Turk Toraks Derg 2013; 14: 115-22 DOI: 10.5152/ttd.2013.54

INVITED REVIEW / DAVETLİ DERLEME

Climate Change and Global Public Health

İklim Değişikliği ve Küresel Halk Sağlığı

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Abstract

Climate change and global public health is a growing concern among the pulmonary care community. The Turkish Thoracic Society and the American Thoracic Society held special sessions during their 2013 annual conferences to discuss the impact of climate change on the environment and public health. These sessions are summarized in this review to illustrate the global consequences of climate change. Climate and its impact on air pollution and the relative incidence, timing and length of allergens in the atmosphere (pollen and allergen season) are presented. The influence of climate change on housing, indoor air quality and public health is discussed, along with how climate change is uniquely affecting low resource countries due to the process of desertification and its impact on water and food. The European and Caribbean perspectives of climate change on human vulnerability and adaption strategies are discussed, along with how federal and global policies might be implemented to mitigate the effects of climate change.

KEY WORDS: Climate change, lung disease, public health, housing, mitigation

Özet

İklim değişikliği ve küresel halk sağlığı akciğer hastalıkları camiasında giderek büyüyen bir endişe konusudur. Türk Toraks Derneği ve Amerikan Toraks Derneği, çevre ve halk sağlığı üzerine iklim değişikliğinin etkilerini tartışmak üzere, 2013 yıllık konferansları sırasında özel oturumlar düzenledi. Bu oturumlar iklim değişikliğinin küresel sonuçlarını göstermek için bu derlemede özetlenmiştir. İklim ve iklimin hava kirliliği ve atmosferdeki alerjenlerin göreceli sıklığı, zamanlaması ve süresi (polen ve alerjen mevsimi) üzerindeki etkisi sunulmaktadır. İklim değişikliğinin konut, iç ortam hava kalitesi ve halk sağlığı üzerindeki etkisi, çölleşme ve bunun su ve gıda üzerindeki etkisine haiz olmaları nedeniyle düşük kaynaklı ülkeleri iklim değişikliğinin özellikle nasıl etkilediği ile birlikte tartışılmaktadır. İklim değişikliğinin Avrupa ve Karayip perspektifleri; insan zafiyeti ve adaptasyon stratejileri üzerine iklim değişikliğinin Avrupa ve Karayip perspektifleri; iklim değişikliğinin etkilerini azaltmak için federal ve küresel politikaların nasıl uygulanabileceği ile birlikte tartışılmaktadır.

ANAHTAR SÖZCÜKLER: İklim değişikliği, akciğer hastalığı, halk sağlığı, konut, azaltma

Received/Geliş Tarihi: *03.09.2013* ***Accepted/Kabul Tarihi:*** *12.09.2013*

INTRODUCTION

There is increasing concern about how a changing world environment is affecting global public health. Climate change is contributing to rising population exposure to aeroallergens and secondary pollutants associated with adverse cardiorespiratory health effects. The purpose of this review is to provide examples of global issues and recommendations regarding climate change, patient care and policy considerations to protect public health and our global environment. This review is written for physicians, scientists, public health practitioners and health care providers around the world to gain a better understanding of the health effects of climate change and to support evidence-based global health policy.

Understanding How the Environment is Affected By Climate Change

Climate change is caused by anthropomorphic release of carbon-based fuels, including oil, natural gas, coal, and wood. Carbon dioxide (CO_2) measurements on Mauna Loa, Hawaii, have increased from 315 ppm in 1959 to over 400 ppm today. The greenhouse gas (GHG) effect has resulted in at least 0.8°C warming of surface global temperatures. Global leaders at the 15th Conference of the Parties to the United Nations Framework Convention on Climate Change (Copenhagen 15) agreed to limit warming to 2°C in 2009 [1].

The consequences of global warming are becoming increasingly apparent [2]. There is recognition of significant loss of glaciers, such as in Glacier National Park in the United States, and the snows of Kilimanjaro will likely disappear in a decade or so. Considerable melting of the Arctic ice cap has occurred with loss of multi-year ice. Expeditions will soon be unable to reach the North Pole. Melting of Greenland's ice cap is a serious concern because of the greater accumula-

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tion of heat in the northern latitudes, which will contribute to ocean rise.

Global warming will increase the intensity and frequency of storms including hurricanes and cyclones [3]. In the United States more than $150 billion in damages have resulted from the ten most destructive hurricanes, with nine of the ten occurring since year 2000. In 2011, there were 11 one billion dollar weather-related events in the United States. As a result, insurance companies are now among the leaders warning of the dire consequences of climate change.

Other notable United States weather-related events include severe drought that afflicted the Midwest and Great Plains during 2012, leading to dangerous low water levels in reservoirs as well as crop losses.

Warming temperatures are affecting biodiversity. As temperature rise, there is increased risk of pine beetle infestation in the Rocky Mountain forests and risk of wildfires in the Western Unites States. In the Northeastern United States, warmer springs are reducing maple syrup production. Estimates are for 15 to 40% biodiversity loss in some regions as species are unable to adapt to the warmed conditions. A case in point will be the 20,000 polar bears that need Arctic ice to hunt for seals.

Mitigation is important, especially in cities, which are heat islands and the buildings a major cause of carbon emissions [4]. The state of New York is working to restore wetlands that absorb storm surges and act as a sponge. New York City has attempted to reduce its carbon footprint by establishing bike lanes and bicycle rentals, switching to natural gas, purchasing wind power, planting one million trees, and establishing evacuation regulations. Air conditioners are available free of charge to mitigate heat wave-related morbidity. The building industry is recognizing the demand and need to meet specifications for reducing carbon footprint.

The future depends upon switching to renewable fuels and nuclear power under appropriate safety measures, with natural gas as an intermediary step. By 2025, the automotive fleets of the United States will need to average 54.5 miles per gallon, and there will be new regulations for carbon dioxide control on new coal-fired power plants and the older power plant fleet. A carbon tax or trading system will be necessary to provide a level playing field for renewables to compete with carbon-based fuels to prevent a climate-related crises in the foreseeable future [5].

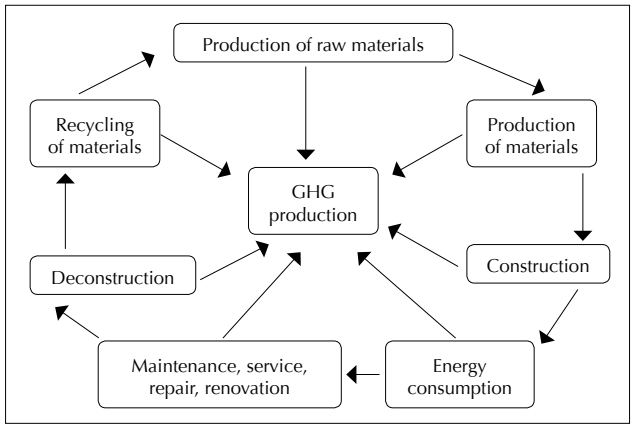

Figure 1. Carbon footprint from the lifecycle of housing

Climate Change, Air Pollution, and Interaction with Allergens

While scientific interest in climate and public health has markedly increased in recent years, only 57% of climate-health literature is primary research, with nearly half of publications representing reviews, editorials and opinions [6]. Climate change may affect lung health by altering at least four major factors: ambient temperature, levels of particulate matter (PM), ambient allergens, and ozone. Ambient temperature change is the only factor consistently recognized with confidence, even among experts [7].

A warmer climate is associated with more PM, including that due to increased forest fires, and more ambient allergen due to a longer growing season, faster plant growth during the growing season, and more pollen per plant [8,9]. Increases in allergen are associated with up to a 10% increase in cardiorespiratory mortality [10]. An important synergy related to exposures associated with climate change is co-exposure to PM plus allergens. This combination has been shown to lead to increase specific IgE in the airways and neoantigens [11-13].

Recent heat waves have been associated with elevated ozone concentrations that exceeded air quality standards, and a warmer climate is expected to lead to further increases in ambient ozone and more days exceeding the regulated standards [14,15]. Increases in ozone are associated with increases in both morbidity and mortality [16]. Ozone enhances airway responsiveness to allergen [17-19].

Thunderstorms, which are increasing with climate change, lead to elevated PM, ozone, and allergen (through decreased barometric pressure leading to pollen rupture), which together may compromise a 'perfect storm' of combined exposures leading to asthma exacerbations [20,21]. These experimental findings lend plausibility to the epidemiological findings of similar co-exposures leading to new asthma [22].

Climate Change, Housing and Public Health

Housing plays an important role both in mitigation of and adaptation to climate change. Housing represents 28% of the carbon footprint in the typical United States household and, therefore, has substantial potential for climate change mitigation [23]. GHG emissions, climate change, health and well-being are linked. Energy production and household consumption from fossil fuels increase GHGs, ambient air pollution and indoor air pollution. Thus, saving energy in housing reduces these factors.

Housing should be considered as a lifecycle, with GHG production minimized over a long time interval, e.g. 100 years (Figure 1). Actions to improve energy efficiency in building and thus, reduce GHG emissions and mitigate climate change include reducing air conditioning (cooling) use by more efficiently controlling and maintaining indoor temperature and air changes with better insulation, which improves air leakage, and reducing indoor emission sources.

By empirically studying the health effects of heat waves, we can predict the long-term consequences of climate change. The effect of heat waves on mortality has been extensively quantified, and it is clear that patients with chronic cardiovascular and respiratory diseases are at a higher risk. However, the weight of evidence shows that working air

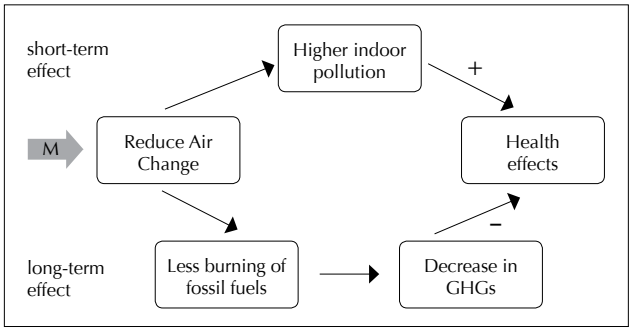

Figure 2. Mitigation (M) example: reducing building air change

conditioning, i.e., cooling in the home, protects against the adverse effects of heat [24].

Unfortunately, action to mitigate climate change and related health impacts in the long-term may increase health risk in the short-term. For example, reducing building air change lowers energy consumption and mitigates climate change, thereby reducing long-term health impact. However, if the air change is reduced without lowering indoor source emissions, levels of indoor pollution may rise and cause short-term health effects (Figure 2).

On the other hand, many actions to mitigate climate change will result in co-benefits for public health. For example, use of biofuels as household fuel is common in developing countries, especially for cooking. Women typically use firewood or charcoal in unvented stoves, exposing themselves and small children to high levels of indoor pollution, which can cause or exacerbate adverse respiratory health effects, especially asthma and chronic obstructive pulmonary disease (COPD). At the same time, use of biofuels contributes to CO_2 emissions. Improving home venting and offering alternative fuels would help mitigate this problem. Reducing household biofuel use would also lower overall ambient air pollution, especially in urban areas, and the ecological effects of deforestation and soil and groundwater pollution associated with biofuel harvest.

New solutions for sustainable housing include solar panel technology and use of geothermal energy. Solar panel technology could produce most needed energy in rural equatorial areas, and costs are declining as larger series are produced. In some areas, such as Iceland, geothermal heat can be used directly for heating. Heat pumps can be used to circulate a carrier fluid to transfer heat during the cold season and cold during the warm season. Both solar panels and transfer of geothermal energy offer the benefit of being climate friendly and not producing air pollution.

Desertification, Water, Food and the Vulnerability of Low Resource Countries

Desertification is an important consequence of climate change. In the last four decades, 15 to 63% of global land has been degraded. It is estimated that 12 million ha of land are transformed into new man-made deserts due to drought and desertification in the dry lands each year. These hotspots include Africa south of the equator, South East Asia, and South China [25]. Sand storms are important consequences of desertification, although a global pattern of sand storms has not been identified from analysis of long-term meteorological records of the Great Plains of the United States, the former Soviet Union, Morocco, the Arabian Gulf, Australia, the Sahel-Sudan zone of Africa, China, Mongolia and Mexico. While some stations, such as those in Sahel, reported a clear upward trend of great severity, some showed a downward trend (e.g., those in Mexico City), while others reported a more cyclical pattern [26].

Studies have demonstrated that dust storms can have serious health effects. In a study by Perez and colleagues, the association between different fractions of PM and daily mortality during Saharan and non-Saharan dust days in Barcelona was investigated [27]. The authors found that short-term exposure to PM during Saharan dust days was associated with both cardiovascular and respiratory mortality. Sand storms have been found to increase cardiopulmonary emergency visits, hospital admissions for COPD, pneumonia, and asthma in Europe, the Middle East, and other parts of Asia [28-31].

Meteorological records demonstrate that over the 20th and 21st centuries, precipitation mostly increased over land in high northern latitudes, while it decreased predominantly from 10° South to 30° North since the 1970s. In addition, the records show that the global area of very dry land has more than doubled since the 1970s. The Mediterranean Basin, Western United States, Southern Africa and Northeastern Brazil areas are under serious threat of water shortages [32]. Many river basins located in the United States, Mexico, the western coast of South America, Northern Africa, the Mediterranean region, the Near East (Western Asia) and South Asia suffer from lack of water. It is estimated that 1.4-2.1 billion people live in these basins [33]. Water shortages and drying may result in increased risk of hunger, malnutrition and related disorders, deterioration in child growth and development, and increases in the burden of diarrheal disease together with increases in the range and transmission of malaria in Africa [34]. Moreover, increased temperature negatively impacts both maize and wheat yields prominently in low latitudes.

It has been suggested that low resource countries are more affected by climate change than high resource countries due to lack of economic resources, a close dependence on natural systems for basic food and water provision and inadequate housing, energy, and waste management. These factors may limit societal adaptation to climate-related shocks, especially when combined with high levels of air pollution, high prevalence of chronic diseases, inadequate nutrition and unsafe water [4,35].

The Middle East Region comprises 16 countries, including Egypt, Turkey, Iraq, Iran, Syria, Saudi Arabia and the Persian Gulf countries. The Middle East is the world's most water-stressed region and among the most vulnerable regions to global climate change. Climate change models expect an increase up to 2ºC in the next 15-20 years and over 4ºC for the end of the century for most Middle East countries. A decline up to 20% in precipitation and increases in global sea levels are expected [36-39]. Meteorological records demonstrate a trend of increased temperature in Turkey since 1941. In parallel, more dry seasons have been recorded since the 1970s, especially in the southwest, inner part and southeast of Turkey [40].

Water resources in the Middle East are rather limited, and the total available water resources are estimated to be 262.9 bil-

lion cubic meter (BCM). Water deficit is expected to increase from 28.3 BCM in the year 2000 to 75.4 BCM in 2030. Increased temperatures will reduce the snow cover in the uplands of the Euphrates and Tigris river watersheds, which are vital for the Middle East. Furthermore, the flow of the Azraq River in Jordan is expected to decrease due to increased temperature [36].

Desertification is a serious threat for the whole Middle East, and the percent of desertificated land ranges from 10% in Syria, 92% in Iraq to nearly 100% in the United Arab Emirates. In Iran, the percentage of land degradation has been reported as 1.5 million ha, whereas 76% of Saudi Arabia is comprised of non-arable lands, of which 38% is deserts. The Southwest, Inner Anatolia and Southeast Anatolia (Mesopotamia Basin) regions of Turkey are reported to be at risk for desertification [41].

Sand storms in the Middle East can be intense and problematic, and there is evidence that the incidence is increasing. According to Israeli records, 966 dust days occurred from 1958 to 2006. The number of dust days associated with Red Sea Troughs has increased by 2.3 days/10 years, with highs of 0.9 days/10 years. The total incidence of dust days has increased an average rate of 2.7 days per decade [42].

Climate change poses serious security concerns, especially since the Middle East already suffers from tension, conflicts and violence from political problems and conflicts between Israel, Palestine, Syria and other countries. The division of water between countries in the region (i.e., Euphrates River between Turkey, Syria and Iraq) is already contentious and could become more so with climate change. Scarce water resources may thus complicate peace agreements in the region. It is thought that climate change may also intensify food insecurity, raising risk for the return/retention of occupied land (Palestine-Israel), and hinder economic growth, thereby worsening poverty and social instability. It may also lead to destabilizing forced migration and increased tensions over existing refugee populations. Furthermore, perceptions of resource shrinking may increase the militarization of strategic natural resources [43,44].

In conclusion, desertification is a major consequence of climate change that could lead to serious health effects in the Middle East. Climate change will have a negative impact on already stressed water and food sources. Low resource countries located in this area are more vulnerable because of their existing problems and inadequate capacity to combat difficulties that come with a changing climate.

European Perspective of Environmental Factors and Climate Change on Public Health

In Europe, climatic changes related to respiratory health are foremost occurring in situations with heat waves, as demonstrated dramatically during August 2003, when more than 20000 excess deaths occurred in England, France, Italy, Spain and Portugal [45]. In the Moscow area, the combination of forest fires and extreme temperatures in 2010 resulted likewise in excess mortality. There has been an increase in forest fires, especially in Southern Europe, during the last few decades, and the consequence is an increase in particulates in the air during the dry season.

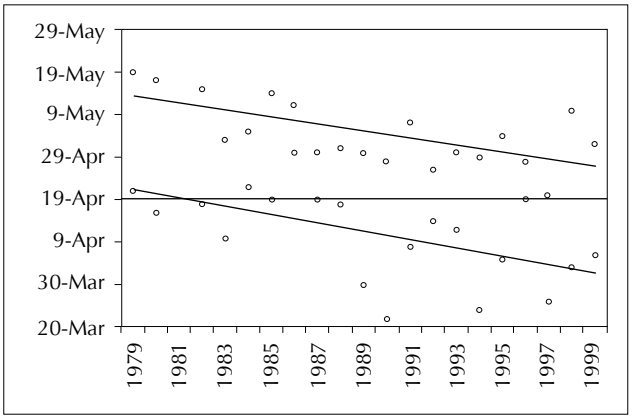

Figure 3. The figure shows the change to earlier birch pollination in Neuchâtel, Switzerland during the period from 1979 to 1999. From: Clot B. Trends in airborne pollen: An overview of 21 years of data in Neuchâtel (Switzerland). *Aerobiologia* 2003;19:227-34

Flooding is the other big driver of adverse health effects from climate change that is occurring in almost all regions of Europe, with the last episode occurring June 2013 in Central Europe; the water from the Donau area caused damage up to 8 BN € in Germany alone. The aftermath of flooding is characterized by mould and other problems related to humid conditions caused by the high water table.

As a consequence of higher temperatures, ozone generation is expected to occur in higher amounts around boreal forests (taiga). The Danish Eulerean Hemispheric Model (DEHM) predicts that temperature dependent biogenic emission of isoprene will increase significantly over land [46]. This would lead to greater ozone production and, together with an increase in water vapor, to enhanced proliferation of free hydroxide radicals. As a consequence, there may be increased airway irritation and respiratory morbidity, especially among susceptible segments of the population. A longer pollen season (Figure 3) and a 2-6 fold increase in pollen concentration, as seen in a Swiss study from 1979-1999, will lead to a higher degree of allergic symptoms in the sensitized population [47].

Caribbean Perspective on Human Vulnerability to Climate Change and Adaption Strategies

Climate change adversely affects the daily lives of numerous people around the world. Although some of the effects depend on the location, for a number of people climate change is simply a change in weather pattern, such as the temperature getting a bit hotter or colder. However, for many people in low or middle-resource countries, adapting to climate change is a matter of survival. The UN Office for Coordination of Humanitarian Affairs has developed a human vulnerability index for climate change [48]. According to their map, there is a negative correlation between the impact of climate change and the contribution to climate change; in other words, those who have contributed least to the climate change problem suffer from most of the effects. Thus, climate change is a major factor for global injustice and inequity around the world.

International discussions of climate change often focus on identifying vulnerable countries and populations. However, vulnerability to climate change does not reflect the same between and within different countries and communities.

The Intergovernmental Panel on Climate Change (IPCC) Report describes vulnerability as "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes" [34]. Vulnerable groups include the young, old, sick, physically or mentally challenged, and disadvantaged, such as the poor, minority, less educated, non-English speakers and women, especially single mother households.

According to popular perspective, the Caribbean region is regarded as a tropical paradise with unharmed environments free from climate change. Unfortunately, this assumption cannot be further from the truth. Caribbean communities are one of the most vulnerable populations, susceptible to the effects of climate change including increasing temperature, rising sea levels, changing rainfall patterns, and more extreme weather events, such as hurricanes and flooding.

We share three of our studies that focus on various vulnerable groups to demonstrate the real impact of climate change in the Caribbean:

Sick or chronic diseases patients: We evaluated the relationship between asthma visits to the emergency room (ER) and seasonal changes in Sahara dust exposure in Grenada [49]. Our statistical analyses showed that ER visits due to asthma attack correlated with Sahara dust exposure levels ($r=0.159$, $p<0.05$).

Young population: We investigated the relationship between flooding and health problems among the youth of Guyana, where children below the age of 14 are 32.4% of the population [50]. Guyana had four major flooding events between 1998 and 2008. We evaluated the prevalence of respiratory symptoms among occupants of water-damaged houses after the 2008 floods and found that 76.1% of houses had flooding and 32.8% of houses had mould. A statistically significant association was found between the presence of mould and runny nose and bronchitis ($p<0.05$).

Women and single mother households: The nutmeg industry is one of the most significant contributors to the local economy in Grenada, serving as a source of employment. In 2004, Grenada was hit by Hurricane Ivan and lost 90% of the nutmeg trees. After Ivan, the only remaining nutmeg processing plant was in Gouyave, a small, poor town. The processing plant employs mostly single mothers. We evaluated working conditions and found that 56% of the nutmeg workers involved in cracking/sorting was exposed to high dust. Work-related wheezing was statistically high among these workers ($x^2=3.849$, $p<0.05$) [51].

According to Smit et al. [52], adaptation "refers to the adjustments of ecological, social, and economic systems in response to actual or expected climatic stimuli and their effects or impacts. Adaptation refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change". Adaption is a continuous process, which includes learning, analyzing, planning, implementing, monitoring, and adjusting. Because vulnerable people often do not have a voice in decision-making, it is critical to establish community-based adaptation strategies. In conclusion, there is a need for combined effort between development and adaptation.

The Role of Regulatory Decision Making in Mitigating the Impacts of Environmental and Climate Changes in Public Health

The United States has seen marked improvement in air quality since the passage of the Clean Air Act (CAA) amendments of 1970. Implementation of the CAA has brought most primary pollutants down by two-thirds or more despite the growing population and economy, as indicated by vehicle miles driven and the Gross National Product (GNP). The benefits include greatly improved visibility; reduction in acidification of lakes, streams and forests; and substantive improvements in public health, with a return of ~$30 for every dollar spent in pollutant reduction [53]. Annually, it is estimated that hundreds of thousands of lives are saved from premature mortality, heart attacks, hospital visits, and asthma attacks with concomitant reduction in lost work or school time.

As population and economic growth draw heavily on energy to fuel their expansion, the natural byproduct of combustion, CO_2, which heretofore had been largely ignored, has increasingly been shown to have a strong, long-term impact on global climate. Paradoxically, it was long felt that the more complete the combustion process, the fewer traditional potentially toxic pollutants would be emitted, with only water and CO_2 as byproducts. It is now known that CO_2 and a number of other gaseous pollutants (including methane [CH_4], nitrous oxide [N_2O], fluoridated gases [HFCs, PFCs, and SF_6] as well as tropospheric ozone) can have major impact on global heating; likewise particles such as carbon black and sulfate have significant radiative potential-the former as a short-term radiative forcer with enhanced heat transfer and the latter reflecting sunlight in the upper atmosphere with a cooling effect.

The potential for climate change to impact public health is large. Its direct effects are often noted and include generalized global temperature rise, sea level rise, and wide variations and changes in precipitation. While these effects themselves can impact communities as well as individuals, indirect effects, such as extreme weather events of heat and storms and intense air pollution, regional shifts in vector-borne diseases and allergens, and shifts in available water quality or supply, can be dramatic with the creation of environmental refugees, especially in vulnerable habitats or regions. As a result, global impacts will be quite disparate and unbalanced with those least able to cope or adapt being most impacted [54].

Climate science is nothing new, with early concerns emerging in the middle of the 20th century with the development of the "Keeling Curve" showing the rise in global CO_2. Many meetings and colloquia have been held around the world sponsored by the UN and other international consortia on the topic. In 1990, the IPCC issued its first report tying global warming to man-made GHGs. A 5th IPCC assessment is due out in 2014 emphasizing socio-economic impacts and risk management choices. In the United States, the Global Change Research Program (USGCRP), which comprises 13 federal agencies, provides a national assessment every 4 years. The assessment report with its recommendations emanates from 240 authors from academia and state/federal governments will be released in 2014 with carefully considered approaches the country might take to minimize climate change impacts on

communities and the nation. These documents serve as important foundations tying climate science with projected health and welfare outcomes associated with global climate change.

In 2003, the United States Environmental Protection Agency (EPA) demurred from a position that the CAA could be applied to CO_2 and other GHG emissions despite arguments to the contrary that climate change can have significant impacts on public health and welfare – thereby linking GHGs impacts to a fundamental tenet of the CAA. This position was also upheld in the DC Circuit Court in 2005. However, in a landmark lawsuit in 2007, the state of Massachusetts argued successfully to the United States Supreme Court that Section 202(a) of the CAA did indeed hold for GHGs and that these gases could be regulated as pollutants. This finding established the foundation for the Endangerment and Cause or Contribute finding by the EPA Administrator in 2009 that decreed that current and projected emissions of six well-mixed GHGs in the atmosphere did indeed threaten public health and welfare of current and future generations. The initial finding would lead to a 2010 rule limiting GHG emissions in new motor vehicles and engines. Related motor vehicle rules such as the Renewable Fuels Standard was extended to 2025 to ensure that new fuels emissions would not exceed those of previous fuels and the Energy Independence and Security Act (2007) expanded to include diesels, provide new biofuel use targets, and mandate the use of life-cycle analyses to assess the full cost of new fuels. Stationary sources requirements rose for collection and reporting CO_2 emissions by industry energy suppliers including the power plants and the oil and natural gas production sector. Finally, EPA is working with the Department of Energy on CO_2 sequestration methods and strategies and has established a registry with strategies for cleaner emissions through the Waste and Recovery Registry.

In parallel, new practices are being explored to manage air quality and climate together to seek out co-benefits by systematically attacking the problem in a more holistic manner that appreciates their inextricable links. Multipollutant thinking is being applied to concept design to broaden the development of Integrated Science Assessments for the National Ambient Air Quality Standards (NAAQS). There is focus on potential climate forcing qualities of air pollutants not formerly appreciated and the potential interactions of air quality and climate change in developing climate impact assessments. Meanwhile evaluation of adaptation strategies and communicating volunteer approaches to minimizing GHG emissions (e.g., Energy Star, Smart Growth and Burnwise) are also in place and growing.

Climate change with it myriad implications for public health and welfare, including ecosystem and public infrastructure, remain an incredibly complex issue. The overarching concept of sustainability embraces virtually all aspects of the climate issue while supporting the elements of "environment, society, and economy." With the global population at 7 billion with projections of 10-15 billion by the century's end, the demands for even the most meager of sustenance by the billions will require energy beyond our current capabilities. New sources of clean energy and strategies with concrete methods to minimize waste and maximize efficient consumption of limited natural resources are required to avoid even wider disparities than exist today or even collapse of society as we know. Population growth will not occur evenly across economic sectors. Some forecasts show energy demand growing disproportionately in the mid-income sectors, which will tend to exacerbate total energy demand across the full economic range.

Until such time as the energy conundrum is resolved, the potential for the climate and air quality to worsen, despite technological advances in clean-up, looms large. While this argument or logic flow appears "gloom-and-doom", it is not intended as such. Rather it argues for investment in innovative approaches incorporating the essentials of sustainability and building across social and economic barriers with a clear sense of environmental resilience.

Conflict of Interest
No conflict of interest was declared by the authors.

Peer-review: Invited.

Author Contributions
Concept - K.E.P., D.C.; Design - K.E.P., W.R., C.C., J.J., H.B., T.S., M.A.E., D.C.; Supervision - K.E.P.; Funding - K.E.P., J.J.; Data Collection and/or Processing - K.E.P., W.R., C.C., J.J., H.B., T.S., M.A.E., D.C.; Analysis and/or Interpretation - K.E.P., W.R., C.C., J.J., H.B., T.S., M.A.E., D.C.; Literature Review - K.E.P., W.R., C.C., J.J., H.B., T.S., M.A.E., D.C.; Writer - K.E.P., W.R., C.C., J.J., H.B., T.S., M.A.E., D.C.; / Critical Review - K.E.P., W.R., C.C., J.J., H.B., T.S., M.A.E., D.C.

Acknowledgements
The contents of this review are based on research and presentations by the authors at the 16th Annual Meeting of the Turkish Thoracic Society (April 2013) and the International Conference of the American Thoracic Society (May 2013). The authors thank the organizers of the Turkish Thoracic Society Congress and the American Thoracic Society Board of Directors for the opportunity to speak on this critical topic in pulmonary and public health. Prof Pinkerton is supported by National Institute of Occupational Safety and Health grant 0H07550. Prof Jaakkola is supported by the Academy of Finland, grant no. 129419 (SALVE Research Program) and grant no. 266314 (Research Council for Health). Suzette Smiley-Jewell provided editorial assistance.

Çıkar Çatışması
Yazarlar herhangi bir çıkar çatışması bildirmemişlerdir.

Hakem değerlendirmesi: Davetli.

Yazar Katkıları
Fikir - K.E.P., D.C.; Tasarım - K.E.P., W.R., C.C., J.J., H.B., T.S., M.A.E., D.C.; Denetleme - K.E.P.; Kaynaklar - K.E.P., J.J.; Veri toplanması ve/veya işlemesi - K.E.P., W.R., C.C., J.J., H.B., T.S., M.A.E., D.C.; Analiz ve/veya yorum - K.E.P., W.R., C.C., J.J., H.B., T.S., M.A.E., D.C.; Literatür taraması - K.E.P., W.R., C.C., J.J., H.B., T.S., M.A.E., D.C.; Yazıyı yazan - K.E.P., W.R., C.C., J.J., H.B., T.S., M.A.E., D.C.; Eleştirel İnceleme - K.E.P., W.R., C.C., J.J., H.B., T.S., M.A.E., D.C.

Teşekkür
Bu derlemenin içeriği Türk Toraks Derneği'nin 16. Yıllık Toplantısındaki (Nisan 2013) ve Amerikan Toraks Derneği'nin

Uluslararası Konferansındaki (May 2013) yazarların araştırma ve sunumlarına dayanmaktadır. Yazarlar, Türk Toraks Derneği Kongresi düzenleyicilerine ve Amerikan Toraks Derneği Yönetim Kuruluna pulmoner ve halk sağlığındaki bu kritik konu hakkında konuşma fırsatı için teşekkür eder. Prof Pinkerton Ulusal Mesleki Güvenlik ve Sağlık Enstitüsü hibe 0H07550 tarafından desteklenmektedir. Prof. Jaakkola Finlandiya Akademisi tarafından desteklenmektedir, hibe no. 129419 (SALVE Araştırma Programı) ve hibe no. 266314 (Sağlık Araştırma Konseyi). Suzette Smiley-Jewell editoryal yardım sağlamıştır.

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