



Climate change and health in South East Asia

Jacob Kumaresan

World Health Organization Center for Health Development, Kobe, Japan

Jai P. Narain

Communicable Diseases, World Health Organization, New Delhi, India, and

Nalini Sathiakumar

*John J. Sparkman Center for Global Health,
University of Alabama at Birmingham, Birmingham, Alabama, USA*

Abstract

Purpose – The purpose of this paper is to illustrate the public health and societal implications of climate change in South East Asia, and create a framework for planning national and regional responses.

Design/methodology/approach – The paper elaborates on the adverse consequences of climate change in South East Asia, the current efforts taken by the regional countries, the current barriers to deal with the problems and presents a framework for planning responses.

Findings – The consequences of climate change from a public health perspective, as well as from an economic, political and resource security standpoint, for South East Asia can be disastrous. Consequently, there is an urgent need to plan national and regional level measures for climate change mitigation and develop comprehensive plans in response to the current and projected climate-related health risks.

Practical implications – The paper attempts to provide a detailed framework for addressing the health-related risks of climate change, in such a manner that it can be followed by all countries of the region.

Originality/value – South East Asia could face disastrous public health consequences due to climate change. A detailed framework for mitigating climate change effects in the context of public health has been suggested, focusing on strengthening the evidence base to aid climate change policy, advancing knowledge and training to mitigate climate change, implementing adaptation measures, greenhouse gas reduction and developing collaborative work. Following the framework could yield substantial benefits for the South East Asian countries.

Keywords South East Asia, Global warming, Public health, Social welfare planning

Paper type Viewpoint



Introduction

Climate change poses a significant and emerging threat to public health, with a growing contribution to the global burden of disease. At the March 2009 Climate Change Global Risks, Challenges, and Decisions conference in Copenhagen, World Health Organization (WHO) experts stressed the health impact of climate change as a “critical issue that

policy makers should be aware of while setting priorities for action and investment to mitigate the impact of global climate change". In this paper, we present guidelines based on the WHO action plan on climate change for an integrated regional action plan for the South East Asia region of the WHO, which is comprised of 11 countries: Bangladesh, Bhutan, Democratic People's Republic of Korea, India, Indonesia, Maldives, Myanmar, Nepal, Sri Lanka, Thailand and Timor-Leste.

Background

Scientific evidence strongly suggests that climate change has diverse impacts on human health, ranging from increased risks of extreme weather events and sea level rise, to effects on infectious disease dynamics (WHO, 2009a, b). The WHO estimates that about 150,000 deaths occur in low-income countries each year, due to four main climate-sensitive health outcomes:

- (1) crop failure and consequent malnutrition;
- (2) diarrheal disease;
- (3) malaria; and
- (4) flooding (WHO, 2009a, b).

The health impacts of climate change are felt unequally around the world, with the poor, the very young, women, the elderly and those lacking access to health services at greatest risk for climate-related health disorders and premature deaths (WHO, 2009a, b). Geographically vulnerable populations, those living in small island states, arid and high mountain zones, and in densely populated coastal areas, such as the large urban agglomerations in delta regions in South East Asia, are also disproportionately affected by climate change (WHO, 2009a, b).

The Intergovernmental Panel on Climate Change (IPCC) reports that there is overwhelming evidence that humans are affecting the global climate by engaging in activities that produce greenhouse gasses (GHG) (IPCC, 2001; Environmental Protection Agency, 2009). Increasing amounts of these gases pose significant health hazards (Environmental Protection Agency, 2009). Major environmental issues related directly or indirectly to GHG that impact health include outdoor air pollution (800,000 annual global deaths), traffic accidents (1.2 million annual deaths), physical inactivity (1.9 million deaths) and indoor air pollution (1.5 million annual deaths) (WHO, 2004). The WHO estimates that feasible practices to reduce GHG could decrease the global disease burden by more than 25 per cent (WHO, 2004).

Current scientific literature shows the burden of climate change on the world economy and urges countries to reduce GHG emissions (Stern, 2007; Ackerman and Stanton, 2006). Inaction on climate change could also have serious consequences on human health and has been justified as the biggest threat to health in the twenty-first century (Costello *et al.*, 2009) and reduction of GHG emission has become vitally important. Additionally, there are several economic and public health co-benefits associated with decreasing GHG. Co-benefits are the additional, or indirect, benefits of policy implementation that extend beyond the intended outcomes or direct benefits of GHG mitigation (IPCC, 2001). For example, some of the initiatives to mitigate climate change such as reducing motor vehicle use for transportation and instead walking, running or biking could also help to prevent the obesity epidemic, diabetes, colon cancer

and depression (Capon *et al.*, 2009; Younger *et al.*, 2008). Improving access to public transport could possibly decrease air pollution, with consequent reduction in chronic obstructive pulmonary disease, cardiovascular morbidity and mortality and lung cancer (Peel *et al.*, 2005; Diez Roux *et al.*, 2001; Nyberg *et al.*, 2000). Further, alternative forms of transportation will reduce traffic injuries and accidental deaths (Younger *et al.*, 2008). Thus, the South East Asian countries should view mitigation as a long-term investment for the future health, economy and security of their citizens.

Climate change issues in South East Asia

Scale of impact

South East Asia is home to more than 25 per cent of the global population (*Statistical Yearbook for Asia and the Pacific*, 2008). Because of the large population in the region, the consequences of climate change could be disastrous. Climate change could lead to increase disparity between rich and poor nations in terms of food productivity as poorer nations would be affected adversely (Parry *et al.*, 2004). This could lead to increased malnutrition negating the improvements in child growth and development achieved in the past few decades (McMichael and Haines, 1997) in poorer nations. Climate change also has a visible impact on communicable diseases, especially vector- and water-borne diseases, which, due to climate change, is expected to worsen in the foreseeable future (WHO, 2007a, b). The changes in weather conditions are expected to create an environment conducive to increased transmission and incidence of vector- and water-borne diseases. It has been projected that sea levels could rise by 70 cm by the end of this century in SE Asia, where 563 million people are concentrated in coastal areas (Asian Development Bank (ADB), 2009). Increased average temperatures could possibly prolong transmission periods for mosquito-borne diseases (Patz *et al.*, 1996), and extreme weather events such as cyclones and floods, create ideal conditions for mosquito-borne diseases, cholera and other diarrheal diseases (Haines and Patz, 2004). In much of SE Asia, dengue is now spreading geographically, and was reported for the first time in mountainous countries of Nepal (Pandey *et al.*, 2004) and Bhutan (WHO, 2007a, b) in 2004. The 1994 plague outbreak in Surat, Western India, was possibly due to the increased human-rodent interface that resulted from intense heat waves followed by heavy rainfall that forced rodents to leave their natural habitat (WHO, 2000, 2007a, b; Githeko, 2000).

Preliminary efforts

Some of the South East Asian nations have made preliminary efforts to address the issues of climate change (WHO, 2007a, b; Constantin de Magny *et al.*, 2008; Singh and Sharma, 2002; Devi and Jauhari, 2006; Bhattacharya *et al.*, 2006; Dev and Dash, 2007). The effect of climate change on endemic diseases like malaria, dengue and cholera has been evaluated in Bangladesh (WHO, 2007a, b). Time-series analysis has shown climate patterns as significant predictors for cholera epidemics in Bhutan and India (Constantin de Magny *et al.*, 2008). The role of climate factors on incidence and transmission of vector-borne diseases like malaria has been assessed in Bhutan, India and Indonesia (WHO, 2007a, b; Constantin de Magny *et al.*, 2008; Singh and Sharma, 2002; Devi and Jauhari, 2006; Bhattacharya *et al.*, 2006; Dev and Dash, 2007). These assessments have led to the call for immediate reduction in GHG emission in Maldives, Nepal and Sri Lanka (WHO, 2007a, b).

While these efforts are commendable, researchers have cautioned that they are more reactive than proactive. In countries such as Indonesia and Thailand, the lack of concrete efforts to tackle climate change could result in economic losses of 6.7 per cent of their combined gross domestic product (GDP) by 2,100, compared to a global GDP loss of 2.6 per cent during the same period (ADB, 2009). The ADB urgently recommends substantial investments in climate-proof infrastructures, energy-efficient industries, and forest fire protection systems. Furthermore, governments are urged to collaborate and initiate measures to safeguard shared resources, such as rivers, and cooperate on controlling disease outbreaks and managing disaster relief programs (ADB, 2009).

Barriers

South East Asian countries face a number of challenges in assessing the overall impact of climate change. Scientific expertise is a key barrier to gathering climate change-related health data and conducting research on hazard mitigation. Other significant hurdles include inadequate public health legislation, fragmentation of health systems, weak infrastructure and the lack of human and financial resources. Thus, developing the regional capacity to adapt for climate change could play a major role in addressing the above barriers and improve human health.

Action framework

We present a framework (adapted from the general WHO framework for action on climate change) for national action to develop comprehensive plans for South East Asian countries to respond to the current and projected climate-related health risks.

Strengthen the evidence base to aid policy change

Interdisciplinary research is warranted in the following key areas to address the knowledge gaps in climate change and health (WHO, 2009a, b):

- *Interactions with other health determinants and trends.* An understanding of the interaction of climate change with important health determinants, such as economic development, globalization, urbanization and inequities, both in exposure to health risks and access to care.
- *Direct and indirect effects.* From vector- and water-borne diseases, and characterization of the long-term health impact on vulnerable populations from risk factors, such as increasing air pollution, heat stress, drought, decline in freshwater resources and population displacement (WHO, 2009a, b).
- *Comparing effectiveness of short-term intervention.* An evaluation of the outcomes of the various national approaches dealing with climate change-related health threats, such as heat waves and floods.
- *Assessing health impact of policies of non-health sector.* Health implications of specific climate change mitigation and adaptation policies in multi-sectors, for example, the positive health effects of sustainable energy and transport policies (WHO, 2009a, b).
- *Strengthening public health systems to address health effects of climate change.* Identifying the most effective means of implementing integrated preventive public health strategies that reduce climate change-related threats, as well as other environmental health risks (WHO, 2009a, b).

National actions. Each country should develop and maintain a database of past and current research projects related to climate change, and a directory of national and regional experts who will serve as resource persons for the implementation of research projects and for conducting national capacity building workshops. Research should be strengthened to improve quality of data sources, and upgrade existing climate, non-climate and health outcomes data (WHO, 2009a, b). Coordinating the dissemination of research results within the scientific and non-scientific community should also be a priority within the region.

Advance knowledge and training

Increasing community awareness and education is a prerequisite for behavioral change and for gaining public support for the implementation of climate change measures. Specific targets in the population are vulnerable groups such as children, the elderly and the poor (WHO, 2009a, b). Achieving an optimal level of understanding of climate change in communities depends on the level of education, understanding and participation of its members.

National actions. South East Asian countries should identify focal points for national education and training and develop training materials for the local communities (WHO, 2008). National communication plans should be developed based on thorough needs assessments (WHO, 2008).

Implement adaptation measures

Adaptation refers to the process of designing, implementing, monitoring and evaluating strategies, policies and measures designed to reduce climate change-related impact (IPCC, 2007). Policies and actions must be tailored to strengthen national capacity to adapt to climate change, by reducing vulnerabilities and ensuring equity. Adaptation requires a concentrated multi-sectoral effort initiated by government policies and implemented by public health organizations and the community (IPCC, 2007). It is a multi-pronged process integrating a government-led approach and community-based approach. Adaptation measures must be integrated into existing emergency preparedness and disaster management plans (IPCC, 2007).

National actions. South East Asian countries must identify health priority areas for intervention and work with stakeholders in developing strategic plans for adaptation. Strengthening primary health care systems (including preventive care) to be resilient to address the health consequences of climate change should be a priority (WHO, 2009a, b). As part of emergency preparedness and adaptation, governments should develop and maintain centralized electronic tracking mechanisms that can link large metropolitan areas within each country to detect changes in the real-time distribution and prevalence of vector-, water- and food-borne diseases.

Contribute to global GHG reduction

There is ample evidence that the co-benefits of good public health practices contribute to reductions of GHG, and vice versa (IPCC, 2007). Thus, reducing carbon emissions through mitigation strategies should be a key public health strategy:

- *Emission standards.* Factory and vehicle emissions together constitute the maximum amount of GHG in South East Asia (HEI, 2004). Progressively raising emission standards and enforcement of mandatory catalytic converters in vehicles would contribute to a reduction in GHG.

- *Renewable energy.* The South East Asia region thrives on coal-powered plants, known to be one of the major sources of GHG (HEI, 2004). Policy changes should provide the major impetus for using newer energy production technologies, which would include the use of wind, solar, biomass and geothermal energy.
- *Hybrid vehicles.* South East Asia has an extensive network of public transportation.

Most of the people in this region use some form of public transportation, which run on fossil fuels. Hybrid vehicles lead to substantial reduction in gaseous emissions and should be promoted as a priority.

National actions. South East Asian countries should promote the use of renewable energy and energy-efficient technologies, encouraging best practices. Each country should design culturally relevant programs to engage community-level participation, encourage traditional and cultural practices that result in GHG reduction. Countries should support businesses that are pro-active in GHG mitigation strategies.

Develop partnerships and networks

Since scientific data are closely linked to policy formulation, partnerships between the scientific communities, policy leaders, local governments and non-governmental organizations need to be strengthened (UNDP, 2005). It is vital to engage all relevant stakeholders, as the choices made by other sectors, such as energy, agriculture and transport, have a direct impact on human health (WHO, 2009a, b). Networking with these sectors to determine how mitigation and adaptation decisions affect various sectors (UNDP, 2005) and developing evaluation tools at national, regional and local levels will support avoidance of health risks and achievement of health benefits.

National actions. Maintaining a current list of all agencies engaged in climate-related work, coordinating national meetings between partners and promoting national and international partnerships are critical actions that countries should undertake.

Conclusions

The implications of climate change for public health are becoming increasingly important and, therefore, addressing them requires rigorous scientific investigation and evidence-based strategic planning. The magnitude of the problem necessitates increased public awareness, especially among policymakers, and the implementation of policies that mitigate the effects of climate change on health. Concerted action to strengthen health systems by developing preparedness plans and surveillance systems can enhance public health, as well as reducing vulnerability to climate change. An effective, sustainable response requires integrated action, financial investment and multi-sectoral collaboration.

References

- Ackerman, F. and Stanton, E. (2006), "Climate change – the costs of inaction", *Report to Friends of the Earth England, Wales and Northern Ireland*, Global Development and Environment Institute, Medford, MA.
- ADB (2009), "The economics of climate change in Southeast Asia: a regional review", available at: www.adb.org/Documents/Books/Economics-Climate-Change-SEA/PDF/Economics-Climate-Change.pdf (accessed 14 May 2009).

- Bhattacharya, S., Charma, C., Chiman, R.C. and Mitra, A.P. (2006), "Climate change and malaria in India", *Current Science*, Vol. 90 No. 3, pp. 369-75.
- Capon, A.G., Synnott, E.S. and Holliday, S. (2009), "Urbanism, climate change and health: systems approaches to governance", *The NSW Public Health Bulletin*, Vol. 20 Nos 1/2, pp. 24-8.
- Constantin de Magny, G., Murtugudde, R., Sapiano, M.R., Nizam, A., Brown, C.W., Busalacchi, A.J., Yunus, M., Nair, G.B., Gil, A.I., Lanata, C.F., Calkins, J., Manna, B., Rajendran, K., Bhattacharya, M.K., Huq, A., Sack, R.B. and Colwell, R.R. (2008), "Environmental signatures associated with cholera epidemics", *Proceedings of the National Academy of Science (USA)*, Vol. 105 No. 46, pp. 17676-81.
- Costello, A., Abbas, M., Allen, A., Ball, S., Bell, S., Bellamy, R., Friel, S., Groce, N., Johnson, A., Kett, M., Lee, M., Levy, C., Maslin, M., McCoy, D., McGuire, B., Montgomery, H., Napier, D., Pagel, C., Patel, J., de Oliveira, J.A., Redclift, N., Rees, H., Rogger, D., Scott, J., Stephenson, J., Twigg, J., Wolff, J. and Patterson, C. (2009), "Managing the health effects of climate change", *Lancet*, Vol. 373, pp. 1693-733.
- Dev, V. and Dash, A.P. (2007), "Rainfall and malaria transmission in north-eastern India", *Annals of Tropical Medicine and Parasitology*, Vol. 101 No. 5, pp. 457-9.
- Devi, N.P. and Jauhari, R.K. (2006), "Climatic variables and malaria incidence in Dehradun, Uttarakhand, India", *Journal of Vector Borne Disease*, Vol. 43 No. 1, pp. 21-8.
- Diez Roux, A.V., Merkin, S.S., Arnett, D., Chambless, L., Massing, M., Nieto, F.J., Sorlie, P., Szklo, M., Tyroler, H.A. and Watson, R.L. (2001), "Neighborhood of residence and incidence of coronary heart disease", *The New England Journal of Medicine*, Vol. 345 No. 2, pp. 99-106.
- Ezzati, M., Lopez, A.D., Rodgers, A. and Murray, C.J.L. (Eds) (2004) *Comparative Quantification of Health Risks: Global and Regional Burden of Disease Due to Selected Major Risk Factors*, World Health Organization, Geneva, available at: www.who.int/healthinfo/global_burden_disease/cra/en/index.html
- Environmental Protection Agency (2009), "Greenhouse gas emission", available at: www.epa.gov/climatechange/emissions/index.html (accessed 14 May 2009).
- Githeko, A.K. (2000), "Climate change and vector-borne diseases: a regional analysis", *Bulletin of the World Health Organization*, Vol. 78 No. 9, p. 1136.
- Haines, A. and Patz, J. (2004), "Health effects of climate change", *JAMA*, Vol. 291, pp. 99-103.
- HEI International Scientific Oversight Committee (2004), "Health effects of outdoor air pollution in developing countries of Asia: a literature review", Special Report 15, Health Effects Institute, Boston, MA, available at: <http://pubs.healtheffects.org/getfile.php?u=13> (accessed 8 October 2010).
- Intergovernmental Panel on Climate Change (2001), "Climate change", IPCC Third Assessment Report, available at: www.grida.no/publications/other/ipcc%5Ftar/?src=/climate/ipcc_tar/ (accessed 28 May 2009).
- Intergovernmental Panel on Climate Change (2007), "Adaptation to climate change in the context of sustainable development and equity", *Climate Change 2001, Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Fourth Assessment Report of the IPCC*, available at: www.ipcc.ch/ipccreports/ar4-wg2.htm (accessed 11 December 2010).
- McMichael, A.J. and Haines, A. (1997), "Global climate change: the potential effects on health", *BMJ*, Vol. 315, pp. 805-9.
- Nyberg, F., Gustavsson, P., Jarup, L., Bellander, T., Berglund, N., Jakobsson, R. and Pershagen, G. (2000), "Urban air pollution and lung cancer in Stockholm", *Epidemiology*, Vol. 11 No. 5, pp. 487-95.

- Pandey, B.D., Rai, S.K., Morita, K. and Kurane, I. (2004), "First case of dengue virus infection in Nepal", *Nepal Medical College Journal*, Vol. 6, pp. 157-9.
- Parry, M.L., Rosenzweig, C., Iglesias, A., Livermore, M. and Fischer, G. (2004), "Effects of climate change on global food production under SRES emissions and socioeconomic scenarios", *Global Environmental Change*, Vol. 14, pp. 53-67.
- Patz, J.A., Epstein, P.R., Burke, T.A. and Balbus, J.M. (1996), "Global climate change and emerging infectious diseases", *The Journal of American Medical Society*, Vol. 275, pp. 217-23.
- Peel, J.L., Tolbert, P.E., Klein, M., Metzger, K.B., Flanders, W.D., Todd, K., Mulholland, J.A., Ryan, P.B. and Frumkin, H. (2005), "Ambient air pollution and respiratory emergency department visits", *Epidemiology*, Vol. 16 No. 2, pp. 164-74.
- Singh, N. and Sharma, V.P. (2002), "Patterns of rainfall and malaria in Madhya Pradesh, Central India", *Annals of Tropical Medicine and Parasitology*, Vol. 96 No. 4, pp. 349-59.
- Statistical Yearbook for Asia and the Pacific* (2008), United Nations Economic and Social Commission for Asia and the Pacific, available at: www.unescap.org/stat/data/syb2008/16-Employment.asp (accessed 14 May 2009).
- Stern, N. (2007), *The Economics of Climate Change: The Stern Review*, Cambridge University Press, Cambridge.
- UNDP (2005), "Engaging stakeholders in the adaptation process", available at: www.undp.org/gef/documents/publications/apf-technical-paper02.pdf (accessed 10 December 2010).
- World Health Organization (2000), *WHO Report on Global Surveillance of Epidemic-prone Infectious Diseases*, available at: www.who.int/csr/resources/publications/surveillance/WHO_Report_Infectious_Diseases.pdf (accessed 28 May 2009).
- World Health Organization (2007a), "Climate change and health implications for SEAR countries; Bhutan takes action to mitigate impact", available at: www.searo.who.int/LinkFiles/Advocacy_Efforts_Climate_change_and_health_Implications_Aug07.pdf (accessed 28 May 2009).
- World Health Organization (2007b), "Climate change and human health in Asia and the Pacific: from evidence to action", Report of the Regional Workshop, Bali, 10-12 December, available at: http://203.90.70.117/PDS_DOCS/B3181.pdf (accessed 4 May 2009).
- World Health Organization (2008), "2008-2009 regional plan of action to protect health from climate change", available at: www.searo.who.int/LinkFiles/World_Health_Day_2008_RPA_CC0409.pdf
- World Health Organization (2009a), "Protecting health from climate change: connecting science, policy and people", available at: http://whqlibdoc.who.int/publications/2009/9789241598880_eng.pdf (accessed 10 October 2010).
- World Health Organization (2009b), "Protecting health from climate change", Global Research Priorities, available at: http://whqlibdoc.who.int/publications/2009/9789241598187_eng.pdf (accessed 10 October 2010).
- Younger, M., Morrow-Almeida, H.R., Vindigni, S.M. and Dannenberg, A.L. (2008), "The built environment, climate change, and health: opportunities for co-benefits", *American Journal of Preventive Medicine*, Vol. 35 No. 5, pp. 517-26.

About the authors

Jacob Kumaresan, MD, DrPH, has been Director of World Health Organization (WHO), Centre for Health Development in Kobe, Japan since 2008. Earlier he served at the WHO Office for the UN in New York and was President of the International Trachoma Initiative, a non-profit organization

dedicated to eliminating the leading cause of preventable blindness. His public health career spans many continents, having worked with the governments of Zimbabwe and Botswana during the 1980s. He joined WHO headquarters in Geneva 1992, where he eventually headed the Stop TB Partnership expanding efforts to meet the global targets to stop TB.

Jai P. Narain is presently the Director, Department of Communicable Diseases at the WHO Regional Office for South East Asia (SEARO) in New Delhi, responsible for coordinating WHO response in the South East Asia Region to various communicable diseases including influenza, HIV, TB, Malaria and neglected tropical diseases. He holds MBBS and MD degrees from the All India Institute of Medical Sciences (AIIMS), New Delhi, and MPH and MS from Harvard University School of Public Health, Boston. Before joining SEARO, he worked with the PAHO/AMRO Caribbean Epidemiology Centre as Head of HIV/STI program and from 1990 to 1992 coordinated WHO TB/HIV research efforts in WHO/HQ, Geneva. From 1992 to 2003, he served as Team Leader, Global Program on AIDS and Regional Adviser for HIV and TB programs in SEARO. Jai P. Narain participated in the Global Smallpox Eradication Program during 1975 and has served over the years in various prestigious institutions including the National Institute of Communicable Diseases, AIIMS and the Indian Council of Medical Research, all in New Delhi, and also at the Centers for Disease Control (CDC), Atlanta, Georgia, USA as an Epidemic Intelligence Service officer. He has many publications to his credit and has edited/authored several books on various aspects of communicable diseases.

Nalini Sathiakumar, MD, DrPH is an Associate Professor of Epidemiology and International Health, with joint appointments in the Cancer Comprehensive Center and in the UAB Sparkman Center for Global Health. Dr Sathiakumar is an Epidemiologist and Pediatrician with substantial research and training experience overseas and with foreign trainees in the USA. She holds an MD from the Institute of Child Health in Madras, India and a DrPH from the University of Alabama at Birmingham. She has approximately 30 years of experience in clinical pediatrics and research as well as over 19 years experience in occupational and cancer epidemiology. Her past research includes investigations of workers in the synthetic rubber, petroleum, chemical, plastics and pesticide manufacturing industries. Her current research includes investigations of female synthetic rubber industry workers, chemotherapy-induced thrombocytopenic purpura, triazine herbicides and cancer, as well as a CDC and prevention-funded research project to study the adverse effects of environmental tobacco smoke (ETS) on children's health and a mother-child intervention to reduce ETS exposure. Dr Sathiakumar has published extensively in peer-reviewed publications in the fields of epidemiology, environmental and occupational health, maternal and child health and international health. Nalini Sathiakumar is the corresponding author and can be contacted at: nalini@uab.edu

To purchase reprints of this article please e-mail: reprints@emeraldinsight.com
Or visit our web site for further details: www.emeraldinsight.com/reprints