 3.6 degrees Celsius of warming.[6] But this projection is based on all INDCs being met by 2030.

It is therefore important to recognize that the Paris Agreement will not lower global emissions levels, and the Agreement does not mean a reduction in the use of fossil fuels. In fact, there is every indication that extraction and burning of fossil fuels will continue to increase as a result of rising global energy demand. As has been documented by TUED in its Working Papers series,[7] renewable energy use is also increasing—but not fast enough to seriously impede the growth in fossil fuel use. Coal use has risen dramatically in the last two decades; although this growth has slowed considerably since 2012 and actually fell roughly three percent in 2015.[8] Nevertheless, coal use has risen by a staggering 60 percent since year 2000. The IEA has also reported that the Paris Agreement would see electricity generation from coal grow by 24 percent by 2040.[9] Therefore the recent fall in coal consumption needs to be viewed alongside both its upward trajectory over the last two or three decades and the anticipated ris-

ing demand for electrical power over the next several decades.

Meanwhile, the consumption of gas and oil has also increased during the same period and is projected to increase into the future. The health effects of both are also serious. As will be discussed below, the growing use of "unconventional" fuels—such as tar and shale oil as well as shale gas—have generated new health concerns.

These energy-related trends mean that CO_2 emissions are expected to rise 45% by 2035 (based on 2010 levels), according to the International Energy Agency's 2014 *World Energy Outlook*.[10] British Petroleum's own *Energy Outlook* for 2015 projects that, "Total carbon emissions from energy consumption increase by 25% between 2013 and 2035 (1% p.a.)... the profile for emissions is well above that recommended by the scientific community."[11] Even if the INDCs in the Paris Agreement are fully implemented, emissions will remain on an upward course. The IEA notes, "There is no peak in sight for world energy-related CO_2 emissions in the INDC Scenario: they are projected to be 8% higher than 2013 levels in 2030 (reaching 34.8 gigatonnes [Gt]), while primary energy demand grows by around 20%."[12]

The Paris Agreement therefore does little to alter the fact that the effects on health of climate change and fossil-based pollution are presently expected to worsen over time. Nevertheless, the Agreement will probably help *slow the rise* in CO_2 emissions, and governments are expected to be pressured to submit more ambitious targets in future.

Health in a Warmer World

The health implications of a 2.7 degree Celsius rise in warming are extremely serious. However, the amount of fossil fuels that will be burned under the INDCs will also generate massive amounts of additional pollution. This is particularly serious for countries like China and India, where existing pollution levels already pose a major health threat. China has stated its emissions will peak in 2030, but its emissions have grown by roughly nine percent per year in the past decade, and the pollution levels associated with its economic expansion are already reaching intolerable levels.[13] India's INDC offers no date for a peak in the country's emissions. Meanwhile, measured in per capita terms, the OECD countries' emissions levels remain far higher on average than those of the Global South.

A Crisis of Two Dimensions

This paper examines the two sides of this health crisis separately, even though the two dimensions are clearly connected. The paper is divided into three parts. Part One discusses the impact of fossil fuels on human health, with an emphasis on the most recent studies from bodies like the World Health Organization (WHO). Part Two will summarize the recent data on the health impacts of fossil fuel extraction and transportation, with a focus on coal and shale gas. However, the full health related impacts of fossil fuel extraction are beyond the scope of this paper. In Part Three we turn to the health-related impacts of climate change and what studies say the future may hold.

Part One: Fossil Fuel Pollution and Human Health

The risks from air pollution are now far greater than previously thought or understood, particularly for heart disease and strokes. Few risks have a greater impact on global health today than air pollution; the evidence signals the need for concerted action to clean up the air we all breathe.

Dr. Maria Neira, Director of WHO's Department for Public Health, Environmental and Social Determinants of Health[14]

I have to keep working to earn a living. I haven't bought any facemasks. Pollution is a serious issue, but ordinary people like me have no say in how to deal with it.

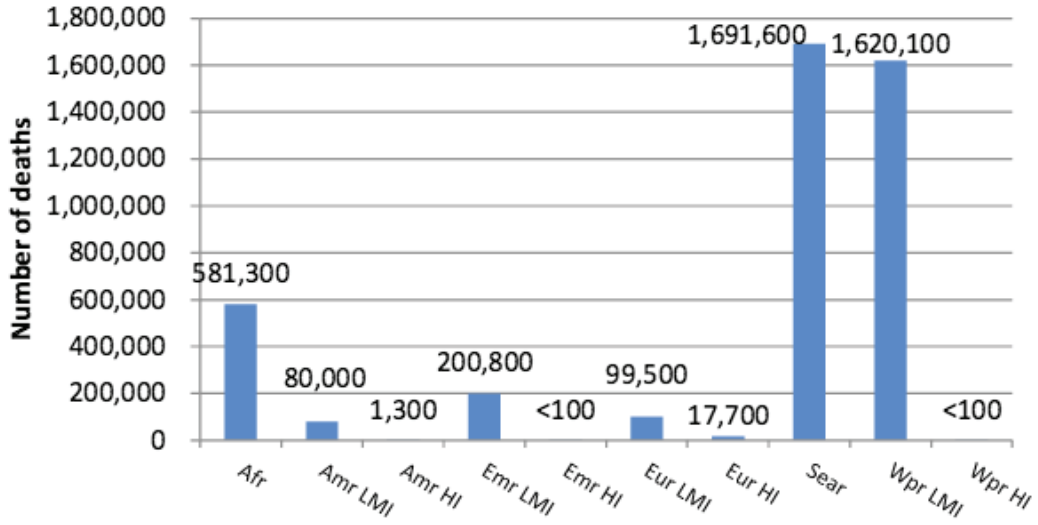
Beijing key cutter, BBC interview, December 1, 2015[15]

The negative health impacts of fossil fuel use are already firmly established and quite widely recognized. However, new estimates released by the WHO in March 2014 suggest that the problem is much worse than earlier research had suggested.

Drawn from numerous studies, the WHO's data directs special attention to the impact of airborne "particulate matter" (PM) or "particulates." Particulate sources include coal-fired power plants, factories, cars and trucks, biomass burning, and coal, oil (particularly diesel), and gas used in homes and factories for heating. But not all particulates are created equal. Extremely small particulate matter (PM2.5 or PM10) is one of the most important pollutants as it more easily penetrates into sensitive regions of the respiratory system.[16]

According to the WHO's new data, around seven million people died in 2012—one in eight of total global deaths—as a result of air pollution exposure. According to the WHO, "This finding

Figure 1. World Health Organization, "Burden of disease from Household Air Pollution for 2012." *Household air pollution; Amr: America, Afr: Africa; Emr: Eastern Mediterranean, Sear: South East Asia, Wpr: Western Pacific; LMI: Low and middle income; HI: High income.*[19]



Coal's Health Impacts

The impact of coal-related pollutants on human health is well established.[20] Coal pollutants, such as sulfur dioxide, nitrogen oxides, particulate matter, arsenic, cadmium, mercury, and hydrogen fluoride, are known to affect all major human organs and to contribute to a wide range of both acute and chronic conditions, among them heart disease, cancer, stroke, and chronic lower respiratory diseases. Nitrogen dioxide (NO_2) is associated with adverse effects on health, as high concentrations cause inflammation of the airways and reduced lung function. NO_2 also contributes to the formation of secondary inorganic particulate matter and tropospheric (ground-level) ozone.

According to Harvard University's Paul R. Epstein, "Each step of the coal lifecycle—mining, transportation, washing, combustion, and disposing of post-combustion wastes—impacts human health. It interferes with lung development, increases the risk of heart attacks, and compromises intellectual capacity."[21]

Coal mining produces large amounts of waste products, such as coal "slurry," which along with coal ash waste from coal combustion pose risks to human health due to the presence of toxic pollutants.[22]

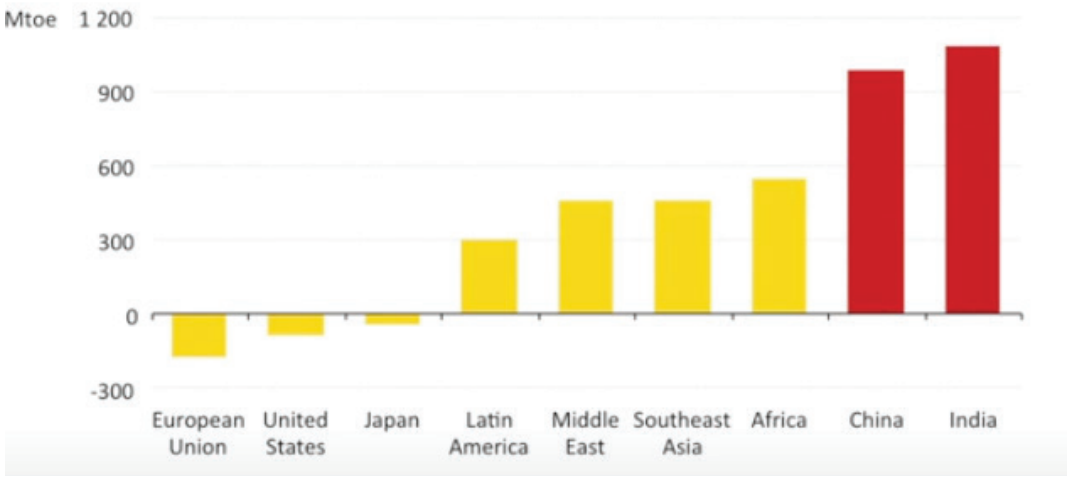
Coal use has risen a staggering 60% since 2000, with China burning almost 47% of the world's coal output (2013 figures). In 2012, the Chinese government announced plans for new coal-fired power stations that could effectively double the country's coal consumption,[23] but the slump in coal use from 2012-2015 triggered by China's economic slowdown has led to a government-imposed moratorium on new power plant construction until 2017.[24] Not surprisingly, the overall rise in coal use is being reflected in the statistics dealing with life expectancy in the large developing countries.[25] In India, coal-fired power generation may cause more than 100,000 premature deaths annually.[26] A recent study from the International Agency for Research on Cancer made a clear connection between levels of outdoor air pollution—much of it from coal—and increased cancer levels.[27] These and other negative impacts of coal are disproportionately borne by working class people, people of color, and migrants—people who are more likely to be living near or working in coal mines, coal-fired plants, and coal waste sites.

more than doubles previous estimates and confirms that air pollution is now the world's largest single environmental health risk. Reducing air pollution could save millions of lives."[17]

The new data reveal a stronger link between both indoor and outdoor air pollution exposure and cardiovascular diseases, such as strokes and ischemic heart disease, as well as the relationship between air pollution and cancer. This merely underscores air pollution's role in the development of respiratory diseases, including acute respiratory infections and chronic obstructive pulmonary diseases.[18]

The East Asia and Western Pacific regions had the largest air pollution-related burden in 2012, with a total of 3.3 million deaths linked to indoor air pollution and 2.6 million deaths related to outdoor air pollution. The WHO estimates indoor air pollution was linked to 4.3 million deaths in 2012, mainly in households cooking over coal, wood, and biomass stoves. Today more is known about air pollution's role

Figure 2: Change in energy demand in selected regions, 2014-2040, International Energy Agency, World Energy Outlook November 2015[28]



in the development of both cardiovascular and respiratory diseases and different cancers. In the case of outdoor air pollution, WHO estimates there were 3.7 million deaths in 2012 from urban and rural sources worldwide.

The Air-pocalypse

Air pollution generated by fossil fuels is sometimes regarded as a 19th-century problem associated with "First World" industrialization. *But in terms of the number of people impacted, air pollution is a bigger problem today than at any time in human history.* The industrial output of the developing world has skyrocketed, generating pollution of all kinds. The immediate impacts of this pollution are felt locally, but emissions like CO_2 and methane do not need a visa to move across borders and are everyone's problem due to their contribution to the "greenhouse effect" and global warming.

Studies from the WHO and leading research bodies have confirmed that air quality in countries like China, India, and in many urban areas of the Global South and North is shortening the lives and ruining the health of millions.[29]

China's air pollution has made headlines in the last several years. Particulate pollution levels rose an estimated 20 percent between 2005 and 2011.[30] Beijing has experienced PM2.5 levels (smaller, and more dangerous, particulates) nearly 30 times the WHO's "safe" level. But according to one analysis of hour-by-hour data derived from air quality monitoring sites in China over a four-month period (April to August 2014), pollution is extensive across China and is particularly severe in the northeast of the country. The study estimated that, nationwide, "observed air pollution is calculated to contribute to 1.6 million deaths/year in China, roughly 17% of all deaths in China."[31]

India's pollution levels have also grown dramatically in recent years. Analyzing NASA satellite data, Greenpeace India reported that, in 2015, the Indian population's exposure to dangerous levels of particulate pollution stands higher than China's, after increasing at an average rate of two percent over the past decade.[32]

At the same time, India and China are among the major developing countries (Indonesia and Turkey are others) that anticipate burning even more fossil fuels in order to continue their economic expansion. According to the International Energy Agency, India and China will lead the world in terms of new energy demand until 2040 and perhaps beyond. (See Figure 2).[33] A November 2015 *Washington Post* article reported that India's current government plans to supply coal-based electric power 24 hours a day to each and every Indian town and village would contribute to its becoming the world's largest greenhouse gas emitter by 2040.[34] India's INDC notes that "Coal based power as of now accounts for about 60.8% (167.2 GW) of India's installed capacity. In order to secure reliable, adequate, and affordable supply of electricity, coal will continue to dominate power generation in future."[35]

Most of the health impact studies reviewed by the WHO have focused on respiratory and cardiovascular effects attributed to exposure to air pollution. But more recent studies show that exposure to air pollutants at different times of life, ranging from prenatal exposure all the way through childhood and adult life, is also damaging. Exposure during pregnancy has been associated with reduced fetal growth, pre-term birth, and spontaneous abortions.[36] Maternal exposure to air pollution during pregnancy also increases the risk of children developing allergies and asthma later in life.[37] The mechanisms by which air pollution may act on the nervous system are now more clearly understood.[38] Several epidemiological studies have made a clear link between exposure to air pollution and impaired cognitive function.[39] Epidemiological studies also attribute the most severe health effects of air pollution to particulate matter (PM). The WHO (2013) has concluded that long-term exposure to fine particles with cardiovascular and respiratory deaths and increased levels of respiratory illness amongst children.[40]

The levels of air pollution in urban areas are also projected to grow rapidly. According to a study released in 2015, growing urbanization combined with worsening outdoor pollution levels will see premature mortality by outdoor air pollution in urban areas more than double by 2050 (from 2010) to 4.3 million people annually.[43]

Figure 3. Mortality linked to outdoor air pollution in 2010[41]

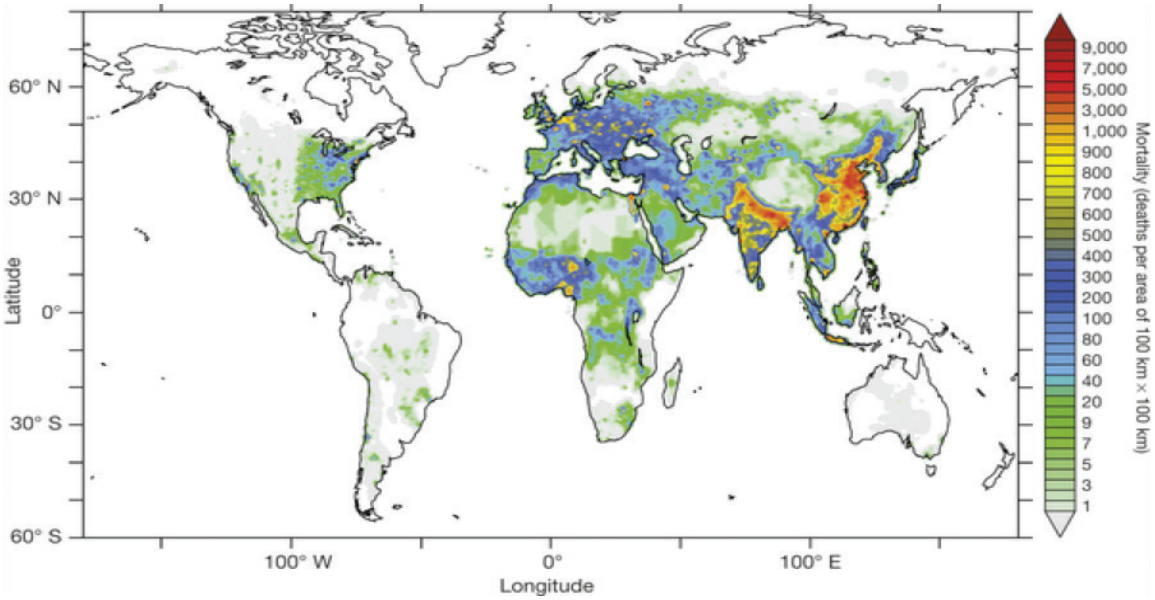
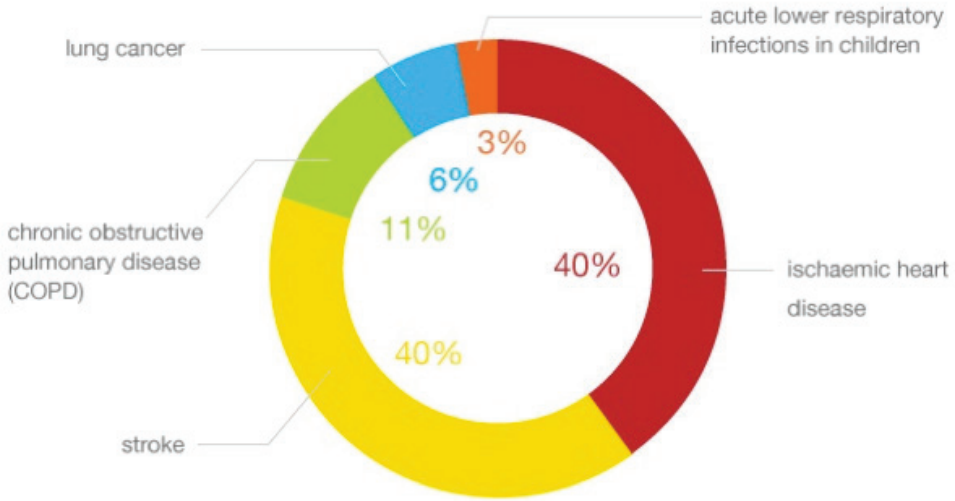


Figure 4. Death related to outdoor air pollution by disease, World Resources Institute, The City Fix, November 20, 2014[42]



Traffic Pollution and Vehicle-related Deaths

Traffic pollution is a significant contributor to premature mortality, causing a fifth of deaths in the rich countries. Globally, it caused only five percent of premature deaths from outdoor pollution, but this is likely to rise as more cars and trucks appear on the roads of the developing world.[44]

Another major health problem associated with fossil fuel use is vehicle-related deaths and accidents as the result of traffic accidents. From 1958 to 2008 the number of vehicles on the world's roads increased from 86 million to 620 million.[45] In 2015, more than 89 million new cars and trucks were purchased, with fewer than 600,000 being electrically powered.[46]

Worldwide, the total number of road traffic deaths reached 1.24 million in 2015, and the number of non-fatal accidents totaled an estimated 20-50 million, according to the WHO.[47] Road traffic injuries are the eighth leading cause of death globally and the leading cause of death for young people aged between 15–29 years. According to the WHO, "the cost of dealing with the consequences of these road traffic crashes runs to billions of dollars. Current trends suggest that by 2030 road traffic deaths will become the fifth leading cause of death. These injuries and deaths have an immeasurable impact on the families affected, whose lives are often changed irrevocably by these tragedies, and on the communities in which these people lived and worked."[48]

What is striking about vehicle-related deaths is the number of pedestrians and bicyclists killed by cars and trucks (almost one third of traffic-related fatalities), especially in the developing countries, where road safety laws either do not exist or are not enforced and where emergency services are inadequate. Rampant motorization has led to a situation in which 80% of road traffic deaths occur in middle-income countries, which account for only 52% of the world's registered vehicles.[49]

Clearly, converting vehicle fleets from fossil fuels to electricity or hydrogen power will not on its own appreciably reduce traffic accidents, but the lack of road safety policies or adequate

emergency services is testament to the fact that, in order to protect human health, major social and economic reorganization is needed that goes beyond the issue of emissions reductions. Furthermore, the development of safe and good quality public transportations systems can also lead to fewer vehicle miles traveled (VMTs) and therefore help lower vehicle-related deaths and injuries.

Energy Poverty and Illness

Globally, more fossil-based energy is being generated and consumed with each passing year. And yet, as of 2011, more than 1.3 billion people worldwide are without access to electricity and another 1 billion have unreliable access. At least 2.7 billion people lack access to modern, non-polluting fuels.[50] This means that communities and households rely on candles, kerosene lamps, paraffin lanterns, firewood, or car and tractor batteries—with often-fatal consequences. Every year, thousands of people die in fires and accidents involving kerosene stoves and lamps, and tens of thousands suffer serious burns. According to the WHO, "Nearly 2 million people die prematurely from illness attributable to indoor air pollution from household solid fuel use. Nearly 50% of pneumonia deaths among children under five years old are due to particulate matter inhaled from indoor air pollution. More than 1 million people a year die from chronic obstructive respiratory disease (COPD) that develop due to exposure to such indoor air pollution."[51]

People without access to electricity presently have no choice but to turn to other energy sources for their basic needs—such as heating their homes and cooking—which also contribute to air pollution and climate change. As long as a large share of electrical power is used to service industry and industrial agriculture and not to meet basic needs, then the health impacts of energy poverty will continue to be serious and perhaps worsen.

Part Two: Fossil Fuel Extraction and Human Health

Extracting fossil fuels has a major impact on the health of workers who engage in coal mining and blasting, oil drilling, and other "upstream" operations. However, a discussion on the full health-related impacts of fossil fuel extraction is beyond the scope of this paper. Rather, we briefly summarize the recent data on the health impacts of coal transportation, shale gas drilling, and tar sands extraction, each of which have increased in recent years.

Coal Transportation

The global trade in coal has grown dramatically over the past two decades as the overall demand for coal has increased. Global trade of coal grew dramatically from 2008 to 2013, but in 2014 it declined for the first time in 21 years. China and India accounted for 98% of the increase in world coal trade from 2008 to 2013, but declines in China's import demand have led to declines in total world coal trade in 2014 and, based on preliminary data, in 2015 as well. Nearly all the 47% growth in total world coal trade between 2008 and 2013 was driven by rising coal import demands by countries in Asia, specifically China and India. Today the major exporters of coal are Indonesia, Australia, Russia, the US, Colombia, and South Africa; and the leading importers are Pacific Rim countries, namely China, India, Japan, South Korea, and Taiwan.[52] This means that, while the increase in coal extraction, use, and transpor-

Figure 5. Coal exporting and importing countries, in millions of metric tons, International Energy Agency[53] (p-provisional)

Coal-exporting Countries, 2012-2014

Country	2012	2013	2014p
Indonesia	387.4	427.9	410.9
Australia	301.5	336.1	375
Russia	131.7	140.8	155.5
USA	114.1	106.7	88.3
Colombia	88.3	80.2	80.3
South Africa	76	74.6	76.4
Netherlands	13.7	31.9	37.7
Canada	34.8	39.1	34.5
Kazakhstan	32.7	33.8	28.9
Mongolia	20.9	18.4	19.3

Coal-importing Countries, 2012-2014

Country	2012	2013	2014p
China	288.8	327.2	291.6
India	164.2	188.8	239.4
Japan	183.9	195.6	187.7
Korea	124.3	126.5	130.9
Taiwan	64.6	66	67.1
Germany	49	54.3	57
Netherlands	24.4	46.7	54.7
United Kingdor	44.8	49.4	40.6
Turkey	29.2	26.6	29.8
Russia	30.3	29.4	25.3

tation may have peaked, its impacts are both substantial and also increasingly concentrated in a few countries.

In some countries the movement of coal over land—mostly by rail—has increased in tandem with the global coal trade. In the US, coal is by far the largest commodity volume moved by rail, with 4.9 million carloadings per year. Rail moves US coal to power stations and also to various points for export.[54] In New South Wales, Australia, each year 22,000 trains with four million uncovered coal wagons travel through the Hunter Valley region to the port of Newcastle (the world's largest coal port).[55] In addition, coal dust arises from coal stockpiles, both prior to transportation and at the port prior to export. According to the Climate and Health Alliance, "In addition to air emissions from transport, the increased volume of traffic on the region's roads from increased mining activity has prompted health and community concerns about a higher risk of road trauma." The Alliance cites a 2005 study that found there were an average 29 car crashes involving vehicles travelling to and from coal mines in New South Wales each year, with associated injuries and deaths amounting to a cost of $4.5 million (Australian) annually.[56]

Studies documenting the health impacts of coal transportation are still somewhat few in number. In the US, the process of hauling coal from mines to power plants releases 600,000 tons of nitrogen oxide and 50,000 tons of particulate matter into the air every year.[57] This largely comes from trucks and trains and the diesel engines they use to transport coal. During transit, coal dust is released into the air, exposing surrounding communities to dust inhalation.

In the case of China, the volume of coal moving long distances is extremely large. Coal production is mostly concentrated in its northern and western regions, while demand is centered in the east and along the Pacific coast. In the decade leading up to 2012, mining activities moved even further away, toward the western inland regions of Inner Mongolia, Shaanxi, Gansu, Qinghai, and Xinjiang provinces, thus extending the distances travelled. The capacity of the three existing major rail links that connect the western inland coalfields to the northern coal ports nearly doubled between 2005 and 2010.

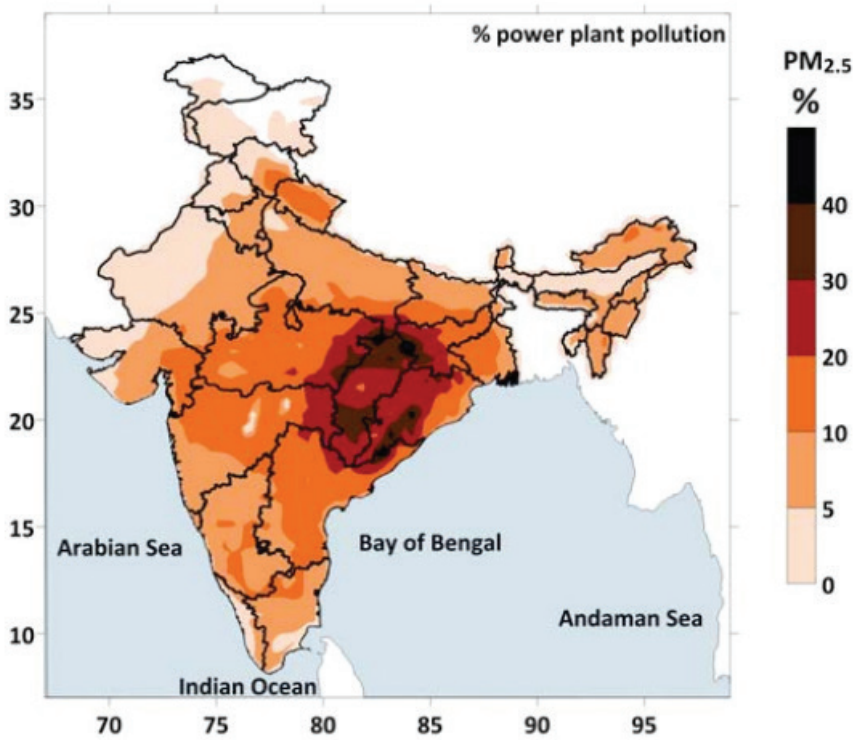
Communities near mining operations are normally subjected to the effects of blasting, the collapse of abandoned mines, and the disper-

sion of coal dust from coal trucks and trains. In the case of surface mining, forests and groundcover are removed and destroyed, often leading to erosion, flooding, and contamination of water supplies for nearby communities. The global growth in surface mining relative to traditional underground mining also increases pollution levels.[58] Dust from mining operations is less effectively contained in surface mining, and the impact on the surrounding communities is greater. In 2013, the Multnomah County Health Department, which includes Portland, Oregon, released a report on the health effects of transporting coal through Multnomah County. The authors review the literature, which shows that heart and lung problems, cancers, growth and development problems, stress and mental health problems, injury, and death are all strongly correlated with the local environmental effects of coal transportation.[59] At the same time, coal transport has effects that go beyond human health, as the National Wild Life Federation showed in its 2012 report, "The True Cost of Coal."[60] The report shows that coal transport would threaten key fish habitats, which means that flying coal dust from transporting coal negatively impacts fish stocks used for human consumption.

But the shift in coal use from the OECD countries to the Global South, particularly Asia, almost certainly means that the health impacts of coal transportation that are well documented in countries like the US are being replicated in the non-Western regions of the world. A 2013 report on coal from Greenpeace India is un-

Figure 6. Percentage contribution of power plant emissions to ambient PM2.5 concentrations (based on satellite measurements in India).

"For cities like Delhi, Chennai, Mumbai, Ahmedabad, Kolkata, and some medium to smaller size cities like Nagpur, Raipur, Ranchi, Kota, Bhatinda, Raichur, with power plants in the vicinity of 100km, do measure significant (5-30%) ambient contributions from these point sources."[62]



equivocal on the negative health impacts of coal transportation there. The report, entitled "Coal Kills," includes flying particulate matter from coal transportation as one of coal's emissions, rather than limiting its definition of emissions to the smoke and fly ash that results from burning it. In addition to the well-known respiratory effects of coal transportation, the report also shows that coal transport is having an impact on irregular monsoons, which are having a devastating impact on farmers and farm workers.[61]

Because most new coal extraction is now happening in Australia, South Africa, and Indonesia, as well as India, most new coal transport is happening in and between these countries as well. This means that the negative health impacts of pollution resulting from transportation will also increase in these countries, unless policies regarding coal extraction change soon.

Fracking

Hydraulic fracturing, or fracking, refers to the process of injecting water and other chemicals at very high pressure into the earth, such that it breaks open shale deposits several kilometers underground. With better technology available for this process, there has been an increase in the places that the oil and gas industry wants to look for oil and natural gas. The 2014 TUED Working Paper *Global Shale Gas and the Anti-Fracking Movement* noted the

> *severe impacts in terms of water contamination and access. Fracking just one well can use between 2 million to 5.6 million gallons of freshwater (7.6 million liters to 21 million liters) and produce between 420,000 to 2.5 million gallons of wastewater (1.6 million liters to 9.4 million liters), known as "produced" water or "flowback," which is water mixed with fracking fluid. The remaining high volume mix of non-biodegradable waste remains underground and under pressure. Freshwater aquifers, waterways and drinking wells can, and have been, contaminated when hydraulic fracturing inadvertently pierces and then leaks gas and drilling chemicals into fresh water drinking supplies.*[63]

A coalition of physicians called Concerned Health Professionals of New York, working with Physicians for Social Responsibility, has produced extensive documentation on the harmful health effects of fracking in a series of regularly updated reports. Their most recent report, "Compendium of scientific, medical, and media findings demonstrating risks and harms of fracking" ("Compendium"), released in October 2015, discusses seventeen separate categories of risks from fracking, ranging from water contamination and air pollution to carcinogens to "Inaccurate jobs claims, increased crime rates, threats to property value and mortgages, and local government burden."[64] Reports like this one have contributed to official bans or moratoria on hydraulic fracking in New York State, the Canadian province of New Brunswick, Lancashire in England, and the state of Maryland. In addition to the Compendium, the New York State Department of Health (NYSDOH) also released a report in December 2014, which concludes that the health risks of hydraulic fracking are too significant to ignore.[65]

Both reports prioritize the impact of fracking on local air quality. The volume of water, and the speed used to force it underground, results in increased levels of particulate matter, diesel exhaust, and volatile organic chemicals being released into the air. This has the strong possibility of reducing respiratory health among the workers doing the fracking, as well as local residents. The second serious health concern both of these reports discuss is that of water pollution. Groundwater clusters become contaminated by the underground migration of methane from badly constructed wells. The NYSDOH report discussed how, "Shallow methane migration has the potential to impact private drinking water wells, creating safety concerns due to explosions."[66] Both of these reports also point to fracking's community impacts. They emphasize that fracking is conducted in rural areas and in communities that often have poor infrastructure, including poor access to ba-

The Alberta Tar Sands

There appear to be many similarities between the negative health effects of fracking and those of extracting, transporting, and refining tar sands. In addition to the similarity between impacts that rural communities face, a host of specific health conditions that are associated with fracking are also associated with tar sands. According to the National Resources Defense Council (NRDC), mining tar sands releases more pollutants and particulate matter into the air, many of which can cause cancer. The NRDC reports that tar sands extraction in the province of Alberta has resulted in "complaints that tar sands operations have caused nausea, headaches, skin rashes, memory loss, joint pain, exhaustion, and respiratory problems, and have forced families to leave the area." The most immediate and, perhaps, dramatic effects of sourcing crude oil from tar sands have been in the movement of tar oil (as well as shale oil). This movement has led to a new phenomenon, the "train bomb," where derailed trains carrying tar oil have exploded. According to Eco Watch, "more oil was spilled from railroad cars in 2013 than the entire period from 1975-2012."[69]

sic health care. When health problems due to fracking arise, these communities often have little or no recourse and few advocates.

In addition to respiratory problems, the NYSDOH report mentions data that indicate statistical associations between some birth outcomes (low birth weight and some congenital defects) of babies whose mothers had been living near oil and gas wells drilled using fracking while they were pregnant. For example, the proximity of pregnant women to "higher-density HVHF (HVHF = high volume hydraulic fracturing) well pad development" was associated with the increased incidence of congenital heart defects and neural-tube defects in a study published in 2014.[67] Both reports also mention a host of health problems that have been observed in children and adults living near wells. These include "skin rashes or irritation, nausea or vomiting, abdominal pain, breathing difficulties or cough, nosebleeds, anxiety/stress, headache, dizziness, eye irritation, and throat irritation in people and in farm animals."[68] Noise pollution and seismic activity are also mentioned in both reports in relation to harms to human health resulting from fracking. Despite this list of serious potential health problems resulting from fracking, both reports are ultimately cautious about pointing to direct causality between fracking and these health problems. Rather, they both say that fracking should be stopped until the health impacts are more clearly understood.

Part Three: Climate Change and Human Health

The Intergovernmental Panel on Climate Change

Research on the health impacts of climate change is now extensive. The data summarized below are based on hundreds of peer-reviewed studies considered by the Intergovernmental Panel on Climate Change (IPCC).

Lack of space prevents either discussion or specific reference to each study individually, but these are more than adequately refer-

Consequences of a Warming World

Just two degrees Celsius of warming would not only make the air hotter, it would also acidify the world's oceans, wiping out much of the plankton upon which the marine ecosystem depends. The IPCC notes that the earth's temperature has already risen to 0.85 degrees Celsius above preindustrial levels. Even if emissions were to be stabilized to year 2000 levels, temperatures are likely to rise another 0.6 degrees by the end of this century.[70]

enced by the IPCC in its *Assessment Report 5* (AR5), released in March 2014, and in its earlier *Assessment Report 4* (AR4), released in 2007.[71] Chapter 11 of AR5 and Chapter 8 of AR4 specifically focus on health, although the data presented in other parts of AR4 and AR5 also show that the impact of climate change on health is a complex and still unfolding story.

The impact of climate change on health is often more indirect and therefore perhaps less obvious than is the impact of pollution from the use of fossil fuels on human health. But the impact of climate change is no less serious—and may prove to be an even bigger challenge over the longer term.[72] The IPCC has warned that the impact of global warming on health is already apparent.[73] It concludes,

> *Although some (health) risks would be reduced, aggregate health impacts would increase, particularly from malnutrition, diarrheal diseases, infectious diseases, floods and droughts, extreme heat, and other sources of risk.*[74]

The IPCC has identified three ways by which changes in climate affect human health:

1. *Primary*, direct-acting, climatic-environmental exposures. A good example would be exposure to excessive heat and the physical hazards of extreme weather events. The official death toll of typhoon Yolanda in the Philippines in 2013 was approximately 6,300.
2. *Secondary* health risks resulting from disruptions to ecosystems and inter-species relations. Examples include malnutrition from falling harvest yields and poor livestock health as well as infectious disease transmission.
3. *Tertiary* risks to physical and mental health from social and economic disruptions, job losses and changes, and even wars, which all produce resource shortages (of water, food, habitable land, etc.). [75]

Poor Countries and Poor People Are More Vulnerable

The fact that the very poorest countries are most impacted by climate change is a tragic irony. The countries likely to feel the deepest effects of climate change—among them Madagascar, Mozambique, the Philippines, Haiti, Zimbabwe, Myanmar, Ethiopia, Cambodia, Vietnam, Thailand, and Malawi—themselves have some of the lowest emissions levels in the world. In other words, the effects of the warming caused by the emissions of rich countries and, increasingly, major developing countries like China, India, and Brazil are actually being felt in countries that are among the poorest on the planet. It is here that the health impacts are also often being felt most acutely.

In the AR5, the IPCC shows how class ("socioeconomic status") can play an important role in determining the severity of certain climate-related illnesses and vulnerabilities.[76] In many countries, race and ethnicity are powerful markers of health status and social disadvantage. A clear example of the intersections of climate change and social disadvantage on health is in the rise in death rates among poor people in countries experiencing heat waves over the past several years. In India's summer

2015 heat wave, when some sections of road in New Delhi melted, 1,100 people died in the southern states of Andhra Pradesh and Telangana.[77] In April 2016, 330 million people—roughly one quarter of the country's population—felt the impact of record temperatures and drought conditions in central, eastern, and southern India, according to government estimates.[78] Several hundred deaths were attributed to the event.

Other consequences of warming are linked with changes in the local resources on which people depend. Indigenous peoples who depend heavily on local resources and live in parts of the world where climates are changing quickly are generally at greater risk of economic losses and therefore at greater risk of poor health. Studies among Inuit people, for example, show that rapid warming of the Canadian Arctic is jeopardizing hunting and many other day-to-day activities, with implications for livelihoods and wellbeing.[79] The fact that warming leads to changes in the environment that may impact livelihoods applies to numerous other communities as well,[80] including, but not limited to, people dependent on fishing, agriculture, and tourism for their survival.

Age is also likely to be a factor in determining climate-related health impacts, but research in this area is only just beginning. Worldwide, the proportion of people aged over 60 is projected to increase from about 10% presently to about 32% by the end of the century.[82] How an older population will deal with climate-related illnesses on top of other age-related conditions remains unclear at this point in time. A 2011 study in the journal of the American Society on Aging showed that older people are more vulnerable to extreme weather events and that the use of pesticides that act as neurotoxins in humans may accelerate neurological issues associate with aging, including Alzheimer's and other forms of dementia. All the vulnerabilities that elderly people face as a result of climate change are exacerbated by other vulnerabilities, such as those of economic class or lack of access to education.[83]

The IPCC has concluded that populations that do not have access to good quality health care and essential public health services are more likely to be adversely affected by climate variability and climate change. It notes how, for example, austerity conditions in Europe since 2008 led to cutbacks in health services in some countries, followed by a resurgence of climate-sensitive infectious diseases including malaria.[84] Some of these sentiments are echoed in a World Bank report on the intersections between climate change and poverty. The report shows that not only are poorer people more vulnerable to climate related illnesses but that "Diseases—and more generally poor health—increase poverty for several reasons. Health expenditures can absorb a large share of a household's income."[85] In this con-

Children's Health and Climate Change

In October 2015, *The Guardian* reported that the American Academy of Pediatrics released a policy statement which states that children's health is "uniquely" vulnerable to the effects of climate change. "Because of their growing minds and bodies, children are uniquely vulnerable to changes in their environment," said Dr. Samantha Ahdoot, the statement's lead author and assistant professor of pediatrics at Virginia Commonwealth University School of Medicine..." The report cited changing weather conditions as one of the main causes of trauma to children as "they are exposed to increased risk of injury, death, loss of or separation from caregivers and mental health consequences."[81]

text, climate change becomes part of a cycle of inequality and impoverishment that is both caused by and exacerbates poverty.

Mosquito-borne Diseases, Allergies, and Global Warming

Warming temperatures are known to exacerbate the problems caused by fossil fuels discussed in Parts One and Two of this paper. Concentrations of air pollutants in general, and fine particulate matter (PM) in particular, may change in response to climate change because their formation depends, in part, on temperature and humidity. Warming is known to increase the negative impacts of PM, which is known to affect morbidity and mortality. Over the past decade, a large number of studies have shown that climate change and global warming stemming from increased GHGs in the atmosphere will lead to greater rates of mosquito-borne diseases and allergies.[86] Studies also show that climate change has caused an earlier onset of the spring pollen season in the northern hemisphere.[87] The introduction of new invasive plant species with highly allergenic pollen, ragweed (*ambrosia artemisiifolia*) in particular, presents important health risks. Several laboratory studies show that increasing CO_2 concentrations and temperatures increase ragweed pollen production and prolong the ragweed pollen season, although this is a relatively new area of research and more studies are needed.

A solid foundation of research exists on the relationship between climate change and mosquito-borne illnesses. In 2010 there were an estimated 216 million episodes of malaria worldwide, mostly among children under five in Africa. The number of global malaria deaths was estimated to be 1,238,000 in 2010. Generally speaking, outbreaks of malaria have decreased as health services have generally improved, so any climate-related increases in malaria outbreaks are not easy to measure. However, the IPCC warns that malaria could be on the increase in some regions due to climate change combined with cuts in public health expenditures (as recently seen in Greece, for example).[88] A number of other illnesses have been on the rise as temperatures have increased, including dengue fever and chikungunya.[89] These illnesses have generally been on the rise in places where they have historically been common. Others, like West Nile virus,[90] have appeared in places where they have never existed before. The incidence of some, like Lyme disease, are likely to increase as temperatures rise.[91] It is very difficult to say whether and how much the rise in global temperatures has contributed to the rise and movement of these tick and mosquito borne illnesses already. However, given that a 2° C increase in average global temperatures this century seems very likely, it seems equally likely that many climate-related illnesses will become more prevalent over time.

While some studies suggest that climate change is responsible for an increase in outbreaks of dengue fever, the evidence is still inconclusive. Nonetheless, we do know that dengue is the most rapidly spreading mosquito-borne viral disease, showing a 30-fold increase in global incidence over the past 50 years. Heavy precipitation seems to favor the spread of dengue fever, but drought can also be a cause if households store water in containers that provide suitable mosquito breeding sites.[92] The journal *Nature Reviews Microbiology* compared two different ways of modeling the spread of dengue over the course of the next century. The model based on climate suitability show dengue spreading into most of the US and Europe by 2050. The more conservative model, based on statistical incidence projections of dengue, still shows dengue spreading over a vast area, though at a slower pace.

Overall, the transmission of mosquito-borne diseases is often affected by drought events.

During droughts, mosquito activity is reduced and, as a consequence, the population of non-immune persons increases. When the drought breaks, there is a much larger proportion of susceptible hosts to become infected, thus potentially increasing transmission.

There is also evidence that diseases transmitted by rodents and water-based parasites sometimes increase during heavy rainfall and flooding. There have been reports of flood-associated outbreaks of leptospirosis (Weil's diseases) from a wide range of countries in Central and South America and South Asia. Risk factors for leptospirosis for periurban populations in low-income countries include flooding of open sewers and streets during the rainy season.[93] In the US, one of the most alarming signs of climate change in relation to these kinds of epidemiological phenomena is the appearance of plague in Yosemite National Park. In 2015, two park visitors were diagnosed.[94] Rather than indicate an anomaly, scientific studies back up the fear that the incidence of plague will increase with increasing temperatures.[95]

The problem of mosquito- and water-borne diseases is linked with a host of other concerns for human health, not the least of which is the effects of warming on our food supply. The link between high ambient temperatures and increased incidence of salmonella food poisoning, for example, has been demonstrated in many places.[96] This last point is part of a larger discussion taking place among policy makers and scientists about the increased prevalence of malnutrition due to climate change, due to the damage to food stocks and production that higher temperatures will cause, and the subsequent increase in food insecurity.[97]

Extreme Weather Events

It is now indisputable that extreme weather events (EWEs) are becoming more frequent.[98] According to the World Meteorological Organization (2007) and the Inter-American Development Bank (2013), global warming is leading to more EWEs worldwide.[99] In October 2013, the IPCC also pointed to a changing pattern of extreme weather since 1950, with more heat waves and downpours in many parts of the world.[100] A recent study noted how "Cyclones have become more powerful, sea surges and storms become more violent, rainfall and flooding become more extreme, wind-assisted wild fires become fiercer and drought severity increases. Already a widespread upturn in weather disasters is evident, most of them probably amplified by the underlying (global) warming."[101]

Major storm and flood disasters have occurred in the last two decades. In 2003, floods in China affected 130 million people, and major flooding has claimed the lives of several tens of thousands since the late 1990s. Flood-related health impacts range from deaths, injuries, infectious diseases, and toxic contamination to mental health problems.[102] In 2014, record floods in Bangladesh resulted in more than 500,000 people being left homeless.[103] Over the past decade, monsoon-season floods have affected major cities and regions throughout India as well, including the devastating floods in Mumbai in 2005[104] and a continuing pattern of monsoon flooding. In 2015, floods have affected more than a million people in the northeastern state of Assam,[105] and have claimed 71 lives in the southern city of Chennai.[106]

The IPCC has noted that in 2011 six of the ten most serious natural disasters were flood events when measured in terms of both number affected (112 million people) and number of deaths (3,140 people).[107] Globally, the frequency of river flood events has been increasing, as have economic losses, due to the expansion of population and property in flood plains.[108] Severe floods in Australia in 2010-2011[109] and in the Northeastern United States in 2012 due

to Hurricane Sandy indicate that rich countries are not immune from flood-related damage and mortality, either.

Overall, the health impacts of EWEs and patterns are a rising concern. Hot days, hot nights, and heat waves have become more frequent. Heat waves are associated with marked short-term increases in mortality. Eighteen heat waves were reported in India between 1980 and 1998, resulting in a total 3,400 deaths. Heat waves in South Asia are associated with high mortality in rural populations and among the elderly and outdoor workers, and are paired with shorter and more unpredictable monsoons. The IPCC report notes that mortality figures from developing countries probably refer to reported deaths from heatstroke and are therefore an underestimate of the total impact of these events.[110] In the US, 11 people died in the state of Texas from surprise tornadoes hitting there in December, while 13 people died in the Midwest in flooding.[111]

Ultraviolet Radiation

Solar ultraviolet radiation (UVR) exposure causes a range of health impacts. Increased levels of UVR result from depletion of the ozone layer in the atmosphere, the layer of atmospheric gas that absorbs UVR. Ozone is depleted due to natural causes, but is greatly increased by certain refrigerants (like Freon), propellants (in aerosols), and solvents. The greatest health burdens of UVR exposure result from cortical cataracts and cutaneous malignant melanoma. Climate change will alter human exposure to UVR exposure in several ways, although the balance of effects is difficult to predict. It is anticipated that higher ambient temperatures will influence clothing choices and time spent outdoors, potentially increasing UVR exposure in some regions and decreasing it in others. In addition to having a detrimental effect on human health, increased UVR affects terrestrial[112] and aquatic[113] ecosystems, impacting everything from drought and rain cycles on land, to ocean acidification and warming. Increased UVR therefore impacts human health indirectly, because it also impacts food production and atmospheric temperature.

Climate change is also associated with exposure to elevated concentrations of ozone, which has led to increased hospital admissions for pneumonia, chronic obstructive pulmonary disease, asthma, allergic rhinitis, and other respiratory diseases and with premature mortality. It bears mentioning that increased ozone on the ground is as detrimental to human health as depleted ozone is in the sky. Tropospheric ozone is ground level ozone—the main component of smog. Tropospheric ozone is created by chemical reactions between various kinds of vehicle emissions and emissions from industrial facilities.[114]

The WHO is clear that while UVR exposure does have some health benefits, including for people who suffer from rickets, psoriasis, and vitiligo, "the harmful effects of exposure to UV radiation usually far outweigh its benefits."[115] These harmful effects are clear and cohere around effects to the skin, eyes, and immune system. While all of the research clearly shows that some UVR exposure is beneficial to human health, the concern regarding climate change focuses on increased exposure that will only grow as the ozone layer becomes more depleted due to our continued use of chemicals like CFCs and Freon, as well as the continued release of toxic smoke and fumes from vehicles and factories that use some form of combustion as part of their manufacturing processes.

Methane Leakage

"Methane leakage," or "fugitive methane," refers to the amount of methane that escapes from wells during the process of fracking. Re-

search has shown that the amount of methane a fracked oil or gas well releases into the atmosphere or underground water supplies is much higher than was previously known.

The consequences of atmospheric methane leakage are serious because they increase the amount of warming much faster than carbon dioxide. Per molecule, the global warming potential of methane is far higher than that of CO_2. It is 34 times stronger as a heat-trapping gas than CO_2 over a 100-year time scale, and 86 times more powerful over a 20-year time frame, according to the IPCC. Methane leakage levels of just 1.5% to 3% of gas harvested would erase all the GHG-related benefits of using gas instead of coal.[116]

More methane in the air means more warming and therefore more of the harmful health effects of a warming environment. However, unlike carbon dioxide, methane is highly combustible, which means that the immediate health risks of methane leaks from fracking wells include the possibility of fires and explosions in the area where the leak has taken place. While some gases, like cooking gas, emit a distinctive odor, methane is odorless, making it potentially much more hazardous.

Occupational Health

In recent years more attention has been directed toward the impact of climate change on workers and the workplace. The IPCC and the US Centers for Disease Control have noted that researchers have begun to focus more on the effects of heat on people.[117]

Heat stress due to high temperature and humidity is an occupational hazard that can lead to death or chronic health conditions from the after-effects of heatstroke for both outdoor and indoor workers. The occupations most at risk of heatstroke include construction and agriculture. Worldwide, agriculture provides employment to close to 40% of the world's workforce. In a 2001 report, the International Labor Organization showed that 110 million people worldwide work in construction and that this figure grows by 10 to 20 million people each year.[118] A 2013 study in the journal *Industrial Health* reviewed the literature on heat stress in relation to climate change, and concluded that heat stress among workers would affect people in tropical climates and developing countries disproportionately.[119] Metal workers in Bangladesh and rickshaw pullers in South Asia are among those reported to have already been affected, and several of the heatstroke deaths reported in the 2003 and 2006 heat waves in Paris were associated with occupational exposure. Working in hot environments also increases the risk of diminished ability to carry out physical tasks, reduces concentration, and makes workers more vulnerable to accidents.[120] Heat stress is also an issue for those working indoors in environments that are not temperature controlled and even for some workers in high-income countries. Heat has an impact on labor productivity as well. As workers take longer rests to prevent heat stress, or are unable to work due to heat stress, hourly productivity goes down.[121]

As noted above, a 2016 report released by the United Nations Development Program (UNDP) in partnership with the International Trade Union Confederation (ITUC) and Union Network International (UNI) focused on how a warming world could seriously impact occupational health, particularly for those working outdoors in agriculture or construction or in factories without air conditioning. "More than one billion workers," notes the report, "already grapple with dozens of additional extremely hot days in a year due to climate change alone." The report draws attention to how warming temperatures and other climate-related factors will have an impact on productivity, earnings, and the health of workers. The report

A Doctor in Yellowknife, Northwest Territories, Canada, on Wildfires and the ER

My respect for the ability of wildfires to affect day-to-day life skyrocketed last year, when the Northwest Territories, where I live, had one of its worst wildfire years on record. Between June 15th and August 31st we had frequent hazy skies and a near-permanent smell of campfire in the air.

Yellowknife's levels of PM2.5, the small particles that most affect respiratory health, exceeded the 24-hour ambient standard of 28 µg/m3 on 40 different days. Most memorable was the "Smoke Apocalypse" on July 3rd, when black clouds rolled in around 5PM and the "Land of the Midnight Sun" actually went as dark as night while our PM2.5 topped out at 728 µg/m3. When we went outside, the rain that had collected in watering cans and puddles was black.

I felt I was seeing more wheezy people in the ER than usual—and we're now undertaking a study to see if the numbers bear that out. Aside from itchy eyes, cough and cabin fever, for a number of people that I spoke with the fires held an additional symbolism: they were representative of their worst fears of climate change now coming to pass.[128]

notes that "Heat stress and heavy work create injuries, clinical health risks and daily productivity losses. Many workers are paid by production output, so heat causes longer workdays or reduced daily income."[122]

Fire and Drought

In some regions, changes in temperature and precipitation are projected to increase the frequency and severity of fires.[123] Forest and bush fires cause burns, damage from smoke inhalation, injuries, and even death to fire fighters and other first responders. In 2013, 19 Arizona fire fighters were burned to death when a bush fire went out of control. In Australia in 2009, record high temperatures, combined with long-term drought, caused fires of unprecedented intensity and 173 deaths from burns and injury in what are now known as the Black Saturday bushfires.[124] Most of the state of California is now prone to wildfires, with an annual "fire season" that has claimed more territory each year. The regions where these fires are taking place overlap with areas that have been hit by severe drought.[125]

Smoke from forest fires is linked with increased mortality and morbidity.[126] Large fires are also accompanied by an increased number of patients seeking emergency services. Gaseous and particulate air pollutants are released into the atmosphere, which can significantly contribute to acute and chronic illnesses of the respiratory system, particularly in children, including pneumonia, upper respiratory diseases, asthma, and chronic obstructive pulmonary diseases. For example, the 1997 Indonesia fires increased hospital admissions and mortality from cardiovascular and respiratory diseases and negatively affected activities of daily living in Southeast Asia. Pollutants from forest fires can affect air quality for thousands of miles. Wildfires, which occur more commonly following heat waves and drought, release particulate matter and other toxic substances that may affect large numbers of people for days to months.[127]

Drought and the consequent loss of livelihoods is also a major trigger for population movements, particularly rural to urban migration. Population displacement can lead to increases in communicable diseases, poor nutritional

status resulting from overcrowding, and a lack of safe water, food, and shelter. Recently, rural to urban migration has been implicated as a driver of HIV transmission.

Nutrition and Food Security

The scientific literature on climate change acknowledges that the causal chains through which climate variability and extreme weather influence human nutrition are complex and that direct causality is usually difficult to establish. Regional water scarcity, salinization of agricultural lands, destruction of crops through flood events, disruption of food logistics through disasters, and increased burden of plant infectious diseases or pests may all play a part, to varying degrees.[129] Instead of causes, studies aim to assess the association between climate change and various outcomes, and both acute and chronic nutritional problems are clearly associated with climate variability and change. The effects of drought on health, for example, include deaths, malnutrition (undernutrition, protein-energy malnutrition, and micronutrient deficiencies), infectious diseases, and respiratory diseases. In its *5th Assessment Review*, the IPCC reaffirms its earlier conclusion that climate change will increase the likelihood of under-nutrition. "Without accelerated investment in planned adaptations, climate change by 2050 would increase the number of undernourished children under the age of five by 20-25 million globally, or by 17-22 percent."[130]

The International Food Policy Research Institute has produced a number of recent reports that show the strong association between climate change and food insecurity. Of the Pacific Islands, it writes:

> *Climate change projections internationally accepted as being reliable indicate that most countries in the Pacific region will suffer large-scale negative impacts from climate change. These impacts are likely to include elevated air and sea-surface temperatures, increasingly unpredictable rainfall patterns, rising sea levels, and intensification of extreme weather events such as tropical cyclones and El Niño-related droughts. Pacific island countries are particularly vulnerable to such climatic changes, since on average, two-thirds of the region's population depends on agriculture and fisheries for its livelihood and food security.*[131]

The World Food Programme (WFP) states that "Among the most significant impacts of climate change is the potential increase of food insecurity and malnutrition."[132] It shows that in places where malnutrition is already a problem, climate change will make things much worse, and malnutrition will spread to places where it is less of a concern now. According to the WFP, malnutrition and climate change are linked through the cycle of drought and flooding that already characterizes the problems farmers are facing in Bangladesh and in the Pacific Islands.

Migration

Climate change has necessitated the term "environmental migrant," (or even "climate refugee"), which describes someone who has left a place because the environment has changed so much that physical survival is no longer possible there. Research that examines the intersections of climate change, migration, and health is fairly new and has yet to show that "environmental migrants" suffer health problems that are particular to their condition as migrants per se. However, studies show that environmental migrants are at risk for some of the same health problems that refugees currently face. According to one study, "The health risks associated with forced displacement are due to a lack of basic necessities for good health, such as food, shelter, and water, as well as reduced access to health care and loss of social networks and assets."[133] Many of the issues we raise in this paper, particularly those related to food security, drought, and rising sea levels, will have the

knock-on effect of increasing the numbers of people who have no choice but to move in order to find more habitable areas.

At COP 21 in Paris, the head of the World Meteorological Society, Michel Jarraud, warned that, as water becomes more scarce, the number of "climate refugees" will rise. "About 1.6 billion people already live in areas that are classed as having 'water scarcity' and that number is forecast to reach 2.8 billion by 2025. It will go on climbing after that as the planet continues warming…" Experts predict the scarcity will unleash a major refugee crisis as the lack of water for drinking, crops, and manufacturing makes huge populated areas uninhabitable and hundreds of millions of people are forced to move. "Often we think about climate change in terms of temperature but actually the most important parameter which will be affected is the water cycle," Mr. Jarraud told the Carbon Brief website. "In a water-stressed area, there will be even more stress on the water resources."[134]

Mental Illness

In recent years, medical researchers have paid more attention to the connection between climate change and mental illness. For example, farmers in Australia appear to be at increased risk of suicide during periods of drought.[135] Australia's rural suicide rate, 17 per 100,000 people, is above the national suicide rates of Canada and the United States. One Australian newspaper ran a drought-related headline which read "The cost: suicide every four days."

The connection between economic hardship and insecurity and poor health—including death through suicide—has been well established for many years. In the case of Australia, some farmers have had no income for several years and many rely on off-farm work to survive. Drought has wiped US$6 billion off agricultural production since 2002, and national farm debt increased 75% in ten years, from A$40.3 billion in 2004, to A$70 in 2014, as farmers borrow each season to plant crops, only to see them shrivel and die.[136] A similar case can be made for understanding farmer suicides in India. In neither case is climate change the "cause" of suicides; however, it is associated through a number of other factors, like debt burden, increasingly unpredictable crop yields, and the expense of pesticides and seeds.[137]

Depression, anxiety, and post-traumatic stress disorder (PTSD) are increasingly being documented following climate-related disasters such as floods, cyclones, tropical storms, and wild fires. In November 1998, Hurricane Mitch devastated much of Nicaragua and Honduras. A study conducted six months later found that rates of PTSD and depressive disorders were much higher in Nicaragua's worst affected communities than in those less severely affected. Losses of community and livelihoods and uncertainty about the future are key to understanding how mental health and climate change are so strongly associated.[138]

Violence and Conflict

There seems to be a growing body of evidence connecting climate change to political and military struggles over land and resources. Soil degradation, freshwater scarcity, population pressures, and other forces that are related to climate are all potential causes of conflict. Factors associated with risk of violent conflict are sensitive to climate variability, but it is difficult to separate out the influence of climate change on any given war or outbreak of violence. But the connection of war and violence is itself clear enough and requires no further elaboration.[139]

For example, in March of this year, the *New York Times* ran a story linking climate-related drought in Syria with the conflict there. It cited a study published in the Proceedings of the National Academy of the Sciences,[140] which

was unequivocal in stating that Syria's extreme drought, from 2006 until 2009, was anthropogenic. The article connected this with the current conflict, writing, "Some social scientists, policy makers and others have previously suggested that the drought played a role in the Syrian unrest, and the researchers addressed this as well, saying the drought "had a catalytic effect." They cited studies that showed that extreme dryness—combined with other factors, including the misguided agricultural and water-use policies of the Syrian government—caused crop failures that led to the migration of as many as 1.5 million people from rural to urban areas. This in turn added to social stresses that eventually resulted in the uprising against President Bashar al-Assad in March 2011.[141]

A debate currently rages in the natural and social scientific communities about whether climate change is related to the incidence of civil wars in sub-Saharan Africa.[142] Whether or not warming can be directly linked with conflicts in the Congo, South Sudan, and Somalia, for example, links can be made between drought, migration, and access to water, all factors in the conflicts that are currently taking place there. Whether the drought holds, or turns to flooding, as some predict, in regions like the Horn of Africa,[143] the current crisis involving migration and conflict do seem tied with broader global trends.

Conclusion

In the immediate future, accelerating public health and medical interventions to reduce the present burden of disease, particularly diseases in poor countries related to climatic conditions, is the single most important step that can be taken to reduce the health impacts of climate change... Alleviation of poverty is also a necessary condition for successful adaptation.

IPCC, Assessment Report 5[144]

This working paper has attempted to provide a summary of recent health-related research on the impacts of rising fossil fuel use and climate change. It has tried to draw attention to what is already a global health crisis, fully cognizant of the fact that—per the inadequate commitments made under the Paris Agreement—both fossil fuel use and GHG emissions are almost certainly going to *increase* until 2030 and perhaps even beyond that point.

The volume of health-related research on fossil fuel extraction, transportation, and use, as well as climate change, has grown exponentially in recent years, as evidenced by the work of organizations like the Intergovernmental Panel on Climate Change (or IPCC), the World Health Organization (WHO), and numerous research centers and universities. This paper has only been able to provide a scan of the main findings provided by these major bodies as a result of the efforts of thousands of medical scientists and climate researchers who are generating new data with each passing day. The reality is not only more complex than has been presented here; new studies are also bringing to light other issues and concerns, as the interconnectedness of health, pollution levels, and climate change becomes progressively more apparent.

We hope that the paper will help unions better understand what is happening to the health of people and of the ecosystems on which we all depend to survive. If unions need arguments to help them advocate for their members, communities, and the broader public, we hope

this paper has made some kind of contribution—at least by pointing to sources of data that can provide a more in-depth and nuanced assessment of the various topics and issues as they pertain to health.

The prospect of a warmer, more polluted, and more unstable planet will, at a minimum, require health and essential services that are fully staffed and resourced in order to deal with the challenges ahead. However, it is equally pressing to continue to fight to resist the expansion of fossil fuel use, reclaim the energy economy to the public sphere, and to set in motion a restructuring of the relations of energy supply, management, and consumption.

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