1-1-2019

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Recommended Citation

Sly, P., Trottier, B., Carpenter, D., Cha'on, U., Cormier, S., Galluzzo, B., Ghosh, S., Goldizen, F., Heacock, M., Jagals, P., Joshi, H., Kathuria, P., Ha, L., Magsumbol, M., Navasumrit, P., Prabhakaran, P., Sen, B., Skelly, C., Suraweera, I., Vong, S., Wangdi, C., & Suk, W. (2019). Children's environmental health in south and Southeast Asia: Networking for better child health outcomes. *Annals of Global Health, 85* (1)
https://doi.org/10.5334/aogh.2403

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Annals of Global Health

Sly PD, et al. Children's Environmental Health in South and Southeast Asia: Networking for Better Child Health Outcomes. *Annals of Global Health*. 2019; 85(1): 17, 1–11. DOI: https://doi.org/10.5334/aogh.2403

EXPERT CONSENSUS DOCUMENT

Children's Environmental Health in South and Southeast Asia: Networking for Better Child Health Outcomes

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Children are particularly vulnerable to environmental hazards because they receive higher doses of pollutants in any given environment and often do not have equitable access to social protection mechanisms such as environmental and health care services. The World Health Organization established a global network of collaborating centres that address children's environmental health (CEH). The network developed a focus on low- and middle-income countries (LMICs) and is broadening its reach by conducting regional workshops for CEH.

Objective: This paper reports on the outcomes of a workshop held in conjunction with the 17th International Conference (November 2017) of the Pacific Basin Consortium for Environment and Health, focused on the state of CEH in South and Southeast Asia as presented by seven countries from the region (India, Bangladesh, Nepal, Bhutan, Vietnam, Thailand, Sri Lanka).

Workshop outcomes: Country reports presented at the meeting show a high degree of similarity with respect to the issues threatening the health of children. The most common problems are outdoor and household air pollution in addition to exposure to heavy metals, industrial chemicals, and pesticides. Many children still do not have adequate access to clean water and improved sanitation while infectious diseases remain a problem, especially for children living in poverty. Child labour is widely prevalent, generally without adequate training or personal protective equipment. The children now face the dual burden of undernutrition and stunting on the one hand and overnutrition and obesity on the other.

Conclusion: It is evident that some countries in these regions are doing better than others in varying areas of CEH. By establishing and participating in regional networks, countries can learn from each other and harmonise their efforts to protect CEH so that all can benefit from closer interactions.

Introduction

Children are one of the most vulnerable groups within our society. They are exposed to higher doses of pollutants in any given environment, including low-level exposures occurring during fetal development and in early postnatal life that increase the lifelong risk of chronic disease. In many circumstances, children do not have equitable access to health care services or social protection mechanisms [1–3].

As highlighted by the recent Lancet Commission on Pollution and Health [3], pollution was responsible for 16% of global deaths in 2015, or approximately 9 million, which was three times more than deaths from AIDS, tuberculosis, and malaria combined. These deaths were

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not evenly distributed, with around 92% occurring in low- and middle-income countries (LMICs). Children are among the most vulnerable members of the population for both death and disability. Even low-level exposures occurring during fetal development and in early postnatal life increase the lifelong risk of chronic disease [3].

The World Health Organization (WHO) Department of Public Health, Environment, and Social Determinants of Disease is improving awareness of the health consequences of pollution and other adverse environmental exposures by establishing a series of WHO Collaborating Centres (WHOCCs) that work on various aspects of children's environmental health (CEH). These centres have formed a network [4] coordinated by the WHOCC for Environmental Health Sciences, located at the National Institute of Environmental Health Sciences in Research Triangle Park, North Carolina, United States. The network has been active in promoting awareness of CEH through publications [1, 5, 6] and has a focus on in low- and middle-income countries (LMICs) [7–9].

The Network of WHO collaborating centres for CEH proactively broadened its reach beyond formal WHOCCs by holding regional workshops [8], with the most recent workshop held in conjunction with the 17th International Conference of the Pacific Basin Consortium for Environment and Health in New Delhi in November 2017. The purpose of the workshop was to gauge the state of CEH in South and Southeast Asian countries. Child populations in these countries vary considerably in size and also contribute substantially to the burden of disease in terms of mortality and disability-adjusted life years (**Table 1**). Delegates from several of these countries (India, Bangladesh, Nepal, Bhutan, Vietnam, Thailand, and Sri Lanka) attended the workshop and included representatives from government ministries, academia, national institutes of occupational and environmental health and sciences, and nongovernmental organizations. This paper summarises the reports presented at this workshop by the represented countries.

CEH in India

There are a number of health threats to children in India related to the environment. Indoor and outdoor air pollution from industries, traffic, and biomass fuel burning increase exposures. Small-scale industries emit dangerous nanoparticles from their processes. Electricity generators, including those used domestically, release diesel exhaust particulates. Children also constitute a substantial section of the informal labour workforce in Indian cities, engaging in garbage collection, segregation and disposal, electronic waste recycling, and several other occupations that expose them to hazardous environmental pollutants. Pollutants in water bodies, often the only source of drinking water for many sections of society in India, are major sources of waterborne diseases.

Other sources of environmental pollutants that Indian children are exposed to are landfill sites. Families from lower socioeconomic strata live on these sites and earn a living from rummaging around the landfills all day and picking out waste that have financial value. Whole families collect waste together, in poor living conditions near or on dumping sites that have toxins, chemicals, and other hazards. There is an added social dynamic where children and families move as large groups and are territorial about their areas of collection. Working on these landfill sites, children—in utero or in postnatal life—are exposed to a toxic cocktail of chemicals due to lack of personal protection equipment, such as overall clothes, gloves, masks, goggles, and footwear. This results in eye, skin, and finger-prick injuries; respiratory and gastrointestinal disorders; and often poor intellectual and cognitive development. The National Institute of Occupational Health (NIOH) is conducting a study of "rag pickers" in Bangalore as part of their effort to collect exposure and health outcome data on children in the informal waste disposal and recycling sector. Some Indian studies have reported that these children have poor hygiene and nutrition, are exposed to waste materials, and commonly have leg injuries, gastrointestinal infections, worm infestation, scabies, skin diseases, pediculosis, and rabies (because of stray dogs) [10, 11]. Other research has found polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) at dumping sites at levels that exceed guidelines [12]. The risk of cancer, particularly due to polycyclic aromatic hydrocarbons (PAHs) and other carcinogens and leachate from landfills, is high [13, 14]. An increased risk of tuberculosis, bronchitis, asthma, and pneumonia has been reported [11].

Children in rural areas often work in agriculture, frequently as unpaid labor for their own family. Pesticide exposure, particularly when it is prepared as well as used within the home, is a major health risk [15]. Children also work in supposedly nonhazardous roles, such as picking flowers. This requires that children be in fields before they attend school later in the day. This sometimes coincides with early morning pesticide applications and thus exposures. Children often don't use protective apparel and therefore have dermal pesticide exposure, which is compounded by taking their food with them and not washing hands before eating. The resultant exposure can cause neurological disorders, even at low doses [16].

Another NIOH study looking at sheep farming reported on two more exposures. Sheep wool (used for carpets) expose nearby children through inhalation of dust and proteins from sheep wool. The study team also found dichlorodiphenyltrichloroethane (DDT) and other pesticides on the persons of the farming families, including their children.

Brick kilns remain a major health and occupational safety challenge in India in terms of emissions and heat stressors associated with these industries [17–19]. The government banned child labour in the brick industry, except for children working with their family in the industry. Children also work in extremely dangerous stone quarries [20], or parents have to bring the children to work with them, exposing nonworking children to high levels of silica dust in the vicinity of the quarries [21]. Mining and quarries are very noisy areas, and noise-induced hearing loss is common, even in children.

Table 1: Contribution of Children to the Burden of Disease in Terms of Mortality and Disability-Adjusted Life Years (DALYs) in Countries in South and Southeast Asia, 2016.

Country	Total population			Children under 5 years			Children 5–14 years		
	Number[1]	Mortality*[2]	DALYs+[2]	Number[3]	Mortality*[4]	DALYs+[2]	Number[3]	Mortality*[5]	DALYs+[2]
Afghanistan	33,369,944	13.4	18,559,913.78	4,925,453	70.4	6,668,140.81	9,529,049	9.5	1,563,032.74
Bangladesh	157,826,578	5.4	44,604,974.52	15,348,064	34.2	8,927,010.09	31,784,370	4.9	3,112,784.50
Bhutan	758,288	6.5	217,940.45	64,238	32.4	48,462.11	142,017	7.1	15,665.39
Cambodia	16,204,486	7.5	5,151,857.17	1,769,672	30.6	1,156,240.29	3,199,351	5.3	317,402.72
India	1,281,935,911	7.3	466,336,532.09	122,905,717	43	82,178,860.46	253,480,869	6.3	28,678,894.59
Indonesia	260,580,739	6.5	72,732,990.22	25,390,959	26.4	10,578,185.18	46,353,414	5.3	3,829,692.22
Laos	7,126,706	7.4	2,924,169.05	837,524	63.9	1,325,941.62	1,543,987	9.9	175,417.86
Malaysia	31,381,992	5.1	6,737,516.32	2,565,658	8.3	355,847.46	4,877,968	2.6	313,839.04
Maldives	392,709	4.0	60,862.34	37,880	8.5	5,214.37	63,593	2.5	4,293.56
Mauritius	1,277,459	7.1	381,231.49	70,171	13.7	18,854.55	170,552	1.8	12,091.07
Myanmar	55,123,814	7.4	17,015,425.21	4,510,575	50.8	2,442,508.47	10,166,907	8.2	904,869.13
Pakistan	204,924,861	6.3	70,625,422.15	24,938,283	78.8	23,090,427.29	42,325,803	11.3	5,107,578.01
Philippines	104,256,076	6.1	30,068,249.49	11,363,634	27.1	5,388,348.70	21,048,184	6.5	2,130,934.32
Seychelles	97,026	7.0	27,257.19	8,299	14.3	1,879.32	14,597	3.8	958.53
Sri Lanka	22,409,381	6.2	5,000,512.32	1,602,492	9.4	220,579.92	3,450,933	2.3	236,149.00
Thailand	68,414,135	8.0	18,341,441.31	3,739,823	12.2	417,806.67	8,136,696	3.2	536,483.62
Timor-Leste	1,211,244	5.9	322,385.06	217,743	49.7	108,399.07	300,858	8.0	28,388.64
Vietnam	96,160,163	5.9	24,140,772.25	7,751,809	21.6	1,928,964.37	14,042,712	2.8	872,845.00

* Per 1,000 live births.
\+ All causes, all sexes.
[1] The World Factbook. Washington D.C.: Central Intelligence Agency. https://www.cia.gov/library/publications/the-world-factbook/index.html. Accessed July 12, 2018.
[2] GBD Compare Data Visualization. Seattle, WA: Institute for Health Metrics and Evaluation, University of Washington; 2017. https://vizhub.healthdata.org/gbd-compare. Accessed July 12, 2018.
[3] Population Pyramids of the World from 1950 to 2100. https://www.populationpyramid.net. Accessed July 12, 2018.
[4] Global Health Observatory Data Repository. Probability of dying per 1000 live births: Data by country. Geneva: World Health Organization; 2017. http://apps.who.int/gho/data/view.main.182?lang=en. Updated September 19, 2017. Accessed July 12, 2018.
[5] Global Health Observatory Data Repository. Probability of dying per 1000 children, aged 5 to 14: Data by country. Geneva: World Health Organization; 2017. http://apps.who.int/gho/data/node.main.CM5TO14?lang=en. Updated September 21, 2017. Accessed July 12, 2018.

CEH in Bangladesh

Air pollution is a serious issue in Bangladesh. It gets the most attention in the major cities, but rural air pollution remains poorly understood and might also be a major problem, especially for mothers and children who are impacted the most by indoor air pollution [22, 23].

The collection and disposal of waste in Bangladesh presents a major problem for the population and the municipal authorities [24]. Collected waste is disposed mostly in landfills. Child waste pickers are often at the landfills, with significant adverse health outcomes common [25, 26].

Lead poisoning from lead paint remains a major issue in many parts of the world, including Asian countries [27]. Elevated blood lead levels is a problem for children in Bangladesh [28, 29]. In 2012, seven different organizations in Asia started Switchasia [30], a lead-free paint promotion project with Bangladesh, Nepal, Sri Lanka, the Philippines, India, and Indonesia being part of the project. Many manufacturers in these countries have reduced the lead content and are moving to zero lead-containing paint. Regulating the content of paint to reduce exposure is commendable, but enforcement remains a problem. Moreover, the issue of "legacy lead" in the environment will remain a problem unless adequate remediation is undertaken [27].

Toxic toys are an underreported issue but are of increasing recognition and importance [31, 32]. Tests of toys sold in Bangladesh have found it to contain lead, cadmium, bromine, and chromium—some at levels more than 97% above the EU ceiling [33]. In one test, a Rubik's cube from Bangladesh was found to have OctaBDE, a chemical banned under the Stockholm Convention. Most of the unsafe toys are produced in China, Thailand, and India. The products are spreading all over Asia, beyond countries where the toys are produced. Children's cosmetics and toy jewellery may also have elevated levels of harmful substances. The Environment and Social Development Organization found arsenic in baby lotion and titanium dioxide in children's jewellery [33].

Diarrhea, one of the leading causes of death in children younger than five years, accounted for 9% of 5.8 million global deaths and 6% of 0.119 million deaths in Bangladesh in 2015 [34].

The occupational hazards of child labour are another major issue in Bangladesh [35]. For instance, children who work in tanneries are exposed to heavy metals (lead, cadmium, mercury) [36]. Bangladesh has 50,000 children working in informal electronic waste (e-waste) recycling. Shipbreaking is a major industry in Bangladesh, but the shipbreaking yard is a "killing field." Many children working there are exposed to toxic heavy metals from e-waste and scrap materials from the ships [37, 38].

CEH in Nepal

Indoor and outdoor air pollution are major risks for children [3]. Use of solid and biomass fuel is a problem in Nepal; 64% of indoor cooking is done with firewood, and 10% of households burn cow dung. This is particularly problematic in the mountainous areas of the country, where there is limited or no ventilation in the home due to cold outdoor temperatures [39], resulting in prolonged exposure to high levels of PM_{10} and $PM_{2.5}$. These exposures result in increased rates of eye and respiratory ailments [40]. Ambient air pollution, particularly in Kathmandu, is a major challenge and problem [41]. Pollution comes from brick laying, construction projects, and vehicles. The pollution is so hazardous that a government campaign encourages people not to walk in the mornings in the Kathmandu Valley. This pollution is particularly a threat to children walking to school in the mornings.

Water, sanitation, and hygiene (WASH) challenges are major threats to CEH. Although 48% of households have safe drinking water, 38% have unimproved sanitation, and 15% practice open defecation or have no sanitation facility. There is limited systemic monitoring of water quality, and many studies have found varying levels of contaminants, making the water unsafe to use [42]. In schools, government policy requires one toilet for every 50 students, however the reality is that there are, on average, 127 students per toilet. Lack of toilet facilities has been shown to reduce female school attendance and therefore, female literacy. There is a correlation between toilets in schools and female literacy across Nepal.

Additional exposures and risks to children in Nepal include child labour in brick laying and similar industries, lead pollution, and climate change [43]. All five major vector-borne diseases are now endemic in Nepal, and there has been an observed shift in the range of vectors to more than 2,000 meters above sea level. Cold waves are a new issue in Nepal, with an observed 5% increase in the incidence of acute respiratory illnesses (ARI) in cold months. Deaths from ARI have increased by 2.68% for every one degree Celsius decrease in the daily minimum temperature.

In terms of CEH policies in Nepal, health is noted in the 2016 constitution. The National Health Policy of 2014 and National Water Supply and Sanitation Policy of 2014 are relevant to CEH issues. Nepal has had a climate change policy since 2011, and national improvement plans for WASH and for the health sector have been established. Implementation of most policies is overseen by the Ministry of Health, however child welfare is governed by the Ministry of Women, Children, and Social Welfare.

The challenges to improving CEH in Nepal are mainly a lack of coordination among government organizations and a lack of, or weak, implementation and enforcement of existing policies. Some health interventions require a change in cultural practices and behavior, such as the relationship between preferred household design and indoor cookstove use. Geographic challenges make delivery of care difficult and compound the complexity of disasters, deforestation, and climate change.

CEH in Bhutan

The total population of Bhutan is less than 1 million people. Seventy percent of the country is forested, with a constitutional mandate to maintain a 60% forest cover; 58% of the population is dependent on agriculture; 99.5% of households have access to improved drinking water; and 92% have access to improved sanitation [44].

The leading causes of disease in children under five years in Bhutan are ARI, skin diseases, diarrhea, and digestive system diseases.

Although population access to electricity is very high, air pollution-related diseases remain in the top 10 diseases among children [44]. While 95% of the population has access to electricity for cooking, around 20% uses solid fuels for cooking. There is a preference for wood-style cooking for the flavor imparted to the food. This is particularly common in rural areas, where solid fuel is used by more than 33% of the population. In many of these homes, women carry the children on their back when cooking, thus increasing cooking-related indoor air exposures. Wood combustion for winter heating is used in traditional homes and in rural areas. Some urban areas continue to use traditional stoves and kerosene heaters during winter.

Drinking water and sanitation coverage has improved throughout the country, however diarrhea and waterborne diseases remain a leading cause of under-five mortality and morbidity. A preference for open defecation remains in some areas, despite the availability of improved sanitation facilities.

The health of children in Bhutan has been steadily improving [45, 46] Stunting in children has decreased significantly but remains in rural areas and the eastern region of the country. Anemia remains common in children under five in Bhutan. Although rates have declined, more than 43% of children are anemic. Pregnant women have good health coverage, with many attending prenatal visits and with anemia rates lower than those of nonpregnant women, however only 52% of pregnant women receive prenatal care in the first trimester. Breastfeeding rates are high, with nearly half of women reporting exclusive breastfeeding. Upon weaning from breastfeeding, there is reported low dietary diversity for introduced complementary foods, with a low percentage of children being given iron-rich foods at ages 6–23 months. The Ministry of Health is seeking to distribute nutrition powder to health centres, particularly where iron-rich foods are less available.

Waste generation and disposal is an emerging problem, especially in urban areas. There is no separation of waste in Bhutan [47]. Informal waste collectors sort and resell scraps from waste. The capital, Thimphu, generates nearly 50 tons of waste per day, which is disposed of into one landfill 12 kilometers from the city. None of the wastes are segregated, sorted, or recycled. Leaching of chemicals and fires (accidental and intentional) at landfills contribute to water and air pollution, respectively.

Very few chemicals are manufactured in the country, with most products imported from India. Pesticides are used often, and asbestos is commonly used in many areas. Legislation to deal with carcinogenic chemicals is nonexistent, with no regular monitoring or awareness of carcinogens.

CEH in Vietnam

There are increasing health disparities between the Kinh majority and ethnic minorities, between urban and rural residents, and between those in mountainous areas of the country compared to the lower delta areas [48, 49]. Forty percent of poor children live in rural areas, with child poverty especially high in the northern mountains. Approximately 50% of rural children attend preschool, whereas 75% of urban children do.

The under-5 mortality rate in Vietnam is 20.2 per 1,000 live births, and diarrhea is the leading cause of under-5 death [50]. Additional diseases commonly impacting children include dengue fever and hand, foot, and mouth disease. A high proportion of Vietnamese children do not have access to clean drinking water, reaching upward of 80% in the Highlands and Mekong River Delta. More than half (53%) of schools don't provide drinking water for students during school hours. Although 73% of schools have latrines, more than 50% are estimated to not meet adequate sanitation standards [51, 52].

Neglected tropical diseases, including soil transmitted helminthiasis (STH), are a major threat to children's health. Sixty-seven million people live in STH-endemic areas, and the most at risk are school-age children. In some areas, infection is as high as 86% of the population. Leading contributors to these high rates are lack of adequate sanitation, use of composted human waste in agriculture, barefoot walking, and consumption of raw vegetables [53, 54].

Lead poisoning in children remains a problem in Vietnam [55]. Sources of lead exposure include lead mines, industrial production, recycling "villages" (where a majority of their industries are those that dismantle lead batteries), the use of traditional drugs which can include lead, and lead paint in toys. Lead battery recycling used to be common in residential areas, however new policies have moved activities to an industrial zone. A study in the recycling village of Dong Mai found blood levels of children in excess of 45 ug/dL (which usually is treated with chelation) [56]. After an intervention in the village, no children were found to have levels in excess of 45 ug/dL and the average level was reduced to under 15 ug/dL. Children's blood levels have also been found to be elevated near lead mines in the country. There is a continued need to reduce lead poisoning in children. In doing so, efforts must include education, worker protection, and continued monitoring of interventions. Research is still needed in villages with issues similar to those in Dong Mai to explore preventative measures that may prevent children's exposure.

Chronic arsenic contamination is common in many provinces and the main source of exposure is from contaminated groundwater [57]. There continues to be a need for sanitation and water in remote areas, but efforts to provide water from groundwater sources must address natural arsenic contamination as well, which makes the provision more difficult. A study on the effects of arsenic exposure on physical development, mental health in children, and genetic polymorphisms related to arsenic metabolism would be welcomed [58–60].

CEH in Thailand

Neonatal and child mortality is low in Thailand, with a neonatal mortality rate of 3.5 per 1,000 live births and an under-5 mortality rate of 8.6 per 1,000 live births.

Eight percent of live births are diagnosed with congenital anomalies, with the five most common birth defects in Thailand are congenital heart defects, limb abnormalities, cleft lip and palate, Down syndrome, and congenital hydrocephalus [61].

Thai women don't breastfeed at the rates of many other neighboring countries, and they often breastfeed for a shorter duration of time [62]. An estimated 16% of children are stunted [63], yet Thailand has the fastest increasing rate for childhood obesity in the world [64]. There is a high prevalence of junk food consumed (food high in calories and fat), and soft drinks and sugary coffee are common in children's diets.

Pesticides are commonly used on fruits and vegetables because growers like to protect crops from insects. Glyphosate and paraquat are commonly used in agriculture and have been found in high levels in maternal and foetal serum [65].

Flooding is a major threat to children's health. In addition to threats usually associated with floods, schools often don't have clean water after floods and thus, if open, are not safe for children. Chronic kidney disease of unknown aetiology (CKDu) is a growing problem, and the relationship between CKDu and exposures in water is being investigated [66].

Children's exposure to toxic chemicals is a public health concern because children are one of the most susceptible groups in the population for exposure to environmental toxicants. The Chulabhorn Research Institute (CRI) has conducted research on children's health impacts of exposure to environmental pollutants, such as traffic-related air pollutants, e-waste, and in utero exposure to arsenic. The potential health effects of urban air pollution related to traffic, particularly carcinogenic compounds including benzene, 1,3 butadiene, and PAHs, on children aged 9–13 years old was investigated through the use of various biomarkers. CRI studies clearly showed that children in Bangkok who were concurrently exposed to significantly higher levels of benzene, 1,3-butadiene, and PAHs had significantly higher levels of DNA damage, observed as elevated levels of 8-hydroxydeoxyguanosine (8-OHdG) and DNA strand breaks, and significantly lower DNA repair capacity compared to those of rural children [67, 68].

The developing foetus is extremely vulnerable to effects of chemicals when exposure occurs in utero. A study in a Thai cohort has shown that arsenic exposure in utero increased expression of genes involved in various biological networks such as apoptosis, stress responses, and inflammation [69], and DNA damage in newborns, observed as increased levels of urinary 8-nitroguanine, which significantly correlated with increased expression of inflammatory genes (COX2, EGR1, and SOCS3) in cord blood [60]. A follow-up study in these prenatally arsenic-exposed children showed an increase in oxidative and nitrative DNA damage, represented by increased levels of 8-OHdG and 8-nitroguanine [60, 70], as well as decreased expression of human 8-oxoguanine DNA glycosylase 1 (hOGG1), suggesting a defect in the repair of 8-OHdG.

Taken together, these results suggest that individuals with prenatal to early childhood exposure to environmental carcinogens are at a higher risk for developing disease and cancer later in life. The knowledge gained from these studies will lead to the establishment of national policies for the protection of health and the minimization of children's health risk.

CEH in Sri Lanka

The total midyear population of Sri Lanka is 21.4 million people [71], and 77% of children live in rural areas [72]. The under-5 mortality rate is 10 per 1,000 live births and the infant mortality rate is 8 per 1,000 live births. It is important to note that although the infant mortality rate has declined, the majority of under-5 deaths are neonatal. Congenital malformations are the most significant cause of neonatal death [50], but there are no studies yet to understand the environmental associations in Sri Lanka.

Outdoor air pollution has increased in Sri Lanka, and the increase is correlated to an increase in private vehicle sales [73]. Open burning of plastics emits dioxins due to lack of formal waste disposal, and it is a common contributor to outdoor air pollution. Estimates have noted that indoor air pollution remains a larger threat than outdoor air pollution in Sri Lanka (as of 2014), however data specific to Sri Lanka is limited. Nearly 66% of the population uses biomass fuel for indoor cooking in Sri Lanka [74, 75]. The highest use of biomass is in the estate sector (80%), followed by the rural sector where an estimated 74% of the population uses firewood. Poor ventilation, the absence of chimneys, and the practice of using polythene (plastic bags, etc) to initiate a fire all contribute to indoor air pollution. Unlike other countries in the region, heating is rarely a contributor to indoor air pollution due to the warm natural climate. A World Bank study in Sri Lanka found that indoor air pollution was a predictor of diabetes among adults and is a predictor of stunting, underweight, and wasting in children under five [76].

Breastfeeding rates are excellent, with 90% of mothers breastfeeding for six months. Almost all deliveries (>97%) are institutional. More than 10% of the population has diabetes, and the proportion is expected to increase [77]. A recent study found that 38% of children aged between 10–14 years were obese, and 20% were overweight [78]. Increasing numbers of children are being exposed to dietary factors, sedentary behaviors, and unhealthy habits. There remains, however, a double burden of disease associated with nutritional problems in Sri Lanka because both malnutrition and obesity are increasing [79, 80].

There are gaps in industries in terms of waste and chemicals disposal. Inappropriate use of agricultural chemicals is common. More than 80% of agricultural workers in the country work in the informal sector and there is limited to no personal protective equipment use while synthetic pesticide usage, particularly herbicides, is increasing [81]. CKDu is a major problem that may be related to pesticide and chemical use [82].

Dengue remains a major problem; 30% of dengue patients in 2017 were 5–19 years old. In 2017, there were more than four times the number of cases compared to the 2010 and 2016 average.

The country has seen an increase in floods, droughts, and landslides, and children and families are often forced to move due to these events.

Improved monitoring and surveillance are needed to capture baseline data, as is increased research on the environment and children's health, particularly understanding of early exposures on adult health.

Summary and Conclusions

Children contribute substantially to the burden of disease in countries in South and Southeast Asia, as shown in **Table 1**. Taken as plausibly representative of the current status of CEH in these regions, the country reports summarized in this paper show a high degree of similarity. Most common are problems with outdoor and household air pollution, with solutions not immediately apparent or implementable. Children are also often exposed to heavy metals, industrial chemicals, and pesticides. Despite advances in some countries, many children still do not have adequate access to clean water and improved sanitation. Infectious diseases remain a problem, especially for children living in poverty. Child labour is still widely prevalent (too common), generally without adequate training or personal protective equipment, exposing the child labourers to occupational hazards. The children of these regions are now facing the dual problems of undernutrition and stunting on the one hand, and overnutrition and obesity on the other.

In conclusion, it is evident that some countries in these regions are doing better than others in varying areas of CEH. By establishing and participating in regional networks, countries can learn from each other and harmonise their efforts to protect CEH so that all can benefit from closer interactions.

Acknowledgements

The authors would like to thank Gwen Collman, director of the National Institute of Environmental Health Sciences (NIEHS) Division of Extramural Research and Training, and John Balbus, NIEHS senior advisor for public health and director of the NIEHS-WHO Collaborating Centre for Environmental Health Sciences, for their continued support of global children's environmental health issues. The authors also wish to thank Gagandeep Kaur Walia, Adanubrati Dutta, Shahriar Hossain, and Beerappa Ravichandran for their participation in the South Asian Children's Environmental Health Workshop.

Funding Information

The National Institute of Environmental Health Sciences provided funding for the South Asian Children's Environmental Health Workshop, held in New Delhi in November 2017. The Public Health Foundation of India organized and funded meeting space. This manuscript is based on information presented at the workshop and in the workshop report.

Competing Interests

The authors have no competing interests to declare.

Author Contribution

This manuscript is based on information presented at the South Asian Children's Environmental Health Workshop (November 2017). Peter Sly coordinated the preparation of the manuscript, and all authors were provided the opportunity to review and comment.

References

1. **Sly PD, Carpenter DO, Van den Berg M,** et al. Health consequences of environmental exposures: Causal thinking in global environmental epidemiology. *Ann Glob Health*. 2016; 82(1): 3–9. DOI: https://doi.org/10.1016/j.aogh.2016.01.004
2. **WHO Regional Office for Europe.** Environmental and health risks: A review of the influence and effects of social inequalaties; 2008. Available from: http://www.euro.who.int/__data/assets/pdf_file/0003/78069/E93670.pdf.
3. **Landrigan PJ, Fuller R, Acosta NJR,** et al. The Lancet Commission on pollution and health. *Lancet*. 2018; 391(10119): 462–512. DOI: https://doi.org/10.1016/S0140-6736(17)32345-0
4. **Sly PD, Neira M, Collman G,** et al. Networking to advance progress in children's environmental health. *Lancet Glob Health*. 2014; 2(3): e129–30. DOI: https://doi.org/10.1016/S2214-109X(14)70004-X
5. **Landrigan PJ, Sly JL, Ruchirawat M,** et al. Health consequences of environmental exposures: Changing global patterns of exposure and disease. *Ann Glob Health*. 2016; 82(1): 10–9. DOI: https://doi.org/10.1016/j.aogh.2016.01.005
6. **Suk W, Ruchirawat M, Stein RT,** et al. Health consequences of environmental exposures in early life: Coping with a changing world in the post-MDG era. *Ann Glob Health*. 2016; 82(1): 20–27. DOI: https://doi.org/10.1016/j.aogh.2016.01.006
7. **Laborde A, Tomasina F, Bianchi F,** et al. Children's health in Latin America: The influence of environmental exposures. *Environ Health Perspect*. 2015; 123(3): 201–209. DOI: https://doi.org/10.1289/ehp.1408292
8. **Sly P, Arphacharus N, Aung W,** et al. South-East Asian chidlren's environmental health: Networking to improve health outcomes. *Bhutal Health J*. 2017; 3: 15–18.
9. **Suk WA, Ahanchian H, Asante KA,** et al. Environmental pollution: An under-recognized threat to children's health, especially in low- and middle-income countries. *Environ Health Perspect*. 2016; 124(3): A41–45. DOI: https://doi.org/10.1289/ehp.1510517
10. **Mallik S, Chaudhuri RN, Biswas R** and **Biswas B.** A study on morbidity pattern of child labourers engaged in different occupations in a slum area of Calcutta. *J Indian Med Assoc*. 2004; 102(4): 198–200, 26.
11. **Ray MR, Mukherjee G, Roychowdhury S** and **Lahiri T.** Respiratory and general health impairments of ragpickers in India: A study in Delhi. *Int*

Arch Occup Environ Health. 2004; 77(8): 595–598. DOI: https://doi.org/10.1007/s00420-004-0564-8
12. **Nguyen HM, Tu BM, Watanabe M,** et al. Open dumping site in Asian developing countries: A potential source of polychlorinated dibenz-p-dioxins and polychlorinated dibenzofurans. *Environ Sci Technol*. 2003; 37(8): 1493–1502. DOI: https://doi.org/10.1021/es026078s
13. **Chakraborty P, Prithiviraj B, Selvaraj S** and **Kumar B.** Polychlorinated biphenyls in settled dust from informal electronic waste recycling workshops and nearby highways in urban centers and suburban industrial roadsides of Chennai city, India: Levels, congener profiles and exposure assessment. *Sci Total Environ*. 2016; 573: 1413–1421. DOI: https://doi.org/10.1016/j.scitotenv.2016.07.129
14. **Ghosh P, Gupta A** and **Thakur IS.** Combined chemical and toxicological evaluation of leachate from municipal solid waste landfill sites of Delhi, India. *Environ Sci Pollut Res Int*. 2015; 22(12): 9148–9158. DOI: https://doi.org/10.1007/s11356-015-4077-7
15. **Chitra GA, Kaur P, Bhatnagar T** and **Manickam P** and **Murhekar MV.** High prevalence of household pesticides and their unsafe use in rural South India. *Int J Occup Med Environ Health*. 2013; 26(2): 275–282. DOI: https://doi.org/10.2478/s13382-013-0102-6
16. **Zaidi S, Bhatnagar V, Patel A,** et al. Neurological, biochemical and immunological manifestations in workers exposued to organophophate insecticides. *Indian J Biochem Biophysics*. 2015; 52: 305–310.
17. **Pangtey BS, Kumar S, Bihari V, Mathur N, Rastogi SK** and **Srivastava AK.** An environmental profile of brick kilns in Lucknow. *J Environ Sci Eng*. 2004; 46(3): 239–244.
18. **Thomas BE, Charles N, Watson B,** et al. Prevalence of chest symptoms amongst brick kiln migrant workers and care seeking behaviour: A study from South India. *J Public Health* (Oxf). 2015; 37(4): 590–596. DOI: https://doi.org/10.1093/pubmed/fdu104
19. **Weyant C, Athalye V, Ragavan S,** et al. Emissions from South Asian brick production. *Environ Sci Technol*. 2014; 48(11): 6477–6483. DOI: https://doi.org/10.1021/es500186g
20. **Saha A** and **Sadhu HG.** Occupational injury proneness in young workers: A survey in stone quarries. *J Occup Health*. 2014; 55(5): 333–339. DOI: https://doi.org/10.1539/joh.12-0150-OA
21. **Bhagia LJ.** Non-occupational exposure to silica dust. *Indian J Occup Environ Med*. 2012; 16(3): 95–100. DOI: https://doi.org/10.4103/0019-5278.111744
22. **Khalequzzaman M, Kamijima M, Sakai K, Ebara T, Hoque BA** and **Nakajima T.** Indoor air pollution and health of children in biomass fuel-using households of Bangladesh: Comparison between urban and rural areas. *Environ Health Prev Med*. 2011; 16(6): 375–383. DOI: https://doi.org/10.1007/s12199-011-0208-z
23. **Ram PK, Dutt D, Silk BJ,** et al. Household air quality risk factors associated with childhood pneumonia in urban Dhaka, Bangladesh. *Am J Trop Med Hyg*. 2014; 90(5): 968–975. DOI: https://doi.org/10.4269/ajtmh.13-0532
24. **Matter A, Ahsan M, Marbach M** and **Zurbrugg C.** Impacts of policy and market incentives for solid waste recycling in Dhaka, Bangladesh. *Waste Manag*. 2015; 39: 321–328. DOI: https://doi.org/10.1016/j.wasman.2015.01.032
25. **Lahiry G, Rahman T, Hasan AK, Dutta AK, Arif M** and **Howlader ZH.** Assessment of impact on health of children working in the garbage dumping site in Dhaka, Bangladesh. *J Trop Pediatr*. 2011; 57(6): 472–475. DOI: https://doi.org/10.1093/tropej/fmr002
26. **Linderholm L, Jakobsson K, Lundh T,** et al. Environmental exposure to POPs and heavy metals in urban children from Dhaka, Bangladesh. *J Environ Monit*. 2011; 13(10): 2728–2734. DOI: https://doi.org/10.1039/c1em10480b
27. **UNEP.** Global alliance to eliminate lead paint; 2018. Available from: https://www.unenvironment.org/explore-topics/chemicals-waste/what-we-do/emerging-issues/global-alliance-eliminate-lead-paint.
28. **Mitra AK, Ahua E** and **Saha PK.** Prevalence of and risk factors for lead poisoning in young children in Bangladesh. *J Health Popul Nutr*. 2012; 30(4): 404–409.
29. **Mitra AK, Haque A, Islam M** and **Bashar SA.** Lead poisoning: An alarming public health problem in Bangladesh. *Int J Environ Res Public Health*. 2009; 6(1): 84–95. DOI: https://doi.org/10.3390/ijerph6010084
30. **SWITCH-Asia.** Lead Elimination Project; 2015 (cited July 24, 2018). Available from: http://www.switch-asia.eu/projects/lead-paint-elimination.
31. **Guney M** and **Zagury GJ.** Heavy metals in toys and low-cost jewelry: Critical review of U.S. and Canadian legislations and recommendations for testing. *Environ Sci Technol*. 2012; 46(8): 4265–474. DOI: https://doi.org/10.1021/es203470x
32. **Guney M** and **Zagury GJ.** Children's exposure to harmful elements in toys and low-cost jewelry: Characterizing risks and developing a comprehensive approach. *J Hazard Mater*. 2014; 271: 321–330. DOI: https://doi.org/10.1016/j.jhazmat.2014.02.018
33. **ESDO.** Toxic toys: Heavy metal content and public perception in Bangladesh; 2013. Available from: pen.org/sites/default/files/documents/ESDO Study Report on Toxic Toys in Bangladesh.pdf.
34. **Alam T, Ahmed T, Sharifuzzaman,** et al. Risk factors for death in Bangladeshi children under 5 years of age hospitalized for diarrhea and severe respiratory distress in an urban critical care ward. *Global Pediatric Health*. 2017; 4: 1–5. DOI: https://doi.org/10.1177/2333794X17696685
35. **Khanam R** and **Rahman MM.** Child work and schooling in Bangladesh: The role of birth order. *J Biosoc Sci*. 2007; 39(5): 641–656. DOI: https://doi.org/10.1017/S0021932007001976

36. **Bhuiyan MA, Suruvi NI, Dampare SB,** et al. Investigation of the possible sources of heavy metal contamination in lagoon and canal water in the tannery industrial area in Dhaka, Bangladesh. *Environ Monit Assess*. 2011; 175(1–4): 633–649. DOI: https://doi.org/10.1007/s10661-010-1557-6
37. **Hasan AB, Kabir S, Selim Reza AH,** et al. Trace metals pollution in seawater and groundwater in the ship breaking area of Sitakund Upazilla, Chittagong, Bangladesh. *Mar Pollut Bull*. 2013; 71(1–2): 317–324. DOI: https://doi.org/10.1016/j.marpolbul.2013.01.028
38. **Nost TH, Halse AK, Randall S,** et al. High Concentrations of Organic Contaminants in Air from Ship Breaking Activities in Chittagong, Bangladesh. *Environ Sci Technol*. 2015; 49(19): 11372–11380. DOI: https://doi.org/10.1021/acs.est.5b03073
39. **Pant KP.** Cheaper fuel and higher health costs among the poor in rural Nepal. *Ambio*. 2012; 41(3): 271–283. DOI: https://doi.org/10.1007/s13280-011-0189-6
40. **Bates MN, Chandyo RK, Valentiner-Branth P,** et al. Acute lower respiratory infection in childhood and household fuel use in Bhaktapur, Nepal. *Environ Health Perspect*. 2013; 121(5): 637–642. DOI: https://doi.org/10.1289/ehp.1205491
41. **Gurung A** and **Bell ML.** The state of scientific evidence on air pollution and human health in Nepal. *Environ Res*. 2013; 124: 54–64. DOI: https://doi.org/10.1016/j.envres.2013.03.007
42. **Shrestha A, Sharma S, Gerold J,** et al. Water quality, sanitation, and hygiene conditions in schools and households in Dolakha and Ramechhap Districts, Nepal: Results from a cross-sectional survey. *Int J Environ Res Public Health*. 2017; 14(1). DOI: https://doi.org/10.3390/ijerph14010089
43. **Thapa S, Chhetry D** and **Aryal RH.** Poverty, literacy and child labour in Nepal: A district-level analysis. *Asia Pac Popul J*. 1996; 11(3): 3–14. DOI: https://doi.org/10.18356/7a364996-en
44. **National Statistics Bureau.** Bhutan Living Standards Survey 2017. Thimphu, Bhutan: Royal Government Bhutan; 2017.
45. **UNICEF.** Investing in the early years, for every child in Bhutan. *Annual report*; 2016.
46. **WHO.** 2017 Health SDG profile: Bhutan; 2007. www.searo.who.int/entity/health_situation_trends/countryprofile_bhu.pdf.
47. **Phuntsho S, Dulal I, Yangden D,** et al. Studying municipal solid waste generation and composition in the urban areas of Bhutan. *Waste Manag Res*. 2010; 28(6): 545–551. DOI: https://doi.org/10.1177/0734242X09343118
48. **Malqvist M, Hoa DT, Liem NT, Thorson A** and **Thomsen S.** Ethnic minority health in Vietnam: A review exposing horizontal inequity. *Glob Health Action*. 2013; 6: 1–19. DOI: https://doi.org/10.3402/gha.v6i0.19803
49. **Trinh HN** and **Korinek K.** Ethnicity, education attainment, media exposure, and prenatal care in Vietnam. *Ethn Health*. 2017; 22(1): 83–104. DOI: https://doi.org/10.1080/13557858.2016.1196648
50. **Wang H, Liddell CA, Coates MM,** et al. Global, regional, and national levels of neonatal, infant, and under-5 mortality during 1990–2013: A systematic analysis for the Global Burden of Disease Study 2013. *Lancet*. 2014; 384(9947): 957–979. DOI: https://doi.org/10.1016/S0140-6736(14)60497-9
51. **Herbst S, Benedikter S, Koester U,** et al. Perceptions of water, sanitation and health: A case study from the Mekong Delta, Vietnam. *Water Sci Technol*. 2009; 60(3): 699–707. DOI: https://doi.org/10.2166/wst.2009.442
52. **Tuyet-Hanh TT, Lee JK, Oh J,** et al. Household trends in access to improved water sources and sanitation facilities in Vietnam and associated factors: findings from the Multiple Indicator Cluster Surveys, 2000–2011. *Glob Health Action*. 2016; 9: 29434. DOI: https://doi.org/10.3402/gha.v9.29434
53. **Hung BK, De NV, Duyet le V** and **Chai JY.** Prevalence of soil-transmitted helminths and molecular clarification of hookworm species in ethnic Ede primary schoolchildren in Dak Lak Province, Southern Vietnam. *Korean J Parasitol*. 2016; 54(4): 471–476. DOI: https://doi.org/10.3347/kjp.2016.54.4.471
54. **Silver ZA, Kaliappan SP, Samuel P,** et al. Geographical distribution of soil transmitted helminths and the effects of community type in South Asia and South East Asia: A systematic review. *PLoS Negl Trop Dis*. 2018; 12(1): e0006153. DOI: https://doi.org/10.1371/journal.pntd.0006153
55. **Havens D, Pham MH, Karr CJ** and **Daniell WE.** Blood lead levels and risk factors for lead exposure in a pediatric population in Ho Chi Minh City, Vietnam. *Int J Environ Res Public Health*. 2018; 15(1). DOI: https://doi.org/10.3390/ijerph15010093
56. **Daniell WE, Van Tung L, Wallace RM,** et al. Childhood lead exposure from battery recycling in Vietnam. *Biomed Res Int*. 2015; 193715. DOI: https://doi.org/10.1155/2015/193715
57. **Agusa T, Trang PT, Lan VM,** et al. Human exposure to arsenic from drinking water in Vietnam. *Sci Total Environ*. 2014; 488–489: 562–569. DOI: https://doi.org/10.1016/j.scitotenv.2013.10.039
58. **Agusa T, Kunito T, Tue NM,** et al. Individual variations in arsenic metabolism in Vietnamese: The association with arsenic exposure and GSTP1 genetic polymorphism. *Metallomics*. 2012; 4(1): 91–100. DOI: https://doi.org/10.1039/C1MT00133G
59. **Kaushal A, Zhang H, Karmaus WJJ,** et al. Genome-wide DNA methylation at birth in relation to in utero arsenic exposure and the associated health in later life. *Environ Health*. 2017; 16(1): 50. DOI: https://doi.org/10.1186/s12940-017-0262-0
60. **Phookphan P, Navasumrit P, Waraprasit S,** et al. Hypomethylation of inflammatory genes (COX2, EGR1, and SOCS3) and increased urinary

8-nitroguanine in arsenic-exposed newborns and children. *Toxicol Appl Pharmacol*. 2017; 316: 36–47. DOI: https://doi.org/10.1016/j.taap.2016.12.015
61. **Pangkanon S, Sawasdivorn S, Kuptanon C, Chotigeat U** and **Vandepitte W.** Establishing of National Birth Defects Registry in Thailand. *J Med Assoc Thai*. 2014; 97(Suppl 6): S182–188.
62. **Walters D, Horton S, Siregar AY,** et al. The cost of not breastfeeding in Southeast Asia. *Health Policy Plan*. 2016; 31(8): 1107–1116. DOI: https://doi.org/10.1093/heapol/czw044
63. **Mongkolchati A, Thinkhamrop B, Mo-Suwan L, Chittchang U** and **Choprapawon C.** Prevalence and incidence of child stunting from birth to two years of life in Thai children: Based on the Prospective Cohort Study of Thai Children (PCTC). *J Med Assoc Thai*. 2010; 93(12): 1368–1378.
64. **Yamborisut U** and **Mo-Suwan L.** Prevalence of childhood and adolescent obesity in Thailand: A review. *J Med Assoc Thai*. 2014; 97(1): 44–51.
65. **Kongtip P, Nankongnab N, Phupancharoensuk R,** et al. Glyphosate and paraquat in maternal and fetal serums in Thai women. *J Agromedicine*. 2017; 22(3): 282–289. DOI: https://doi.org/10.1080/1059924X.2017.1319315
66. **Wasana HM, Aluthpatabendi D, Kularatne WM, Wijekoon P, Weerasooriya R** and **Bandara J.** Drinking water quality and chronic kidney disease of unknown etiology (CKDu): Synergic effects of fluoride, cadmium and hardness of water. *Environ Geochem Health*. 2016; 38(1): 157–168. DOI: https://doi.org/10.1007/s10653-015-9699-7
67. **Ruchirawat M, Navasumrit P** and **Settachan D.** Exposure to benzene in various susceptible populations: Co-exposures to 1,3-butadiene and PAHs and implications for carcinogenic risk. *Chem Biol Interact*. 2010; 184(1–2): 67–76. DOI: https://doi.org/10.1016/j.cbi.2009.12.026
68. **Tuntawiroon J, Mahidol C, Navasumrit P, Autrup H** and **Ruchirawat M.** Increased health risk in Bangkok children exposed to polycyclic aromatic hydrocarbons from traffic-related sources. *Carcinogenesis*. 2007; 28: 816–822. DOI: https://doi.org/10.1093/carcin/bgl175
69. **Fry RC, Navasumrit P, Valiathan C,** et al. Activation of inflammation/NF-kappaB signaling in infants born to arsenic-exposed mothers. *PLoS Genet*. 2007; 3(11): e207. DOI: https://doi.org/10.1371/journal.pgen.0030207
70. **Hinhumpatch P, Navasumrit P, Chaisatra K, Promvijit J, Mahidol C** and **Ruchirawat M.** Oxidative DNA damage and repair in children exposed to low levels of arsenic in utero and during early childhood: Application of salivary and urinary biomarkers. *Toxicol Appl Pharmacol*. 2013; 273(3): 569–579. DOI: https://doi.org/10.1016/j.taap.2013.10.002
71. **Department of Census and Statistics.** 2017. Available from: Department of Census and Statistics; 2017.
72. **Department of Census and Statistics.** Child Activity Survey 2016, Sri Lanka. Ministry of National Policies and Economic Affairs, Sri Lanka; 2017.
73. **Nandasena YL, Wickremasinghe AR** and **Sathiakumar N.** Air pollution and health in Sri Lanka: A review of epidemiologic studies. *BMC Public Health*. 2010; 10: 300. DOI: https://doi.org/10.1186/1471-2458-10-300
74. **Department of Census and Statistics.** Demographic and Health Survey 2016: Ministry of National Policies and Economic Affairs, Sri Lanka; 2016. Available from: http://www.statistics.gov.lk/page.asp?page=Health.
75. **Elledge MF, Phillips MJ, Thornburg VE, Everett KH** and **Nandasena S.** A profile of biomass stove use in Sri Lanka. *Int J Environ Res Public Health*. 2012; 9(4): 1097–1110. DOI: https://doi.org/10.3390/ijerph9041097
76. **World Bank.** Prevalence of stunting, height for age (% of chidlren under 5); 2017. Available from: http://www.statistics.gov.lk/page.asp?page=Health.
77. **Katulanda P, Constantine GR, Mahesh JG,** et al. Prevalence and projections of diabetes and pre-diabetes in adults in Sri Lanka—Sri Lanka Diabetes, Cardiovascular Study (SLDCS). *Diabet Med*. 2008; 25(9): 1062–1069. DOI: https://doi.org/10.1111/j.1464-5491.2008.02523.x
78. **Wijesuriya M, Gulliford M, Charlton J,** et al. High prevalence of cardio-metabolic risk factors in a uoung urban Sri-Lankan population. *PLOS ONE*. 2012; 7(2): e31309. DOI: https://doi.org/10.1371/journal.pone.0031309
79. **Rannan-Eliya RP, Hossain SM, Anuranga C, Wickramasinghe R, Jayatissa R** and **Abeykoon AT.** Trends and determinants of childhood stunting and underweight in Sri Lanka. *Ceylon Med J*. 2013; 58(1): 10–18. DOI: https://doi.org/10.4038/cmj.v58i1.5357
80. **Wickramasinghe VP, Arambepola C, Bandara P,** et al. Distribution of obesity-related metabolic markers among 5–15 year old children from an urban area of Sri Lanka. *Ann Hum Biol*. 2013; 40(2): 168–174. DOI: https://doi.org/10.3109/03014460.2012.753109
81. **Prasannath K, Prasannath V** and **Mahendran S.** Trends in use and import of agricultural pesticides in Sri Lanka. *Proc Nat Symposium Agiculture*. 2015: 8–10.
82. **Rajapakse S, Shivanthan MC** and **Selvarajah M.** Chronic kidney disease of unknown etiology in Sri Lanka. *Int J Occup Environ Health*. 2016; 22(3): 259–264. DOI: https://doi.org/10.1080/10773525.2016.1203097

How to cite this article: Sly PD, Trottier B, Carpenter D, Cha'on U, Cormier S, Galluzzo B, Ghosh S, Goldizen F, Heacock M, Jagals P, Joshi HD, Kathuria P, Ha LT, Magsumbol MS, Navasumrit P, Prabhakaran P, Sen B, Skelly C, Suraweera I, Vong S, Wangdi C and Suk WA. Children's Environmental Health in South and Southeast Asia: Networking for Better Child Health Outcomes. *Annals of Global Health*. 2019; 85(1): 17, 1–11. DOI: https://doi.org/10.5334/aogh.2403

Published: 25 February 2019