PRIORITIZING CHILDREN:

Environmental Health Indicators for **China**

Vital Strategies

unicef 联合国儿童基金会

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ACKNOWLEDGMENTS

This report was prepared by colleagues from the National Institute of Environmental Health, Chinese Center for Disease Control and Prevention (NIEH), The United Nations Children's Fund (UNICEF) and Vital Strategies. It was produced as part of the Thought Leadership Initiative on Children's Environmental Health Data and Indicators at UNICEF, East Asia and Pacific Regional Office.

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We would also like to thank the Columbia University Mailman School of Public Health 2020 Capstone team, including the following members of the Environmental Health Sciences Department, for their inputs: Haleigh Cavalier, Anita Dev, Yun-Wen Betty Fletcher, Katie Gao, and Jade Watkins.

UNICEF, East Asia and Pacific Regional Office provided funding for this project, with in-kind support from UNICEF, China; NIEH, China CDC; and Vital Strategies.

Designed/edited by Vital Strategies, with editing support provided by Jiaqi Shen and Xiao Wang of UNICEF China and photos provided by UNICEF China.

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Executive Summary

Globally, more than one in four childhood deaths under the age of five are attributable to unhealthy environments.[1] Indicators that systematically track, assess and report on the risks and impact of the environment on children's health can be used to:

- Quantify the magnitude of a public health problem
- Detect notable trends in environmental exposures and health outcomes
- Identify subpopulations at risk of environmentally attributable illnesses
- Generate hypotheses about the relationship between health and the environment
- Direct and evaluate measures for control and prevention
- Facilitate the development of evidence-based policies

Researchers increasingly use children's environmental health indicators (CEHIs) to link environmental factors and adverse children's health outcomes. Children are especially vulnerable to environmental risks due to their distinct biological and social characteristics. In this report, we identify some of the most important children's environmental health indicators for China, based on a rigorous methodology and process, including a thorough literature review of more than 7,500 articles published in the last 20 years. We also provide more detail on environmental risk factors that are potential harzards of children's health in China: climate change, air pollution, industrial waste pollution, the built environment, environmental tobacco smoke and food safety.

While there are hundreds of CEHIs that can be and have been developed, one of the aims of this project was to prioritize a list of CEHIs for initial tracking, awareness and development. The table below represents the top 22 CEHIs that we have prioritized for China.

Environmental Exposure Indicators	
1	Annual mean concentration of ambient $PM_{2.5}$*
2	Percentage of children under 18 years of age living in households where solid fuels are used for cooking or heating
3	Volume of industrial waste gas emission
4	Number of children under 18 years of age living in households in which at least one adult smokes on a regular basis
5	Percentage of soil failing national pesticide standard

6	Percentage of soil failing national heavy metal standard (mercury, cadmium, lead, chromium, copper, nickel, zinc, arsenic)
7	Percentage of drinking water supplies failing national water quality standards
8	Number of children under 18 years of age affected by disasters
9	Percentage of lakes and rivers whose water quality index is below national standard level III**
10	Percentage of children's products*** failing national standards
11	Average blood lead level among children under 18 years of age
Health Outcome Indicators	
12	Prevalence of asthma among children under 18 years of age
13	Incidence of acute respiratory disease among children under 5 years of age
14	Incidence of diarrhea among children under 5 years of age
15	Incidence of congenital malformations in children under 1 year of age
16	Incidence of preterm birth
17	Prevalence of leukemia among children under 18 years of age
18	Incidence of road traffic injury among children under 18 years of age
19	Incidence of dengue fever among children under 18 years of age
Action Indicators	
20	Percentage of local governments that have implemented an environmental health plan that reduces the risks of disasters and climate change
21	Percentage of "key pollutant discharge units"**** that monitor and report their pollution status
22	Annual government budget spent on environmental health

* PM2.5 refers to airborne particles less than 2.5 microns in size, which penetrate deep into the lungs and have been shown to be harmful to health.

** Water quality index national standard level III: Water that is eligible for use as drinking water, surface water source, fish and shrimp wintering field, migration channel, aquaculture and other fishery waters, and swimming. Source: http://www.mee.gov.cn/ywgz/fgbz/bz/bzwb/shjbh/shjzlbz/200206/t20020601_66497.shtml

*** The State Administration for Market Regulation monitors products for children, and this project proposes to track any product for children that the administration reports on.

**** The Ministry of Ecology and Environment requires local governments to annually report a list of "key pollutant discharge units," and those units are encouraged to report their emission status publicly. This is an important indicator of both public and private actions to control pollution.

The CEHI project represents a critical first step toward providing a safer and healthier environment for children in China. It must be followed by efforts to ensure that routinely collected, high-quality data to support each indicator can be captured, analyzed and shared with relevant stakeholders to guide policy that benefits children's health.

Near-term steps to advance the CEHI project in China include:

1. Conducting comprehensive mapping of existing environmental health tracking systems in China and identifying the one most suitable to host CEHIs.
2. Mapping data sources with the goal of populating data tables for each indicator, resolvable at the finest possible geographic level and stratified by important population characteristics such as gender, relative economic advantage and age group.
3. Refining the current list of CEHIs, for aspects such as the indicator definition, computation method, possible data source and characteristics of existing data for each CEHI.
4. Developing a cross-sectoral mechanism to coordinate the health sector, environment sector and other relevant sectors in creating a national children's environmental health plan and tracking system that builds on the CEHI work in China.
5. Publishing children's environmental health profiles regularly at national and subnational levels.
6. Working with children, youth networks and private sector partners to share information about children's environmental health updates in China.
7. Mobilizing specialists in children's health and environmental issues to use CEHIs to advocate for stronger environmental regulation and enforcement by government.
8. Researching emerging threats to children's environmental health and promoting international cooperation to enhance science and policy measures regarding this issue.
9. Identifying environmental health issues that would benefit from improved surveillance and research, with recommendations about data collection, needed resources and time frames for reporting findings.
10. Recommending timely, relevant policies and interventions to improve children's environmental health.

CHAPTER 1:
Environmental Risks That Children in China Face

1.1 Environmental health challenges in China

Globally, more than one in four childhood deaths under five years of age is attributable to environmental hazards such as air pollution, lack of adequate water and sanitation, harmful chemicals and increasing exposure to the impacts of climate change. [1,2] The Lancet Commission on pollution and health estimates that there were 9 million deaths globally and 1.8 million deaths in China in 2015 that can be attributed to hazardous environmental factors.[3] Despite this, many governments in the East Asia Pacific region do not prioritize children's environmental health due to lack of data, resource constraints, competing corporate interests or a lack of coordination between environmental and health agencies.[4]

As China continues its path of rapid economic development, its people are facing multiple challenges brought on by environmental pollution, climate change, environmental degradation and urbanization. These challenges can magnify existing hazards in the environment that cause adverse health outcomes.[5] Environmental hazards that are of particular concern for China include:

- Climate change: China, like much of the world, is experiencing an increased frequency and severity of extreme weather events such as floods, typhoons and extreme temperatures, as well as droughts, threats to secure food and water supplies, and changes in the geographic spread of disease vectors. There is growing evidence about the impacts of climate change on public health. Climate change poses a particular risk to young children through its effects on a broad range of diseases including malnutrition, allergy, neonatal problems and infectious diseases. It is critical to better understand and address the ways climate change affects children's environmental health.
- Air pollution: In the past two decades, air pollution has become one of the leading environmental risk factors for children's health in China. In 2021, it was reported that almost half of the 339 cities monitored did not meet the national standard for ambient air quality.[6] And lower respiratory infections, which are associated with air pollution, are among the top three contributors to disability-adjusted life years[a] for children under five years of age in China.[18]
- Industrial waste pollution: China has seen a proliferation of factories in the past three decades, especially along the east coast. In 2014, 12% of children aged 6 to 17 years lived in areas where there were "key pollutant discharge units" within 1 km, and 16% of schools were located within 1 km of at least one "key polluting factory".[7] The waste discharged from these factories can cause long-term contamination to not only air but also soil and water. Children living in the vicinity are at a higher risk of exposure to hazardous chemicals.

[a] Disability-Adjusted Life Years or DALYs refer to the sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability. https://www.who.int/data/gho/indicator-metadata-registry/imr-details/158

- Built environment: In 2014, 82% of children's main outdoor activity areas were within 50 meters of a main road.[7] Although road traffic injury and drowning are the leading causes of deaths and disability for Chinese children, more actions on modifying the built environment of cities for the protection of children are needed.
- Environmental tobacco smoke: Smoking is widespread in China. In 2014, 41% of parents of Chinese children aged 6 to 17 years smoked, with an average exposure time for children of 6.2 minutes per day.[7] Secondhand smoke can cause bronchitis and pneumonia in children, greatly increasing the risk of asthma, coughing and wheezing. It can also increase the incidence of cardiovascular disease and malignant tumors in children and even affect their intellectual development.
- Food safety: China has repeatedly reported food safety issues linked to microbial or chemical contamination during processing involving bacteria such as salmonella or E. coli, chemical colorings, preservatives and additives. With the rapid development of industrialized food processing and supply, many types of food could potentially transmit contaminants on a large scale.

The government of China has recognized the threats of environmental hazards to people's health in recent years. In 2015, the government amended the Environmental Protection Law of the People's Republic of China for the first time since it was created in 1989 to require greater transparency in sharing environmental data, more public participation in reporting pollution, and sterner penalties for persons and businesses that break the law. The Ministry of Ecology and Environment published a report in 2016, "Report of Environmental Exposure Related Activity Patterns Research of Chinese Population (Children)", that recommended enhanced tracking and reporting of data on environmental health, especially that of children.[7] In 2018, the State Council issued a three-year action plan to protect blue sky, which calls for changing industrial, transportation and energy infrastructures to be greener and more environmentally friendly to reduce air pollution.[8] In 2019, the State Council released "Healthy China Initiative (2019-2030)", a document that outlines health issues the government of China will prioritize in the next 10 years, including promotion of a healthy environment.[9]

1.2 What makes children so vulnerable?

Children are especially vulnerable to environmental hazards due to their distinct biological and social characteristics.[7,10] Beginning at the fetal stage and continuing through adolescence, they are physiologically different from adults. Children are in a dynamic state of growth, with cells multiplying and organ systems developing at a fast rate. At birth, their nervous, respiratory, reproductive and immune systems are not yet fully developed. Young children breathe more rapidly and take in more air in proportion to their body weight compared with adults. They also have higher metabolic rates and a higher absorption of nutrients and contaminants from food and liquids compared with adults.[11] Furthermore, children behave differently than adults (e.g., more hand-to-mouth activity), increasing the potential for exposure to environmental hazards.

The 2016 report "Report of Environmental Exposure Related Activity Patterns Research of Chinese Population (Children)" concluded that the indoor air exposure coefficient[b] for children in China is 1.1 to 2.5 times that for adults, and the water exposure coefficient (through skin) for Chinese children is 1.6 to 3.5 times that for adults.[7] Moreover, when

[b] Exposure coefficient is the product of the intake of the exposure through a given environmental agent (e.g. air, water, soil) per unit body weight of the studied population multiplied by the exposure probability. It reflects the extent of exposure through a certain environmental agent to a certain group of people differentiated by how they behave (e.g. how they breathe).

compared with U.S. children in the same age group, the indoor air exposure and water exposure (through skin) coefficients for Chinese children are respectively 0.1 to 2.0 and 1.5 to 2.5 times higher. Studies have also shown that children living in poverty and children from racial or ethnic minorities are at disproportionate risk for exposure to environmental hazards.[12,13,14] All of these studies confirm that actions addressing children's environmental health risks are urgently needed.

Health issues caused by environmental exposure can lead to lifelong disease, disability and even premature death.[1] Research indicates that in China the disability-adjusted life years lost because of neonatal conditions, congenital malformations and childhood cancer have increased in the past 30 years and are higher than the global average.[7] While a growing body of studies have indicated the causal relationship between toxic chemicals and children's illnesses,[15,16,17] more analysis can be helpful to evaluate the relationship between level of exposure to such chemicals and these conditions. This gap in evaluating the impact of exposure on health outcomes is also true for other environmental health issues, such as the relationships between air pollution and asthma or heavy metal soil pollution and elevated blood lead levels.

1.3 Children's environmental health indicators can promote children's health

An environmental health indicator is a way of presenting summarized, aggregated and non-identifiable[c] data to describe a population's health status in relation to environmental factors. Unlike raw data sets, or effect estimations from research findings, environmental health indicators are descriptive and typically use ecologic data. They may describe the frequency of a health or environmental occurrence, an average exposure or the proportion of a population affected.

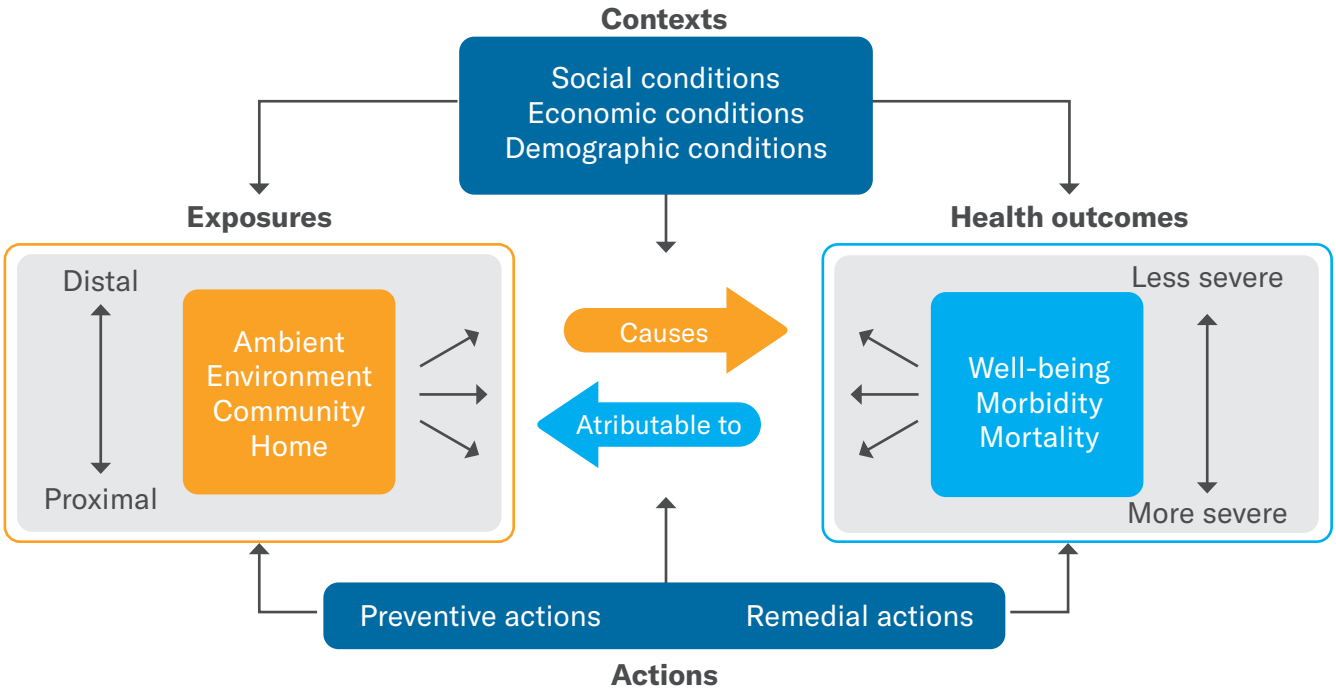
A classical mechanism, such as the Multiple Exposures Multiple Effects model developed by the World Health Organization (Figure 1), can help us understand the relationships among the prioritized indicators and build a framework of environmental health indicators specifically for children. We used the Multiple Exposures Multiple Effects model to categorize indicators into four groups:

- Health outcomes—diseases or conditions that can occur as a result of suspected environmental hazards.
- Exposures—natural or synthetic substances that can affect human health.
- Contexts—social, economic and demographic conditions that can affect potential exposure to contaminants or hazards.
- Actions—activities, programs and policies that reduce or prevent exposure to environmental hazards.

Researching the precise relationship between an environmental hazard or exposure and health outcomes is challenging. High-quality epidemiologic research is costly and time-consuming because it requires individual-level monitoring of both exposures and past or future health outcomes. Despite this limitation, researchers have published excellent studies in the past several decades. Scientific literature reliably establishes whether a relationship exists, how strong that relationship is, and what attributable fraction of disease an exposure may cause. For these well-established relationships, it is not necessary to continually re-prove them in new settings or for different populations through new research.
Indicators that describe the extent of exposure and distribution of health outcomes are valuable for characterizing who may be at risk, whether trends are moving in a positive or negative direction, and

[c] Non-identifiable data refers to data that cannot be traced back to the identity of the individuals linked to the data

Figure 1: The Multiple Exposures Multiple Effects model



Source: World Health Organization, 2009

whether actions are supporting reduction of risks. Once calculated and tracked, these environmental health indicators may be described at common geographies or for common subpopulations, and their variations may be compared ecologically (at group or geographic levels, rather than based on individual-level data).

For these reasons, the selection of environmental health indicators that are appropriate to track should be based on a review of the scientific evidence for their meaning and relevance. Carefully selected environmental health indicators can serve as the core of environmental health surveillance and are an economical and widely understood way of using data. Environmental health indicators can:

- Quantify the magnitude of a public health problem
- Detect notable trends in environmental exposures and health outcomes
- Identify subpopulations at risk of environmentally attributable illnesses
- Generate hypotheses about the relationship between health and the environment
- Direct and evaluate measures for control and prevention
- Facilitate the development of evidence-based policies

CHAPTER 2:
Methodology and Process of Selecting Children's Environmental Health Indicators

2.1 Purpose and goals

Although environmental health risk factors are leading causes of childhood illness and death, governments often do not have the country specific, systematic data needed to improve children's health by reducing exposure to environmental hazards.

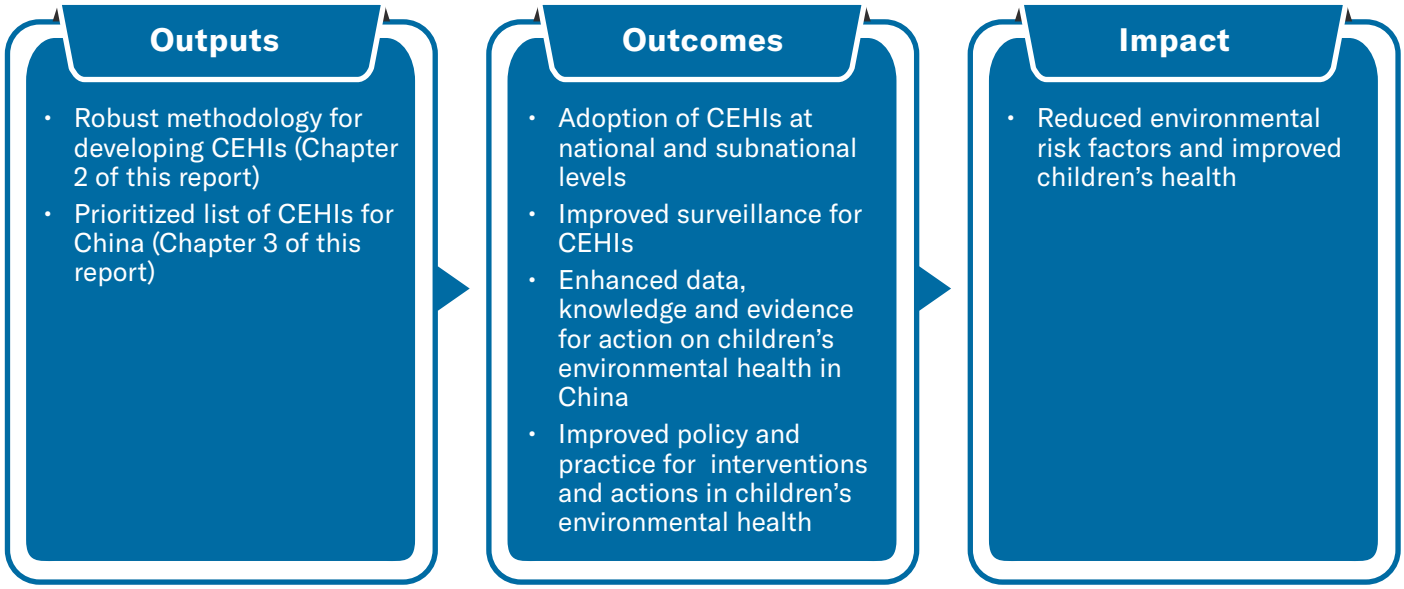
Chinese stakeholders in government, academia and environmental advocacy organizations do not currently have a national or subnational data infrastructure that is easy to use to track children's environmental health situation and share with relevant stakeholders. Making high-quality data available is vitally important to promote policy dialogue, establish protective measures and increase public understanding of how to reduce risks. The experience gained in this project can guide other countries in replicating this effort to measure children's environmental health indicators at national and subnational levels.

Children face a unique set of environmental health risk factors compared with adults. A better understanding of the relationship between environmental hazards and adverse children's health outcomes is necessary to improve national preparedness, responses and community resilience.

We propose a set of children's environmental health indicators for China that will:

- Provide a basis for policymakers to assess and prioritise environmental risks to children's health and create policies to mitigate those risks.
- Facilitate the development of an evidence-based monitoring and evaluation framework for the whole of society to understand children's environmental health issues and actions to prevent or reduce the environmental risks to which children are exposed.
- Offer relevant stakeholders in other countries a template for prioritizing children's environmental health indicators.

Figure 2: Project goals

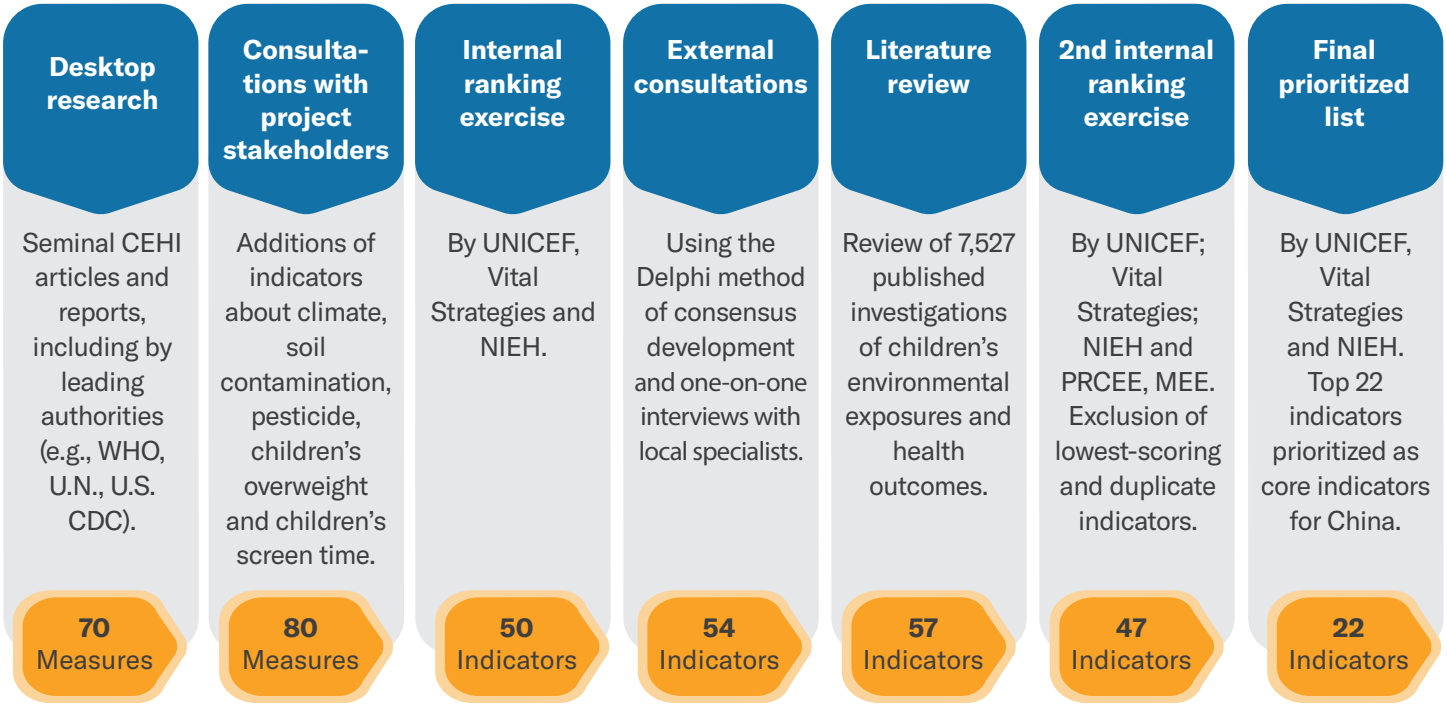


2.2 Overview of the methodology and process

The proposed list of CEHIs is the result of systematic scientific literature analysis as well as substantial expert and stakeholder input.

for Disease Control and Prevention (US CDC), and UNICEF gave us a basis for assembling our initial list of children's environmental health measures (for more information on the desktop research process, please refer to Annex A). Next,

Figure 3: Overview of CEHI development and prioritization



While there are hundreds of environmental health indicators that can be measured, we endeavored to create an initial list of 20-30 priority indicators that can be used to guide policy and outreach. These core CEHIs are intended to emphasize actionable environmental health risks to children and provide a proof-of-concept for further indicator development.

As depicted in Figure 3, we conducted several rounds of development, review and evaluation to produce the list of indicators. From November 2019 to January 2020, we conducted formative desktop research about seminal reports, peer-reviewed journal articles and grey literature on CEHIs. Three seminal reports on children's environmental health from the World Health Organization (WHO), the United States Centers

local and international experts suggested less traditional indicators to provide novel insights into associations between environmental hazards and health. We also used contextual socioeconomic measures to evaluate the relationship among indicators and explore ecologic associations. This led to a list of 80 measures (Annex B) that we prioritized for the next step.

The project partners then ranked the 80 measures and identified relevant indicators to represent each measure (Annex C). Next, we consulted about the ranked indicators with national specialists using the Delphi method[d] of consensus development (Annex D). Finally, we consulted one-on-one with Chinese topical experts to discuss specific indicators (Annex E).

[d] Linstone HA, Turoff M, editors. The delphi method. Reading, MA: Addison-Wesley; 1975 Dec.

2.3 Systematic literature review

We received feedback from several stakeholders that the project should assess each proposed indicator for the strength of scientific evidence of harm, impact or relationship to children's well-being. We therefore conducted a systematic literature review of environmental risk factors that are associated with the most burdensome diseases for Chinese children. The goals of this systematic review were:

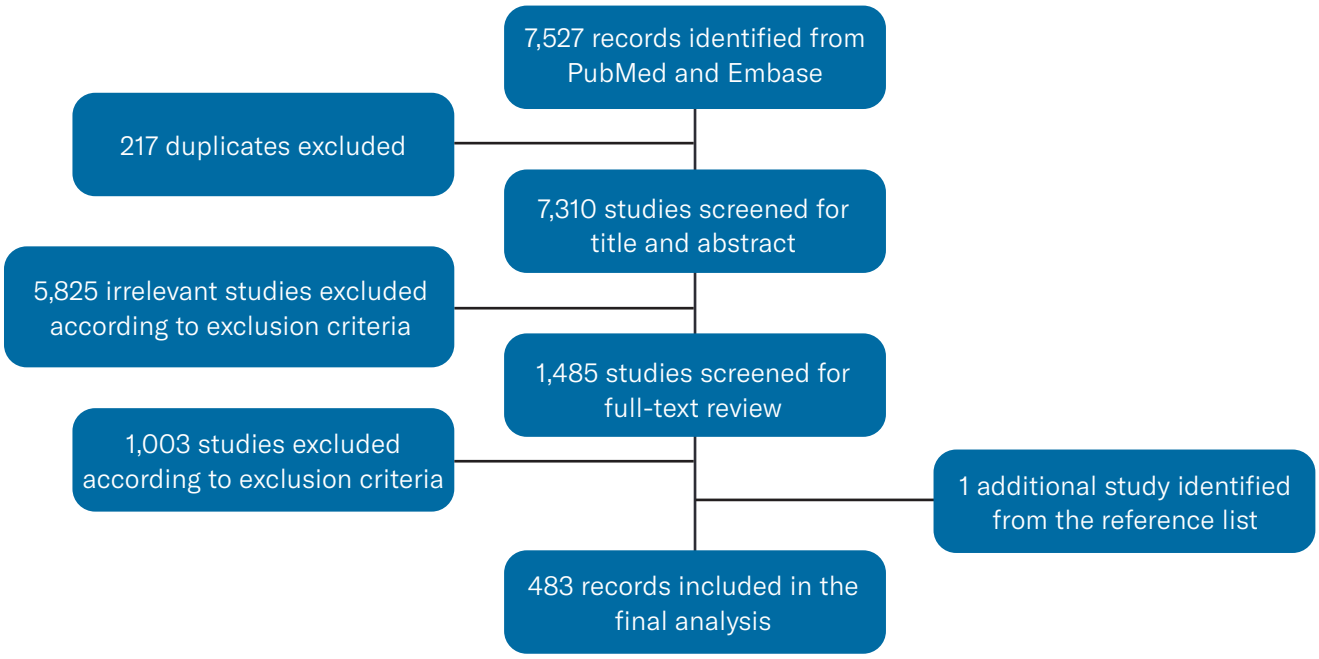
- Obtain evidence to evaluate proposed indicators.
- Identify other important indicators of environmental exposures and health outcomes.
- Collect evidence to guide the final prioritization of core indicators.

We identified the most burdensome diseases for Chinese children in the "Global Burden of Disease Study 2017".[18] Specifically, we looked at disease categories that cause the greatest number of disability-adjusted life years for people under 20 years of age. Based on this and relevant stakeholder opinions on diseases that can be affected by environmental factors, we chose the following 8 categories of diseases for this literature review:

- Neonatal/congenital disorders (with focus on preterm birth, congenital heart anomalies, neonatal encephalopathy due to birth asphyxia and trauma).
- Lower respiratory infections.
- Insect-borne diseases (with focus on dengue fever and Japanese encephalitis).
- Physical injuries (with focus on drowning, road traffic injury and foreign body).
- Mental disorders (with focus on anxiety disorders and conduct disorders).
- Nutritional disorders (with focus on stunting, wasting, obesity, overweight).
- Other noncommunicable diseases (leukemia, brain cancer, asthma, myopia, elevated blood lead level).
- Diarrheal diseases.

In August 2020, we searched PubMed and Embase for peer-reviewed systematic reviews and meta-

Figure 4: Process of identifying literature for systematic review



analyses that studied association between any environmental exposures and the health outcomes listed above. We limited findings to human subject research, children as the study population, Chinese or English as the language and a publication date of 2000 or later. The search yielded 7,527 articles from which we excluded articles that (1) did not study children; (2) did not study the prioritized health outcomes; (3) did not study environmental exposures/risk factors (as defined by the CEHI project); or (4) did not assess association. After these exclusions, the search resulted in 483 articles included for analysis. For exact details of our literature review search methodology, please refer to Annex F.

After examining the 483 articles in depth, we extracted information about each article including:

- Title
- Author(s)
- Journal
- Publication year
- Types of studies included in the review
- Countries included
- Age of the study population
- Number of studies reviewed
- Health outcome studied
- Health indicator used to measure the health outcome
- Environmental factor associated with the health outcome
- Measure of effect (odds ratio[e]/risk ratio[f]) and 95% confidence interval[g]

Using information collected from each review, we further summarized the strength (based on odds ratio/risk ratio) of associations and the amount of evidence (Annex G). Based on the strength and amount of evidence identified for each association, we added 4 additional indicators. These indicators represent a large burden of disease for Chinese children and have a strong evidence base to justify their relevance with children's environmental health. These 4 additional indicators are:

- Prevalence of anxiety among children under 18 years of age
- Prevalence of leukemia among children under 18 years of age
- Incidence of preterm birth
- Percentage of soil failing national pesticide standard

We further summarized the results of the literature review in relation to each indicator to support the final indicator prioritization exercise (Annex H).

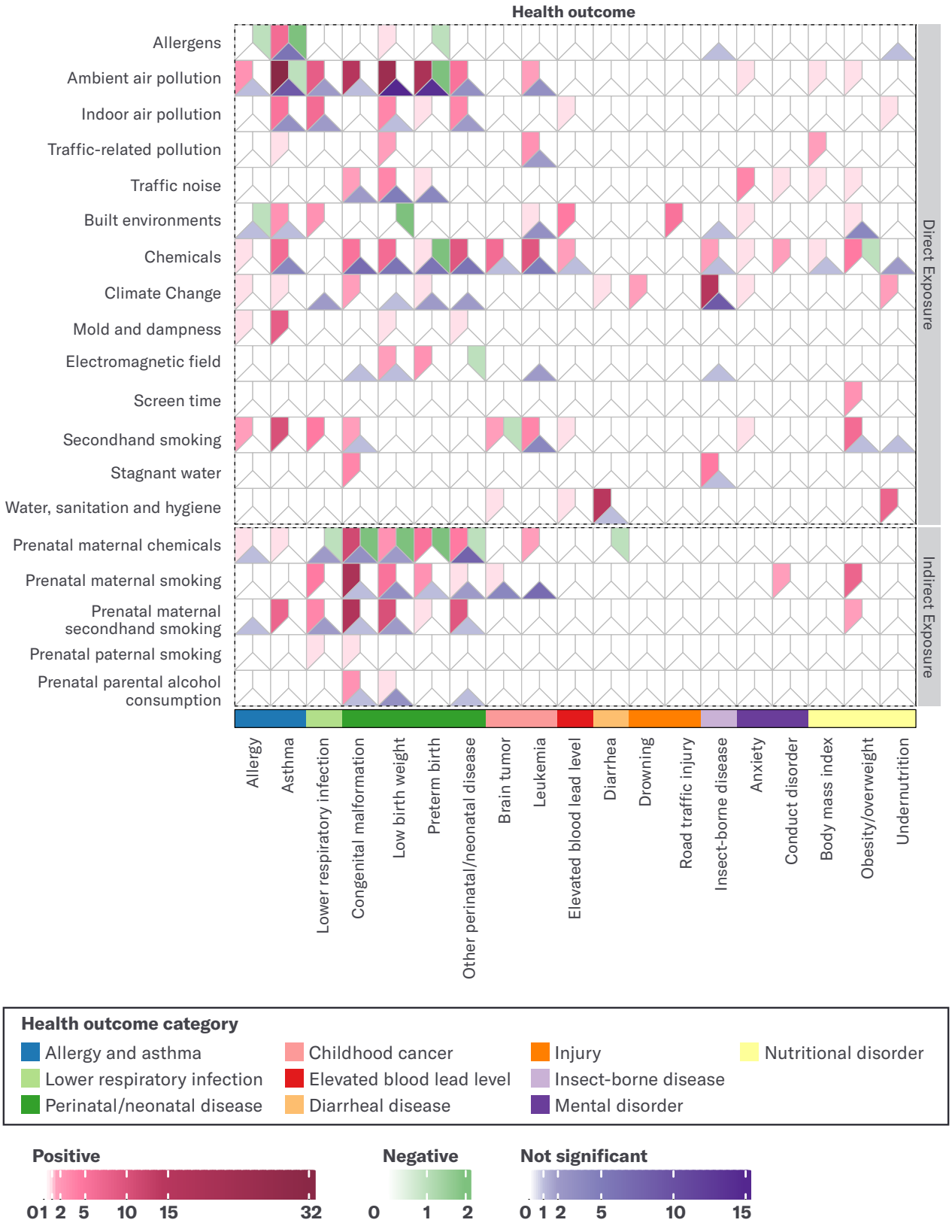
[e] Odds ratio (OR) is a measure of association between exposure and an outcome. Two events (A and B) are independent if and only if the OR equals 1, i.e., the odds of one event are the same in either the presence or absence of the other event. If the OR is greater than 1, then A and B are associated (correlated) in the sense that, compared with the absence of B, the presence of B raises the odds of A, and symmetrically the presence of A raises the odds of B. Conversely, if the OR is less than 1, then A and B are negatively correlated, and the presence of one event reduces the odds of the other event.

[f] Risk ratio (RR) is the ratio of the probability of an outcome in an exposed group to the probability of an outcome in an unexposed group.

[g] The confidence interval (CI) displays the probability that a parameter will fall between a pair of values around the mean or true parameter value. It is often expressed as a % whereby a population mean lies between an upper and lower interval. The 95% confidence interval is a range of values that you can be 95% certain contains the true mean of the population.

Figure 5 summarizes the distribution of evidence for associations found between the environmental exposures and the health outcomes studied. Red colors in the top-left section of each small cell represent numbers of systematic reviews that found significant positive associations between the given

Figure 5: Heatmap of literature review showing the amount of evidence for associations between environmental exposures and health outcomes



Notes to Figure 5:

Allergens: Articles in this category focused on cat hair, dog hair, dust mite, food, pet hair, pollen or undefined allergens.

Ambient air pollution: Articles in this category focused on CO, N_2O, NO, NO_2, NO_x, O_3, SO_2, black carbon, particulate matter (PM), PM10, PM0.1, PM2.5, total suspended particulate matter or general outdoor air pollution.

Built environments: Articles in this category focused on residential greenness, roadway characteristics, presence of playgrounds/recreation areas, traffic calming, biophysical environment, bike lane access, sidewalks access, street connectivity, house structural quality, house size, crowding, living near farm, living near poultry farms, living near main roads or living near water bodies.

Chemicals: Articles in this category focused on antibiotic, mercury, dioxins, electronic waste, endocrine-disrupting chemicals, garbage, iodine, magnesium sulfate, polychlorinated biphenyls, perfluoroalkyl and polyfluoroalkyl compounds, persistent organic pollutants, phthalate, selenium, trihalomethanes, pesticide, arsenic, benzene, bisphenol, dust, heavy metals, hexachlorobenzene, home painting, lead, perfluorooctanoic acid or pentachlorophenol.

Climates: Articles in this category focused on climate change, El Niño-Southern Oscillation (ENSO), humidity, precipitation, rainfall, season, temperature, flooding or droughts.

Prenatal maternal chemicals: Articles in this category focused on chemotherapy agent, zinc, pesticide, glyphosate, dry-cleaning work (high exposure), dry-cleaning work (low exposure), anesthetic gases, arsenic, iron, lithium, magnesium, maternal medication (contraceptive), maternal medication (serotonin reuptake inhibitors), maternal medication (citrate), maternal medication (corticosteroid), organic solvent or undefined chemicals.

Allergies: Articles in this category focused on atopic dermatitis, eczema, rhinitis or other undefined allergies.

Lower respiratory infections: Articles in this category focused on acute lower respiratory infection, lower respiratory tract infections, viral respiratory infections, respiratory infections, respiratory syncytial virus disease, seasonal influenza, sinusitis, pneumonia, coughing, irreversible airway obstruction or tuberculosis.

Congenital malformations: Articles in this category focused on neural tube defect, anal atresia, anencephalus, atrial septal defect, cerebral palsy, cleft lip, clubfoot, congenital heart defect, craniosynostosis, cryptorchidism, digestive malformation, eye defect, face and neck defect, gastrointestinal defect, hernia, hypospadias, limb malformation, musculoskeletal defect, oral cleft, orofacial cleft, undescended testes, urinary system defect, bronchopulmonary dysplasia, coarctation of the aorta, missing/extra digits, other nervous system defect or undefined congenital malformations.

Other perinatal/neonatal diseases: Articles in this category focused on miscarriage, stillbirth, high birth weight, large for gestational age, sudden infant death syndrome or undefined perinatal/neonatal diseases.

Undernutrition: Articles in this category focused on stunting, wasting or underweight.

Insect-borne diseases: Articles in this category focused on dengue fever or Japanese encephalitis.

environmental exposure and a health outcome; purple colors in the middle triangle of each cell represent numbers of systematic reviews that found no significant associations; green colors in the top-right section of each cell represent numbers of systematic reviews that found significant negative associations. Results of this systematic review should be interpreted with caution because of publication bias—whereby there is a tendency in the publication industry to publish work on the strength and direction of the results so that manuscripts with statistically significant “positive” results are published, rather than manuscripts reporting nonsignificant “negative” results.

2.4 Exercise to prioritize indicators

To determine the final list of prioritized indicators, we organized a selection exercise with nine specialists from the NIEH, UNICEF, China; UNICEF, East Asia and Pacific Regional Office; Vital Strategies; and the PRCEE, MEE (for the full list of 57 indicators ranked in this exercise, see Annex I). The specialists scored each environmental exposure and health outcome indicator based on their expertise and additional information provided for each indicator, namely:

- Results from the systematic literature review
- Disease burden for Chinese children
- Prevalence of the exposure in China
- Concern about the indicator-represented environmental health issue on the part of stakeholders and the Chinese public
- The precautionary principle[h]

We totaled the specialists' scores to calculate a final score for each indicator and then deleted indicators with perceived overlap and the lowest scores (for the criteria used for scoring, see Annex J). Finally, we selected 47 top-ranked indicators. The 22 highest-ranking indicators have been further pulled out as the core CEHIs for China. The remaining 25 indicators are referred to as secondary indicators. More information about these indicators is in the next chapter.

[h] In an environmental context, the precautionary principle urges: "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically." (Raffensperger C, Tickner J, editors. Protecting Public Health and the Environment. Washington: Island Press, 1999.)

CHAPTER 3:
Children's Environmental Health Indicators for China

3.1 The selected children's environmental health indicators

The 22 highest-ranking indicators represent a China-specific set of trackable risks and outcomes and are referred to as core CEHIs. Please refer to Table 1 for the list of core CEHIs.

The core CEHIs include 11 environmental exposure indicators that represent the most hazardous environmental exposures for children in China, 8 health outcome indicators that represent the most serious diseases that can be attributed to environmental risk factors, and 3 action indicators that assess public and private monitoring and regulatory actions including environmental health planning, pollution reporting and health financing. It should be noted that these core CEHIs are not intended to cover all environmental health areas. The authors intend to update CEHIs for China regularly to take into account shifts in environmental risks and disease burden as well as the emergence of new scientific evidence.

This project identified an additional 25 indicators (listed in Table 2) as secondary CEHIs for China. We did not prioritize these 25 secondary indicators as highly as the 22 core indicators

Table 1: Core children's environmental health indicators

	Environmental Exposure Indicators
1	Annual mean concentration of ambient $PM_{2.5}$*
2	Percentage of children under 18 years of age living in households where solid fuels are used for cooking or heating
3	Volume of industrial waste gas emission
4	Number of children under 18 years of age living in households in which at least one adult smokes on a regular basis
5	Percentage of soil failing national pesticide standard
6	Percentage of soil failing national heavy metal standard (mercury, cadmium, lead, chromium, copper, nickel, zinc, arsenic)
7	Percentage of drinking water supplies failing national water quality standards
8	Number of children under 18 years of age affected by disasters
9	Percentage of lakes and rivers whose water quality index is below national standard level III**

10	Percentage of children's products*** failing national standards
11	Average blood lead level among children under 18 years of age
Health Outcome Indicators	
12	Prevalence of asthma among children under 18 years of age
13	Incidence of acute respiratory disease among children under 5 years of age
14	Incidence of diarrhea among children under 5 years of age
15	Incidence of congenital malformations in children under 1 year of age
16	Incidence of preterm birth
17	Prevalence of leukemia among children under 18 years of age
18	Incidence of road traffic injury among children under 18 years of age
19	Incidence of dengue fever among children under 18 years of age
Action Indicators	
20	Percentage of local governments that have implemented an environmental health plan that reduces the risks of disasters and climate change
21	Percentage of "key pollutant discharge units" that monitor and report their pollution status****
22	Annual government budget spent on environmental health

* PM2.5 refers to airborne particles less than 2.5 microns in size, which penetrate deep into the lungs and have been shown to be harmful to health.

** Water quality index national standard level III: Water that is eligible for use as drinking water, surface water source, fish and shrimp wintering field, migration channel, aquaculture and other fishery waters, and swimming. Source: http://www.mee.gov.cn/ywgz/fgbz/bz/bzwb/shjbh/shjzlbz/200206/t20020601_66497.shtml

*** The State Administration for Market Regulation monitors products for children. This project proposes to track any product for children that the administration reports on.

**** The Ministry of Ecology and Environment requires local governments to annually report a list of "key pollutant discharge units," and those units are encouraged to report their emission status publicly. This is an important indicator of both public and private actions to control pollution.

because they represent a lower burden to Chinese children, or because there is less evidence that can confirm their relevance to children's environmental health. However, when capacity allows, the secondary indicators should be treated the same way as core indicators. The secondary indicators include 11 environmental exposure indicators, 6 health outcome indicators, 3 action indicators and 5 context indicators. The 5 context indicators allow us to understand associations between exposures and outcomes while stratifying by factors including socioeconomic status, education and more. However, the 5 context indicators do not explain all geographic variation in the distribution of risks, nor are they necessarily the most important factors for stratification.

Table 2: Secondary children's environmental health indicators

Environmental Exposure Indicators	
1	Percentage of population with basic handwashing facility
2	Percentage of schools with safely managed toilet
3	Percentage of population using safely managed toilet
4	Percentage of infants' and young children's food products failing national food security standards
5	Percentage of schools with handwashing facility
6	Percentage of schools evaluated as dilapidated buildings
7	Percentage of cities failing national noise standard
8	Percentage of food products failing national food security standards
9	Number of flooding events
10	Number of children under 18 years of age living in areas of endemic insect-borne diseases
11	Number of days of heat wave
Health Outcome Indicators	
12	Number of perinatal deaths per 1,000 births
13	Incidence of low birth weight
14	Incidence of drowning among children under 18 years of age
15	Prevalence of anxiety among children under 18 years of age
16	Prevalence of stunting in children under 5 years of age

17	Percentage of children under 18 years of age who are overweight*

Action Indicators

18	Percentage of local governments that conduct regular climate change risk assessments including actions to address the needs of children
19	Percentage of people who pass the national government's environmental health literacy test**
20	Percentage of cities/villages verified as "national hygiene city/village"***

Context Indicators

21	Percentage of households falling under 50% of the median household income in that province
22	Percentage of women of childbearing age (15-49 years) who are malnourished (BMI <18.5)****
23	Percentage of children aged 12-14 years who completed primary school
24	Percentage of women aged 18-49 years who completed tertiary education
25	Percentage of children under 18 years of age who are migrant or left behind

* National Institute for Nutrition and Health, Chinese Center for Disease Control and Prevention, retrieved from: http://www.chinanutri.cn/fgbz/fgbzjszn/201501/P020150115511859791641.pdf

** The Ministry of Ecology and Environment has developed a standardized questionnaire and used it since 2018 to assess environmental health literacy.

*** The National Patriotic Health Campaign Committee verifies locales as a "national hygiene city/village" every year based on criteria that include beneficial environmental practices, such as vector control, systematic garbage management and control of tobacco in public areas.

**** Body mass index (BMI) is a value derived from the mass and height of a person. The BMI is defined as the body mass divided by the square of the body height and is universally expressed in units of kg/m^2. For most adults, an ideal BMI is in the 18.5 to 24.9 range. An individual with BMI below 18.5 is in the underweight range. https://www.nhs.uk/common-health-questions/lifestyle/what-is-the-body-mass-index-bmi/

3.2 Application of the children's environmental health indicators

Stakeholders can use CEHIs to understand the interactions among environmental exposures, adverse health outcomes and contextual factors, and thereby strengthen communities' resilience and responses to environmental hazards. Many of these indicators primarily make use of data at the provincial level. When data are available at a more granular level, indicators can be assessed at the prefectural, county or township levels. However, for some indicators, trends will be more important than spatial associations. In those instances, data can be assessed at the national level (e.g., percentage of children's products failing national standards).

Although analysis and visualization of the interactions among indicators is beyond the scope of this report, it is important to anticipate the analytical frameworks, so that it can enable users to understand the interactions among CEHIs, as described by the Multiple Exposures Multiple Effects model in Chapter 1 of this report. Figures 6 and 7 demonstrate how analytical frameworks can visualize the interactions among indicators for two specific groups of health outcomes and interpret data analysis results in easier to understand causal and attributional pathways. Regular evaluation of children's environmental health status using CEHIs together with reliable data and analytical frameworks will enhance our understanding of a country's or a jurisdiction's specific challenges and its progress in addressing them.

Figure 6: Causal and attributional relationships among indicators for perinatal outcomes

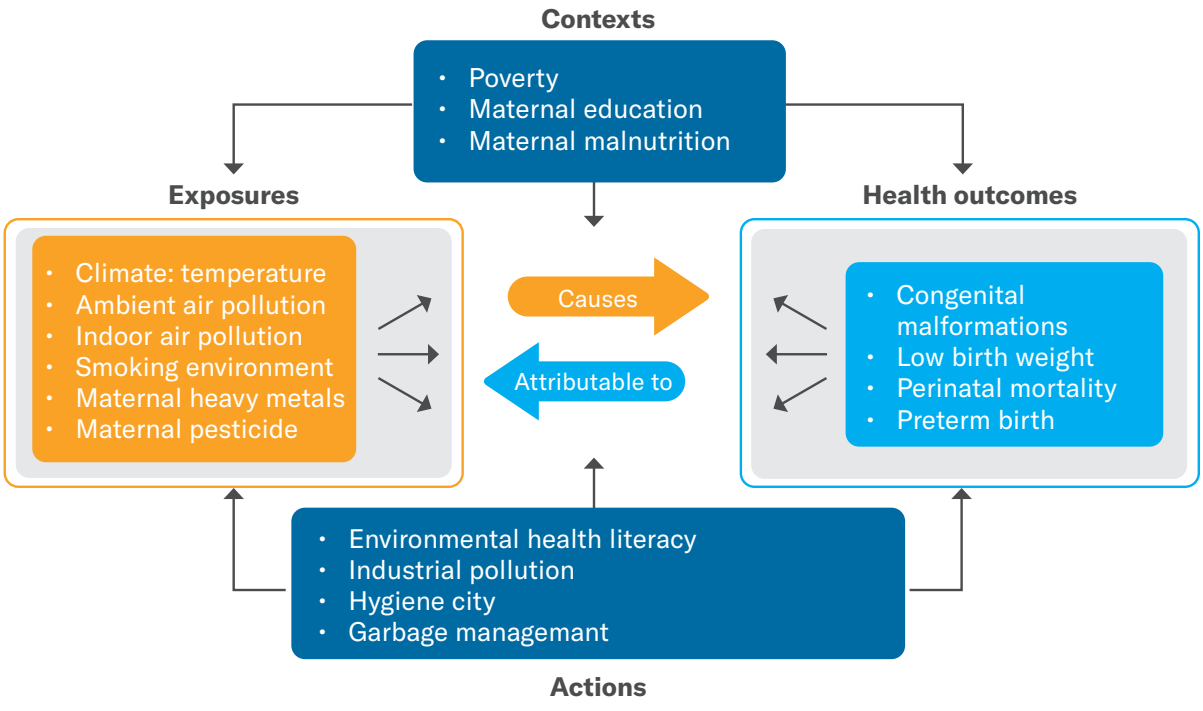


Figure 6 simulates interactions between adverse perinatal outcomes and climate, air pollution, smoking and toxic exposures including heavy metals and pesticides.

Exposures and outcomes are likely to vary by several important contexts such as poverty. For example, high-income households will be much more likely to have access to clean fuels than low-income households. Furthermore, actions by the Chinese government, including promotion of health literacy and enforcement of industrial pollution standards, are likely to affect these associations.

Figure 7: Causal and attributional relationships among indicators for respiratory health

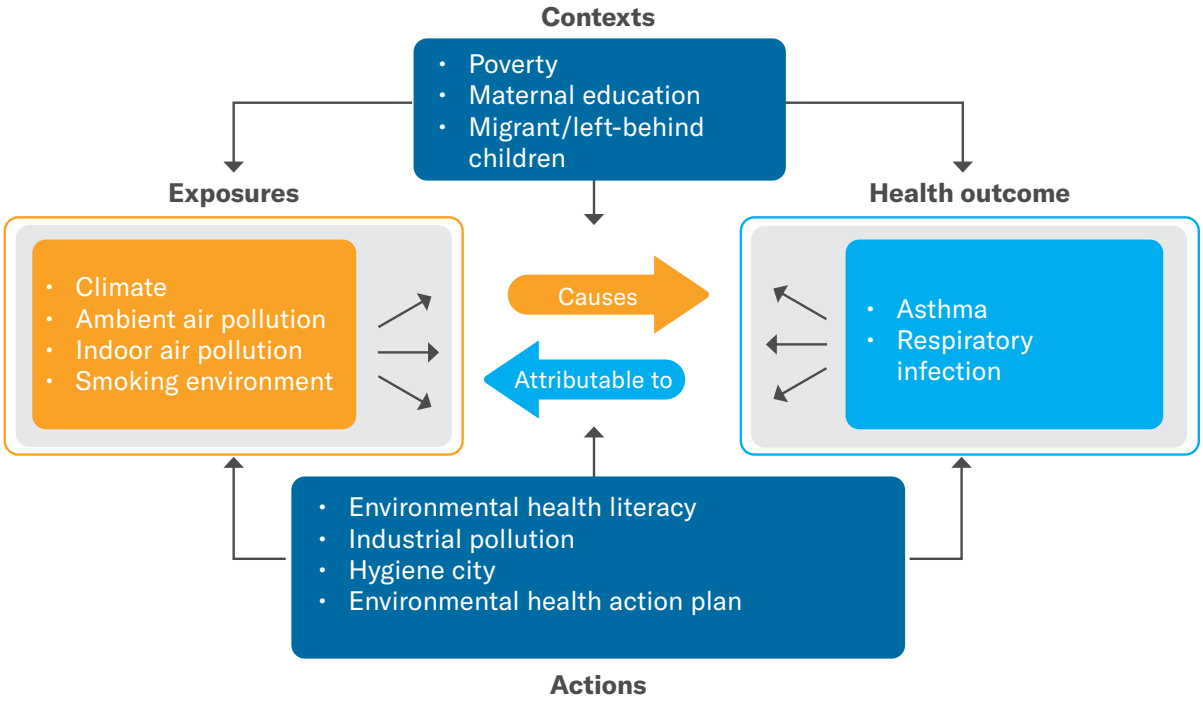


Figure 7 simulates how childhood asthma and respiratory infections are affected by environmental exposures, relevant contextual factors and interventions. Abundant studies have confirmed that ambient and indoor air pollution have significant associations with childhood asthma and respiratory infection. Secondhand smoking and climate factors such as high temperature and seasonal change are also associated with asthma and respiratory infection.

Poverty, maternal education and migrant/left-behind status are possible confounders and should be adjusted when analyzing data. When evaluating environmental effects on children's respiratory health, researchers should take into account actions such as reporting of industrial pollution, efforts to win designation as a hygiene city, and implementation of an environmental health plan.

Conclusion and Next Steps

A safe and healthy environment is essential for children's health and development. This CEHI project represents the first step China has taken to develop a robust list of children's environmental health indicators. The list resulted from a rigorous methodology and technically sound approach using scientific evidence from peer-reviewed research and consultations with national and international experts.

However, having a list of CEHIs is just the beginning. The important work that follows is ensuring that routinely collected, high-quality data to support each indicator can be captured, analyzed and shared with relevant stakeholders to guide policy that benefits children's health. It will also be necessary to identify a data steward to obtain and integrate data from various sources. Stewardship should include data quality review, data updating, analysis, reporting, visualization and data sharing.

Using the data collected for various indicators, researchers can validate associations between the different categories of indicators in the China context and identify relevant interventions and policies to reduce environmental exposures, support appropriate interventions, and ultimately reduce adverse health outcomes for children. Continued tracking and monitoring of CEHIs will enable policymakers to understand the dynamics of the problem areas, prioritize risk factors, target resources efficiently, and accurately measure intervention effects.

Near-term steps that can be taken to advance the CEHI project include:

1. Conducting comprehensive mapping of existing environmental health tracking systems in China and identifying the one most suitable to host CEHIs.
2. Mapping data sources with the goal of populating data tables for each indicator, resolvable at the finest possible geographic level and stratified by important population characteristics such as gender, relative economic advantage and age group.
3. Refining the current list of CEHIs, for aspects such as the indicator definition, computation method, possible data source, and characteristics of existing data for each CEHI.
4. Developing a cross-sectoral mechanism to coordinate the health sector, environment sector and other relevant sectors in creating a national children's environmental health plan and tracking system that builds on the CEHI work in China.
5. Publishing children's environmental health profiles regularly at national and subnational levels.
6. Working with children, youth networks and private sector partners to share information about children's environmental health updates in China.
7. Mobilizing specialists in children's health and environmental issues to use CEHIs to advocate for stronger environmental regulation and enforcement by government.
8. Researching emerging threats to children's environmental health and promoting international cooperation to enhance science and policy measures regarding this issue.
9. Identifying environmental health issues that would benefit from improved surveillance and research, with recommendations about data collection, needed resources and time frames for reporting findings.
10. Recommending timely, relevant policies and interventions to improve children's environmental health.

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ANNEXES

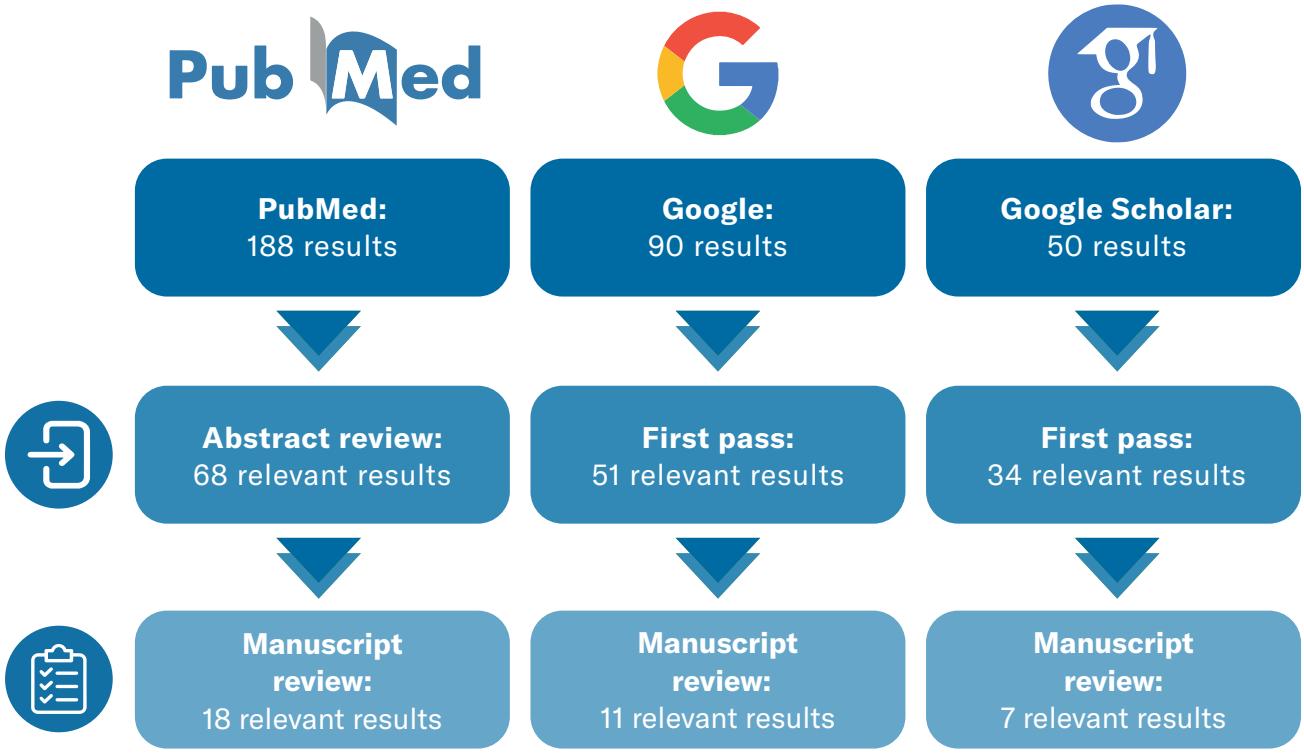
Annex A: Desktop Research Process

Vital Strategies conducted a formative desktop review for seminal reports, peer-reviewed journal articles and gray literature on children's environmental health indicators from November 2019 to January 2020. We implemented this review via three platforms:

- PubMed
- Google Scholar
- Google

Search terms used on all three platforms included "children's environmental health," "children's environmental health indicators," and "children's environmental health data." When searching PubMed, we prioritized meta-analyses and systematic reviews for review. When searching Google Scholar, we sorted findings by relevance and prioritized the first 50 results for review. When searching Google, we prioritized governmental and multilateral agency reports for review. The results from this search appear in Figure 8.

Figure 8: Formative Desktop Review Workflow



36 references were prioritized for final review. After excluding duplicate articles (7) and those considered out of date because an updated version exists (3), we selected 26 references for our final list, which is below.

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After assessing the most frequent citations in the group of 26 references, we prioritized three seminal reports on children's environmental health to derive the basis of our list of children's environmental health indicators. We included all topical indicators from these sources, while excluding indicators with conceptual overlap. The three seminal reports came from the World Health Organization (WHO),[1] the United States Centers for Disease Control and Prevention (U.S. CDC)[2] and UNICEF.[3] Measures proposed by these three reports are listed in the table below:

Measure ID	Source
1-48	WHO
49-55	Climate indicators proposed by UNICEF
56-64	U.S. CDC
65-75	UNICEF
76-80	Proposed by NIEH

[a] World Health Organization, 'Children's Environmental Health Indicators (CEHI)', retrieved from: https://www.who.int/ceh/indicators/en/

[b] United States Centers for Disease Control and Prevention, 'Explore Environmental Health Data', retrieved from: https://ephtracking.cdc.gov/showChildEHIndicators

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Annex B: Initial List of 80 Children's Environmental Health Measures

ID	Measure	Category
1	Children aged 0-14 years living in poverty	Context
2	Famine risk	Exposure
3	People living in informal settlements	Exposure
4	Women of childbearing age who are malnourished	Context
5	Women of childbearing age working in unregulated workplaces	Exposure
6	Births to mothers living in unsafe or hazardous housing	Exposure
7	Perinatal mortality rate	Health outcome
8	Intrauterine growth restriction in newborn children	Health outcome
9	Congenital malformations requiring surgical correction in children under 1 year of age	Health outcome
10	Women of childbearing age within one hour's travel of specialist maternity and perinatal care	Context
11	Change in number of households lacking basic services	Context
12	Prevalence of stunting in children aged 0-4 years	Health outcome
13	Low birth weight	Health outcome
14	Small for gestational age	Health outcome
15	Children aged 0-14 years living in unsafe, unhealthy or hazardous housing	Exposure
16	Overcrowding	Context
17	Children aged 0-14 years living in proximity to heavily trafficked roads	Exposure
18	Mean annual exposure of children aged 0-4 years to atmospheric particulate pollution	Exposure
19	Children aged 0-4 years living in households using biomass fuels or coal as the main source of heating and cooking	Exposure
20	Children aged 0-14 years living in households in which at least one adult smokes on a regular basis	Exposure

ID	Measure	Category
21	Mortality rate for children aged 0-4 years due to acute respiratory illness	Health outcome
22	Morbidity rate for children aged 0-4 years due to acute respiratory illness	Health outcome
23	Prevalence of chronic respiratory illness in children aged 0-14 years	Health outcome
24	Change in tobacco consumption	Exposure
25	Change in atmospheric pollutant concentrations	Exposure
26	Change in number of households relying on biomass fuel or coal as the main source of heating and cooking	Exposure
27	Drinking water supplies failing national microbiological water quality standards	Exposure
28	Children aged 0-14 years living in disaster-affected areas	Exposure
29	Children aged 0-14 years living in households without basic services for water supply, sanitation and hygiene	Exposure
30	Diarrhea mortality rate in children aged 0-4 years	Health outcome
31	Diarrhea morbidity rate in children aged 0-4 years	Health outcome
32	Recurrence rate of outbreaks of diarrheal disease among children aged 0-4 years	Health outcome
33	Change in the number of households lacking basic services	Exposure
34	Change in the number of food outlets failing hygiene standards	Exposure
35	Children aged 0-4 years able to obtain rehydration therapy within 24 hours of need	Exposure
36	Population growth rate in areas of endemic insect-borne diseases	Context
37	Total area of insect vector habitats	Exposure
38	Children aged 0-14 years living in households providing suitable conditions for insect-borne disease transmission	Exposure
39	Children aged 0-14 years living in areas of endemic insect-borne diseases	Exposure
40	Mortality rate for children aged 0-4 years due to insect-borne diseases	Health outcome

ID	Measure	Category
41	Prevalence of insect-borne diseases in children aged 0-14 years	Health outcome
42	At-risk children aged 0-14 years covered by integrated vector control and management systems	Action
43	Children aged 0-14 years involved in routine employment	Exposure
44	Children aged 0-14 years living in homes lacking access to a piped water supply	Exposure
45	Mortality rate of children aged 0-14 years due to physical injuries	Health outcome
46	Incidence of physical injuries to children aged 0-14 years requiring treatment	Health outcome
47	Children aged 0-14 years living within reach of specialist emergency medical services	Action
48	Change in physical injuries to children aged 0-14 years	Health outcome
49	Increase in heat alerts/warnings	Exposure
50	Frequency of wildfires	Exposure
51	Severity of wildfires	Exposure
52	Frequency of droughts	Exposure
53	Frequency of harmful algae blooms	Exposure
54	Excess mortality due to extreme heat	Health outcome
55	Excess morbidity due to extreme heat	Health outcome
56	Respiratory/allergic disease and mortality related to increased air pollution and pollens	Health outcome
57	Flooding vulnerability	Exposure
58	Vulnerability to sea-level rise	Exposure
59	Exposure to urban heat islands	Exposure
60	Exposure to salmonella	Exposure
61	Incidence of salmonellosis	Health outcome

ID	Measure	Category
62	Exposure to lead	Exposure
63	Exposure to ozone	Exposure
64	Exposure to PM 2.5 air pollution	Exposure
65	Incidence of zoonotic diseases	Health outcome
66	Incidence of mosquito-borne diseases	Health outcome
67	Incidence of cryptosporidiosis	Exposure
68	Exposure to contaminated water	Exposure
69	Children completing primary school	Context
70	Children completing secondary school	Context
71	Maternal education—completed primary school	Context
72	Maternal education—completed secondary school	Context
73	Children fully vaccinated at 6 years	Context
74	Admissions to hospital for burns	Health outcome
75	Children aged 0-4 years living in areas with air pollution monitoring	Action
76	Children aged 0-14 years excessively using electronic devices	Context
77	Children aged 0-14 years engaged in daily activities outdoors	Exposure
78	Maternal education—completed tertiary education	Context
79	Asthma	Health outcome
80	Pesticide exposure	Exposure

Annex C: Internal Ranking and Elimination of Low-Priority Children's Environmental Health Measures

Technical experts from NIEH; UNICEF, China; and Vital Strategies ranked the measures by perceived importance to children's health in China. The experts decided to remove measures widely considered of "low importance" and they discussed other measures about which there was less agreement. The table below shows the measures that were removed.

ID	Measure
2	Famine risk
3	People living in informal settlements
53	Frequency of harmful algae blooms
58	Vulnerability to sea-level rise
68	Exposure to contaminated water
71	Maternal education—completed primary school
74	Admissions to hospital for burns
5	Women of childbearing age working in unregulated workplaces
10	Women of childbearing age within one hour's travel of specialist in maternity and perinatal care
11	Change in number of households lacking basic services
14	Small for gestational age
24	Change in tobacco consumption
25	Change in atmospheric pollutant concentrations
26	Change in number of households relying on biomass fuel or coal as the main source of heating and cooking
33	Change in number of households lacking basic services
35	Children aged 0-4 years able to obtain rehydration therapy within 24 hours of need
36	Population growth rate in areas of endemic insect-borne diseases

ID	Measure
37	Total area of insect vector habitats
38	Children aged 0-14 years living in households with conditions suitable for insect-borne disease transmission
43	Children aged 0-14 years engaged in routine employment
44	Children aged 0-14 years living in homes lacking access to a piped water supply
47	Children aged 0-14 years living within reach of specialist in emergency medical services
48	Change in physical injuries to children aged 0-14 years
51	Severity of wildfires
56	Respiratory/allergic disease and mortality related to increased air pollution and pollens
64	Exposure to PM 2.5 air pollution
66	Incidence of mosquito-borne diseases
67	Incidence of cryptosporidiosis
70	Children completing secondary school
72	Maternal education—completed secondary school
32	Recurrence rate of outbreaks of diarrheal disease among children aged 0-4 years
55	Excess morbidity due to extreme heat
60	Exposure to salmonella
63	Exposure to ozone
77	Children aged 0-14 years engaged in daily activities outdoors
79	Incidence of allergic disease

In total, 36 measures were removed, and 6 new measures were added, leaving 50 measures for the next step in the process. Specific indicators were proposed for the remaining 50 measures.

Annex D: Delphi Evaluation and Consultation with Stakeholders

The prioritized list of 50 measures and their associated indicators underwent a Delphi evaluation by 17 Chinese specialists. The 17 specialists were identified through comprehensive stakeholder mapping based on expertise in at least one of the subdomain areas. These specialists averaged 23 years of experience in their area of study. Delphi evaluators were asked to score each indicator from one to three based on the following three dimensions of consideration:

- Relevance to children's environmental health
- Availability of data to support the indicator
- Relevance to environmental health policies in China

Higher scores in the table below represent greater agreement about an indicator's importance and inclusion.

Proposed indicator	Total score
Percentage of children aged 0-17 years covered by 'Di Bao' – China's low-income family financial assistance system	44
Percentage of women aged 15-49 years who are malnourished	35
Percentage of rural women aged 22-49 years living in hazardous housing defined by "Guidelines for evaluating rural hazardous housing" as C-level housing	32
Number of perinatal deaths per 1,000 births	41
Percentage of babies born before 37 weeks completed gestation	42
Incidence of congenital malformations in children under 1 year of age	43
Prevalence (percentage) of stunting (<-2 SDs HAZ score) in children aged 0-4 years	41
Incidence of low birth weight (<2,500 grams)	40
Percentage of rural children aged 0-17 years living in hazardous housing defined by "Guidelines for evaluating rural hazardous housing" as C-level housing.	37
Percentage of children aged 0-17 years studying in crowded classrooms (defined as less than 1.39 square meters per student)	33
Percentage of children aged 0-17 years living within 50 meters of four-lane roads	41
Annual mean concentration of ambient $PM_{2.5}$	46

Proposed indicator	Total score
Percentage of children aged 0-17 years living in households where solid fuels are used for cooking and heating	42
Number of children aged 0-17 years living in households in which at least one adult smokes on a regular basis	48
Mortality rate for children aged 0-4 years due to acute respiratory illness	36
Incidence of acute respiratory disease among children aged 0-4 years	40
Prevalence of chronic respiratory illness in children aged 0-17 years	42
Percentage of drinking water supplies failing national water quality standards	48
Number of people affected by earthquake	25
Number of people living in households with piped water	43
Mortality rate of diarrhea among children aged 0-4 years	43
Incidence of diarrhea among children aged 0-4 years	45
Percentage of food products failing national food hygiene standards	44
Number of children aged 0-17 years living in areas of endemic insect-borne diseases	41
Mortality rate of insect-borne diseases in children aged 0-4 years	38
Incidence of insect-borne diseases in children aged 0-17 years	38
Percentage of at-risk children living in areas with vector control system	32
Number of deaths among children aged 0-17 years caused by injury (burn, fall, drowning)	46
Incidence of injury (burn, fall, drowning) among children aged 0-17 years	44
Number of days having heat wave (highest temperature for the day reaches 32°C and lasts for more than three days)	31
Number of days having wildfires	22

Proposed indicator	Total score
Number of days having droughts	23
Number of deaths caused by extreme heat or cold among children aged 0-17 years	30
Number of floods	34
Number of days of urban heat islands	23
Average blood lead level among children aged 0-17 years	46
Incidence of national notifiable zoonotic diseases among children aged 0-17 years	36
Percentage of lakes and rivers whose water quality index is below national standard level III	36
Percentage of children aged 12-14 years who completed primary school	43
Percentage of children aged 0-6 years vaccinated with all level-1 vaccines	44
Percentage of children living in cities with national air quality monitoring station	35
Percentage of children aged 0-4 years excessively using electronic devices (aged 0-1 years: more than 0 hours; aged 2-4 years: more than 1 hour/day)	41
Education level of women aged 15-49 years	42
Percentage of vegetables failing national pesticide residue standard	41
Percentage of children aged 0-17 years who are overweight (over one standard deviation body mass index for age and sex)	44
Mortality of traffic accidents among children aged 0-17 years	47
Number of days having cold wave (temperature drops more than 8°C within 24 hours and the lowest temperature for the day reaches 4°C; or temperature drops more than 10°C within 48 hours and the lowest temperature for the day reaches 4°C; or temperature drops more than 12°C within 72 hours and the lowest temperature for the day reaches 4°C)	25
Percentage of population using safely managed toilet	47
Percentage of population with basic handwashing facility	48
Percentage of soil failing national heavy metal standard (mercury, cadmium, lead, chromium, copper, nickel, zinc, arsenic)	37

The 39 highest-ranked indicators (scored equal to or greater than 35) were moved to the next phase. A consultation with the evaluators was held virtually to present the Delphi results and review indicators that drew widely differing opinions from evaluators. Live polls were conducted during the discussion, and most evaluators agreed to remove the following 6 indicators:

- Number of deaths among children aged 0-17 years caused by injury (burn, fall, drowning)
- Mortality rate from diarrhea among children aged 0-4 years
- Percentage of rural children aged 0-17 years living in hazardous housing defined by "Guidelines for evaluating rural hazardous housing" as C-level housing
- Mortality rate for children aged 0-4 years due to acute respiratory illness
- Percentage of children living in cities with national air quality monitoring station
- Percentage of children aged 0-6 years vaccinated with all level-1 vaccines

The evaluators agreed to prioritize the following 3 indicators for the next phase:

- Number of days having heat wave
- Number of floods
- Number of days having cold wave

Several Delphi evaluators proposed new indicators for the team to consider. After internal discussion, the following 6 additional indicators were added to the candidate list:

- Percentage of children aged 0-17 years smoking
- Percentage of cities failing national noise standard
- Percentage of people who pass environmental health literacy test
- Percentage of children's toys and appliances exceeding lead standard
- Percentage of children who are migrant or left behind
- Prevalence of asthma among children aged 0-17 years

The Delphi evaluators did not prioritize for the next phase any action indicators from the original 80 measures. During the consultation meeting, evaluators suggested that our proposed environmental indicators should align more closely with existing policy endeavors in China. Thus, we reviewed "Healthy China 2030," a document published by the government of China. Based on the priorities set by this document, the following 8 indicators were added as candidates for the next phase:

- Percentage of cities/villages designated "national hygiene city/village"
- Percentage of "key pollutant discharge units" that monitor and report their pollution status
- Percentage of rural areas implementing a waste management system
- Volume of industrial waste gas emission
- Whether there is a national environmental health plan in place
- Annual government budget spent on environmental health
- Access to and use of clean energy
- Percentage of local governments that conduct regular climate change risk assessments including actions to address the needs of children

At the end of the Delphi process, a total of 50 indicators moved into the next phase, and they are listed in the table below.

ID	Measure
1	Percentage of children aged 0-17 years covered by Di Bao
4	Percentage of women aged 15-49 years who are malnourished
7	Number of perinatal deaths per 1,000 births
8	Percentage of babies born before 37 weeks completed gestation
9	Incidence of congenital malformations in children under 1 year of age
12	Prevalence (percentage) of stunting (<-2 SDs HAZ score) in children aged 0-4 years
13	Incidence of low birth weight (<2,500 grams)
17	Percentage of children aged 0-17 years living within 50 meters of four-lane roads
18	Annual mean concentration of ambient $PM_{2.5}$
19	Percentage of children aged 0-17 years living in households where solid fuels are used for cooking and heating
20	Number of children aged 0-17 years living in households in which at least one adult smokes on a regular basis
22	Incidence of acute respiratory disease among children aged 0-4 years
23	Prevalence of chronic respiratory illness in children aged 0-17 years
27	Percentage of drinking water supplies failing national water quality standards
29	Number of people living in households with piped water
31	Incidence of diarrhea among children aged 0-4 years
34	Percentage of food products failing national food hygiene standards
39	Number of children aged 0-17 years living in areas of endemic insect-borne diseases
40	Mortality rate of insect-borne diseases in children aged 0-4 years
41	Incidence of insect-borne diseases in children aged 0-17 years
46	Incidence of injury (burn, fall, drowning) among children aged 0-17 years

ID	Measure
49	Number of days having heat wave
57	Number of floods
62	Average blood lead level among children aged 0-17 years
65	Incidence of national notifiable zoonotic diseases among children aged 0-17 years
68	Percentage of lakes and rivers whose water quality index is below national standard level III
69	Percentage of children aged 12-14 years who completed primary school
76	Percentage of children aged 0-4 years excessively using electronic devices (aged 0-1 years: more than 0 hours; aged 2-4 years: more than 1 hour/day)
79	Prevalence of asthma among children aged 0-17 years
78	Education level of women aged 15-49 years
80	Percentage of vegetables failing national pesticide residue standard
81	Percentage of children aged 0-17 years who are overweight (over one standard deviation body mass index for age and sex)
82	Mortality of traffic accidents among children aged 0-17 years
83	Number of days having cold wave
84	Percentage of population using safely managed toilet
85	Percentage of population with basic handwashing facility
86	Percentage of soil failing national heavy metal standard (mercury, cadmium, lead, chromium, copper, nickel, zinc, arsenic)
88	Percentage of children aged 0-17 years smoking
89	Percentage of cities failing national noise standard
90	Percentage of people who pass environmental health literacy test
91	Percentage of cities/villages designated "national hygiene city/village"
92	Percentage of “key pollutant discharge units” that monitor and report their pollution status

ID	Measure
93	Percentage of rural areas implementing a waste management system
94	Whether there is a national environmental health plan in place
95	Annual government budget spent on environmental health
96	Volume of industrial waste gas emission
97	Proportion of children's toys and appliances exceeding lead standard
99	Percentage of children who are migrant or left behind
100	Access to and use of clean energy
101	City-level climate change risk assessments

Annex E: One-on-One Consultations with Stakeholders

One-on-one consultations were held with local topical experts on specific indicators that fell within their areas of expertise. The purpose of these consultations was to 1) modify any existing indicator definitions as recommended by experts; 2) add additional indicators suggested by topical experts that may have been missed by the review process thus far; and 3) remove any indicators that might not be relevant for the Chinese context or were similar to another on the list. The consultations yielded the following results and feedback:

5 indicators with adjusted definitions

Original indicator definition	New indicator definition	Feedback from consultation
Percentage of children covered by Di Bao	Percentage of households falling under 50% of the median household income of that province	Di Bao percentage has been low in recent years and may not be a reliable indicator. Annual family income was suggested as a new indicator.
Incidence of insect-borne diseases	Incidence of dengue fever among children aged 0-17 years	Among insect-borne diseases, dengue fever has the highest incidence in China.
Incidence of injury (burn, fall, drowning) among children aged 0-17 years	Incidence of drowning among children aged 0-17 years	Among injuries, drowning has the second-highest disease burden for Chinese children.
Whether there is a national environmental health plan in place	Percentage of local governments that have implemented an environmental health plan that includes climate change and garbage management actions	Local governmental plans offer a better picture of contextualized governmental commitments and actions.
Percentage of children's toys and appliances exceeding lead standard	Percentage of children's products failing national standards	The State Administration for Market Regulation conducts random spot checks on children's products and reports results on products that failed national standards, which include not only a lead standard but also a range of other chemical standards.

9 new indicators added

Indicator definition	Feedback from consultation
Number of people affected by disasters	This is a better measure of the impact of extreme weather events than the number of floods.
Percentage of local governments that conduct regular climate change risk assessments with actions to address the needs of children	The Lancet Countdown recommended this.
Incidence of encephalitis B among children aged 0-17 years	It is the insect-borne disease with the second- highest incidence rate in China.
Mosquito density in the area	Mosquito density is sensitive to climate change and China CDC monitors this.
Percentage of schools evaluated as dilapidated buildings	It can be a measure for housing conditions and the Ministry of Education monitors it.
Percentage of infants' and young children's food products failing national food safety standards	Because infants' and young children's foods are different from those of adolescents and adults, it would be valuable to have a food safety measure specifically for infants and young children.
Percentage of schools with piped water	Because children spend half of their time in schools, WASH conditions in schools are a meaningful environmental exposure for children.
Percentage of schools with handwashing facility	
Percentage of schools with safely managed toilet	

5 indicators removed

Indicator definition	Feedback from consultation
Mortality of insect-borne diseases among children aged 0-4 years	The mortality rate of insect-borne diseases is extremely low in China.
Percentage children aged 0-17 years living within 50 meters of four-lane roads	This is not a good measure of risks for road traffic injury.
Incidence of national notifiable zoonotic diseases among children aged 0-17 years	In China, zoonotic diseases primarily affect adults through occupational exposure.
Percentage of vegetables failing national pesticide residue standard	The food safety indicator measures pesticide residue in vegetables.
Access to and use of clean energy	It measures the same subdomain as indoor solid fuel use.

Annex F: Search strategy for the systemic literature review

We used MeSH terms and Emtree terms in constructing the search formulas. MeSH and Emtree terms are "tags" that the PubMed and Embase databases give articles based on their contents. The benefits of using MeSH and Emtree terms are that they are hierarchically structured vocabularies that match the topics used to catalog articles in the PubMed and Embase databases. We can choose to "explode" the term to include all associated terms that are under the umbrella of the chosen term.

Table 1 presents the exposure terms used for all diseases selected in each database, while Table 2 lists the search terms used in each database for each selected disease. We searched for relevant systematic reviews and meta-analyses that were published after the year 2000 (including the year 2000) disease by disease, combining disease terms with corresponding exposure terms by using "AND" and applying it in PubMed and Embase respectively.

Table 1: Exposure terms used for searches in PubMed and Embase

Exposure terms used	
PubMed	**Embase**
((((environment [MeSH Terms]) OR (environmental pollution[MeSH Terms])) OR (environmental pollutants [MeSH Terms])) OR (climate change[MeSH Terms]))	("environment"/ exp OR "environmental exposure"/exp OR "environmental, industrial and domestic chemicals"/ exp)

Table 2: Disease terms used for searches in PubMed and Embase

Disease/ category of disease searched	Disease terms used	
	PubMed	**Embase**
Drowning	((drowning[MeSH Terms]) OR (drown*[Title/Abstract]))	"drowning"/exp
Traffic accident	((((accidents, traffic[MeSH Terms]) OR (traffic accident*[Title/Abstract])) OR (traffic injur*[Title/Abstract])) OR (road injur*[Title/Abstract]))	"traffic accident"/exp
Foreign body	((foreign bodies[MeSH Terms]) OR (foreign bod*[Title/Abstract]))	"foreign body"/exp

Disease/ category of disease searched	Disease terms used	
	PubMed	Embase
Fall	((accidental falls[MeSH Terms]) OR (fall*[Title/Abstract]))	"fall"/exp
Conduct disorder	((conduct disorders[MeSH Terms]) OR (conduct*[Title/Abstract]))	"conduct disorder"/exp
Anxiety disorder	((anxiety[MeSH Terms]) OR (anxi*[Title/Abstract]))	"anxiety disorder"/exp
Leukemia	(((leukemia[MeSH Terms]) OR (leukemia*[Title/Abstract])) OR (leukaemia*[Title/Abstract]))	"leukemia"/exp
Central nervous system cancer	((((brain neoplasms[MeSH Terms]) OR (brain cancer*[Title/Abstract])) OR (brain tumor*[Title/Abstract])) OR (central nervous system tumor*[Title/Abstract]))	"central nervous system cancer"/exp
Nutritional disorder	(((((((((child nutrition disorders[MeSH Terms]) OR (growth disorder[MeSH Terms])) OR (overweight[MeSH Terms])) OR (malnutrition*[Title/Abstract])) OR (undernutrition[Title/Abstract])) OR (stunt*[Title/Abstract])) OR (wast*[Title/Abstract])) OR (obes*[Title/Abstract])) OR (overweight[Title/Abstract]))	"nutritional disorder"/exp
Elevated blood lead level	((lead poisoning[MeSH Terms]) OR (lead[Title/Abstract]))	("lead poisoning"/exp OR "lead blood level"/exp)
Myopia	(((myopia[MeSH Terms]) OR (myopia[Title/Abstract])) OR (nearsight*[Title/Abstract]))	"myopia"/exp
Diarrhea	((diarrhea[MeSH Terms]) OR (diarrh*[Title/Abstract]))	"diarrhea"/exp
Lower respiratory diseases	((respiratory tract infection[Title/Abstract]) OR (respiratory tract infections[MeSH Terms]))	"respiratory tract disease"/exp

Disease/ category of disease searched	Disease terms used	
	PubMed	Embase
Asthma	((asthma[MeSH Terms]) OR (asthma[Title/Abstract]))	"asthma"/exp
Neonatal/ perinatal diseases	(((((((congenital, hereditary, and neonatal diseases and abnormalities[MeSH Terms]) OR (perinatal death[MeSH Terms])) OR (perinatal mortality[MeSH Terms])) OR (infant, low birth weight[MeSH Terms])) OR (premature birth[MeSH Terms])) OR (sudden infant death[MeSH Terms])) OR (infant, premature[MeSH Terms]))	("congenital heart disease"/exp OR "large for gestational age"/exp OR "low birth weight"/exp OR "prematurity"/exp OR "perinatal death"/exp OR "newborn morbidity"/exp OR "newborn mortality"/exp OR "sudden infant death syndrome"/exp)
Insect-borne diseases	((((encephalitis, Japanese[MeSH Terms] OR (Japanese encephalitis[Title/Abstract])) OR (dengue[MeSH Terms])) OR (dengue [Title/Abstract]))	"Japanese encephalitis"/exp

The search strategy yielded 7,527 search results. A process of deduplication removed 217 results. Next, 10 authors screened all retrieved citations' titles and abstracts, and reviewed in full all articles deemed potentially relevant. Each article was reviewed by at least two authors. They referred to the following prespecified criteria for exclusion:

- Children were not the study population.
- The studied health outcome was not what we searched for.
- The studied exposure/risk factor was not related to the environment (as defined by the project to identify children's environmental health indicators).
- The study did not assess association (it was only a descriptive study).
- The study was a duplicate.
- The study was not a systematic review or meta-analysis.

Each author documented articles that they deemed relevant in a spreadsheet, then compared their selections with those of their fellow authors, and resolved disagreements through discussion Together, the authors excluded 5,825 articles deemed not relevant and selected 1,485 articles for further consideration.

Then, the full texts of the 1,485 eligible articles were retrieved. With the addition of one article, making a total of 1,486 articles, six reviewers read the full texts—regardless of whether the articles found a significant positive or negative association between environmental exposure factors and a health outcome or whether they found no effect. After reviewing full texts of the articles, the reviewers excluded a further 1,003 articles based on our prespecified exclusion criteria. The result was 483 articles included in the final literature analysis.

Annex G: Literature Review Results

Health outcome	Environmental exposure	Summary of association from literature review results
Allergy: allergy	Ambient Air Pollution AAP (2)	two systematic reviews suggest positive association
	AAP: particulate (1)	one systematic review suggests positive association
	environmental tobacco smoke ETS (1)	one systematic review suggests positive association
Allergic: atopic dermatitis	allergen: pet (1)	one meta-analysis concluded 0.5<OR<1.0
	climate change (1)	one systematic review suggests positive association
	Secondhand smoke SHS (1)	one systematic review suggests positive association
	antibiotic (1)	one systematic review suggests positive association
	maternal SHS (1)	one meta-analysis concluded 1.0<OR<2.0
Allergic: eczema	Ambient Air Pollution AAP (1)	one systematic review suggests no agreement association
	maternal medication: contraceptive (1)	one meta-analysis concluded 1.0<OR<2.0
Allergic: rhinitis	maternal medication: contraceptive (1)	one meta-analysis concluded 1.0<OR<2.0
	mold and dampness (1)	one meta-analysis concluded 1.0<OR<2.0
	residence: greenness (1)	one meta-analysis concluded 0.5<OR<1.0
Anxiety: anxiety	per 10 dB(A) increase in day-evening-night noise level (4)*	12 percentage (95 percentage CI: −4 percentage, 30 percentage); three systematic reviews suggest positive association
	AAP: PM2.5 (1)*	one systematic review suggests positive association
	bisphenol A (1)	one systematic review suggests positive association
	flooding events (1)*	one systematic review suggests positive association
	residence: greenness (1)*	one systematic review suggests positive association

Health outcome	Environmental exposure	Summary of association from literature review results
	structural quality, clutter and cleanliness, hazards, indoor climate, and privacy/crowding (1)*	one systematic review suggests positive association
Asthma	Ambient Air Pollution AAP (24)	thirteen meta-analyses concluded 1.0<ORs<2.0, one concluded 2.0<OR<4.0, four systematic reviews suggest no agreement association, six suggest positive association
	AAP: particulate matter (1)	one systematic review suggests no agreement association
	allergen: cat (2)	one meta-analysis concluded 0.9<RR<1.0, one concluded1.0<OR<2.0
	allergen: dog (4)	one meta-analysis concluded 0.5<OR<1.0, one concluded 1.0<OR<2.0, one concluded 0.9<RR<1.0, one concluded 1.2<RR<1.4
	allergen: food (3)	two meta-analyses concluded 2.0<ORs<4.0, one systematic review suggests no agreement association
	allergen: pollen (2)	one meta-analysis concluded 1.0<OR<2.0, one systematic review suggests positive association
	allergen: undefined (3)	one systematic review suggests no agreement association, one suggests no association, one suggests positive association
	climate: temperature (1)	one systematic review suggests positive association
	endocrine disrupting chemicals EDCs (2)	two meta-analyses concluded 2.0<ORs<4.0
	environmental tobacco smoke ETS (4)	four systematic reviews suggest positive association
	Household air pollution HAP (1)	one systematic review suggests no agreement association
	indoor air pollution IAP (6)	three meta-analyses concluded 1.0<ORs<2.0, one concluded OR<0.5, one systematic review suggests no agreement association, one suggests positive association
	IAP: formaldehyde (3)	one meta-analysis concluded 1.0<OR<2.0, two systematic reviews suggest positive association

Health outcome	Environmental exposure	Summary of association from literature review results
Asthma	maternal diet (2)	one systematic review suggests no agreement association, one suggests positive association
	secondhand smoke SHS (5)	four meta-analyses concluded 1.0<ORs<2.0, one concluded 2.0<OR<4.0
	antibiotic (6)	two meta-analyses concluded 1.0<ORs<2.0, one concluded 2.0<OR<4.0, two systematic reviews suggest no association, one suggests positive association
	fungi (1)	one systematic review suggests positive association
	maternal SHS (7)	five meta-analyses concluded 1.0<ORs<2.0, one concluded 1.2<RR<1.4, one systematic review suggests positive association
	maternal traffic related pollution TRP (1)	one systematic review suggests positive association
	maternal medication: contraceptive (1)	one meta-analysis concluded 1.0<OR<2.0
	microbe: respiratory syncytial virus (3)	one meta-analysis concluded 1.0<OR<2.0, one concluded 2.0<OR<4.0, one systematic review suggests positive association
	mold and dampness (8)	six meta-analyses concluded 1.0<ORs<2.0, two systematic reviews suggest positive association
	residence: greenness (3)	three meta-analyses concluded 1.0<ORs<2.0
	allergen: dust mite (1)	one meta-analysis concluded 1.0<OR<2.0
	secondhand smoke (2)	two meta-analyses concluded 1.0<ORs<2.0
	antibiotic (2)	one meta-analysis concluded 1.0<OR<2.0, one systematic review suggests no association
	maternal secondhand smoke (1)	one systematic review suggests positive association
	home painting (1)	one systematic review suggests no agreement association
Brain tumors	residential magnetic field (1)	one meta-analysis concluded OR has no explicit association

Health outcome	Environmental exposure	Summary of association from literature review results
Brain tumors	maternal smoking during pregnancy (4)	one meta-analysis concluded 1.0<OR<2.0, one concluded OR has no explicit association, two concluded RRs have no explicit association
	maternal smoking before pregnancy (1)	one meta-analysis concluded RR has no explicit association
	paternal smoking during pregnancy (2)	one meta-analysis concluded 1.2≤RR≤1.4, oneconcluded 0.9≤RR≤1.0
	paternal smoking before pregnancy (1)	one meta-analysis concluded 1.0≤RR≤1.1
	pesticide: farm-related (2)	two systematic reviews suggest positive association
	pesticide: parental (2)	one meta-analysis concluded 1.0<OR<2.0, one systematic review suggests positive association
	pesticide: residential (3)	one meta-analysis concluded 1.0<OR<2.0, one concluded OR has no explicit association, one systematic review suggests positive association
	heavy metals (1)	one systematic review suggests positive association
	WASH: tap water consumption (1)	one systematic review suggests positive association
	non-ionizing radiation (1)	one systematic review suggests positive association
Conduct disorder: conduct disorder	maternal smoking during pregnancy (2)	one meta-analysis concluded OR>2.0, one systematic review suggests positive association
	lead (1)	effect size r=0.19, (p < 0.001)
Conduct disorders: hyperactivity, inattention, and conduct problems	bisphenol A (1)	one systematic review suggests positive association
Conduct disorders: hyperactivity or inattention	per 10 dB road traffic noise (1)	one meta-analysis concluded 1.0<OR< 2.0
Diarrheal disease: diarrhea	WASH: lack of availability of latrine (1)	one meta-analysis concluded 2.0<OR<4.0

Health outcome	Environmental exposure	Summary of association from literature review results
Diarrheal disease: diarrhea	WASH: point-of-use water filtration (2)	two meta-analyses concluded 0.4<RRs<0.6
	WASH: point-of-use water disinfection (2)	three 0.7<RR<0.8
	WASH: improvement of water quality at source (2)	one 0.7<RR<0.8, one RR suggests no explicit association
	WASH: point-of-use water disinfection (2)	two meta-analyses concluded 0.7<RRs<0.8
	WASH: improvement of water quality at source (2)	one meta-analysis concluded 0.7<RR<0.8, one concluded RR has no explicit association
	WASH: piped water treatment (1)	one meta-analysis concluded 0.7<RR<0.8
	WASH: sanitation interventions (1)	one meta-analysis concluded OR<1.0
	WASH: hand hygiene (1)	one systematic review suggests negative association
	WASH: fecal contamination in drinking water and on hands (1)	one systematic review suggests positive association
	WASH: school-based water, sanitation and hygiene intervention (2)	two systematic reviews suggest positive association
	WASH: neighborhood sanitation conditions (1)	one meta-analysis concluded OR<1.0
	WASH: household sanitation conditions (1)	one meta-analysis concluded OR<1.0
	WASH: community-level sanitation access (1)	one meta-analysis concluded OR<1.0 for children with household-level sanitation access, one concluded OR has no explicit association for children without household-level sanitation access
Diarrheal disease: cryptosporidiosis	climate: rainfall (1)	one systematic review suggests negative association
Drowning: drowning	access to water bodies (2)	two systematic reviews suggest positive association
	climate: summer season (1)	one systematic review suggests positive association
	climate: stormy weather (1)	one systematic review suggests positive association
	rural communities (1)	one systematic review suggests rural areas pose greater risk than urban areas in low- and middle-income countries

Health outcome	Environmental exposure	Summary of association from literature review results
Insect-borne disease: Japanese encephalitis	climate: precipitation (1)	one systematic review suggests positive association
	climate: temperature (1)	one systematic review suggests positive association
Insect-borne disease: dengue fever	allergen: cat (1)	one meta-analysis concluded 1.0<OR<2.0
	climate: El Niño-Southern Oscillation (1)	one systematic review suggests no agreement association
	climate: humidity (3)	two systematic reviews suggest no agreement association, one suggests positive association
	climate: rainfall (7)	two meta-analyses concluded 1.0<ORs<2.0, one concluded 2.0<OR<4.0, three systematic reviews suggest no agreement association, onesuggests positive association
	climate: season (3)	one meta-analysis concluded 1.0<OR<2.0, two systematic reviews suggest positive association
	climate: temperature (10)	four meta-analyses concluded 1.0<ORs<2.0, three systematic reviews suggest no agreement association, three suggest positive association
	garbage (3)	one meta-analysis concluded 0.5<OR<1.0, two concluded 1.0<ORs<2.0
	stagnant water (4)	one meta-analysis concluded 1.0<OR<2.0, three systematic reviews suggest positive association
	stagnant water: used tires (2)	one meta-analysis concluded 1.0<OR<2.0, one systematic review suggests positive association
Lead poisoning: blood lead level ≥15.0 μg per deciliter	dust control (1)	one meta-analysis concluded 0.9<RR<1.0
Lead poisoning: blood lead level ≥10.0 μg per deciliter	dust control (1)	one meta-analysis concluded RR<1.0 but not significant
	home painting (1)	one meta-analysis concluded OR<1.0
	living near main roads (1)	one meta-analysis concluded 2.0≤OR≤4.0
	secondhand smoking (postnatal) (1)	one meta-analysis concluded 2.0≤OR≤4.0
	potential for father's occupational exposure to lead (1)	one meta-analysis concluded 2.0≤OR≤4.0

Health outcome	Environmental exposure	Summary of association from literature review results
Lead poisoning: blood lead level ≥10.0 μg per deciliter	potential for mother's occupational exposure to lead (1)	one meta-analysis concluded 1.0<OR<2.0
	industry near the home (1)	one meta-analysis concluded 1.0<OR<2.0
	WASH: often not washing hands at key times (1)	one meta-analysis concluded 1.0<OR<2.0
	living on the ground floor (1)	one meta-analysis concluded 1.0<OR<2.0
	Indoor air pollution: coal burning (1)	one meta-analysis concluded 1.0<OR<2.0
	peeling walls (1)	one meta-analysis concluded 1.0<OR<2.0
Leukemia: leukemia	permethrin exposure (1)	one systematic review suggests inconsistent association
	pentachlorophenol exposure (1)	one systematic review suggests positive association
	pesticide exposure (residential) (4)	two meta-analyses concluded 1.0<ORs<2.0, one concluded 1.5≤RR≤2.9
	maternal pesticide exposure during pregnancy (4)	two meta-analyses concluded 1.0<ORs<2.0, one concluded 2.0≤one OR≤4.0, one concluded 1.5≤RR≤2.9
	maternal occupational exposure to pesticides (1)	one meta-analysis concluded RR has no explicit association
	paternal occupational exposure to pesticides (2)	one meta-analysis concluded 1.5≤RR≤2.9, one concluded OR has no explicit association
	arsenic (1)	one systematic review suggests no explicit association
	AAP: 1,3—butadiene (outdoor) exposure (1)	one meta-analysis concluded 1.5≤RR≤2.9
	AAP: NO2 (outdoor air) (1)	one meta-analysis concluded RR has no explicit association
	AAP: PM2.5 (1)	one meta-analysis concluded RR has no explicit association
	AAP: PM10 (1)	one meta-analysis concluded RR has no explicit association
	AAP: benzene (outdoor air) (1)	one meta-analysis concluded 1.2≤RR≤1.4
	occupational and household exposure to benzene (1)	one meta-analysis concluded 1.5≤RR≤2.9
	traffic density (2)	one meta-analysis concluded 1.0≤one RR≤1.1, one concluded OR has no explicit association
	traffic density or traffic-related air pollution (1)	one meta-analysis concluded 1.5≤RR≤2.9

Health outcome	Environmental exposure	Summary of association from literature review results
Leukemia: leukemia	residential traffic exposure (prenatal) (1)	one meta-analysis concluded 1.0<OR<2.0
	residential traffic exposure (postnatal) (1)	one meta-analysis concluded OR has no explicit association
	residential proximity to nuclear power plants/electrical facilities (2)	two meta-analyses concluded ORs have no explicit association
	residential magnetic fields (2)	one meta-analysis concluded 1.0<OR<2.0, one systematic review suggests no explicit association
	maternal occupational exposure to extremely low-frequency magnetic fields (1)	one meta-analysis concluded ORhas no explicit association
	paternal occupational exposure to extremely low-frequency magnetic fields (1)	one meta-analysis concluded OR has no explicit association
	low-dose/non-ionizing radiation (2)	one meta-analysis concluded 1.0<OR<2.0, one systematic review suggests no explicit association
	maternal smoking during pregnancy (5)	six meta-analyses concluded ORs have no explicit association
	maternal smoking before pregnancy (1)	two meta-analyses concluded ORs have no explicit association
	maternal smoking after pregnancy (1)	two meta-analyses concluded ORs have no explicit association
	lifetime/overall paternal smoking (2)	two meta-analyses concluded 1.0<ORs<2.0
	paternal smoking during pregnancy (1)	two meta-analyses concluded ORs have no explicit association
	paternal smoking before pregnancy (2)	two meta-analyses concluded 1.0<ORs<2.0, one concluded OR has no explicit association
	paternal smoking after pregnancy (3)	one meta-analysis concluded 1.0<OR<2.0, three concluded ORs have no explicit association
	maternal solvent exposure during pregnancy (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal paint exposure during pregnancy (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal petroleum exposure during pregnancy (1)	one meta-analysis concluded 1.0<OR<2.0

Health outcome	Environmental exposure	Summary of association from literature review results
Myopia: myopia	outdoor light exposure (1)	one meta-analysis concluded OR<1.0
	screen time (1)	one meta-analysis suggests no explicit association
Nutritional disorder: malnutrition/ undernutrition (2)	drought (1)	one systematic review suggests positive association
	WASH: water and sanitation facilities (1)	one systematic review suggests positive association
Nutritional disorder: nutritional status (1)	WASH: water, sanitation and hygiene interventions (1)	weight-for-age z-score: mean difference: 0.05 (-0.01 to 0.12)
Nutritional disorder: stunting (7)	parental migration (1)	one meta-analysis concluded 1.0≤RR≤1.1
	WASH: water, sanitation and hygiene interventions (2)	one meta-analysis concluded 0.9≤RR≤1.0, SMD = 0.14 (0.09, 0.19) for mean height-for-age-z score
	WASH: water interventions (1)	one systematic review suggests positive association
	Poor quality cooking fuels / solid fuel use (1)	one systematic review suggests positive association
	IAP (1)	two meta-analyses concluded 1.0<ORs<2.0
	WASH: less community open defecation (1)	two meta-analyses concluded ORs<1.0
	WASH: dirt floors in the home (1)	one systematic review suggests positive association
	arsenic exposure (1)	one systematic review suggests no explicit association
	mercury exposure (1)	one systematic review suggests no explicit association
	environmental tobacco smoke (1)	one systematic review suggests no explicit association
Nutritional disorder: wasting (2)	parent migration (1)	one meta-analysis concluded 1.0≤RR≤1.1
	drought (1)	one meta-analysis concluded 1.0<OR<2.0
Nutritional disorder: underweight (2)	parental migration (1)	one meta-analysis concluded RR has no explicit association
	WASH: water, sanitation and hygiene interventions (1)	one meta-analysis concluded RR<1.0
Nutritional disorder: overweight (10)	unsafe neighborhood (1)	one meta-analysis concluded OR has no explicit association

Health outcome	Environmental exposure	Summary of association from literature review results
Nutritional disorder: overweight (10)	phthalates exposure (1)	one systematic review suggests negative association
	maternal smoking during pregnancy (6)	six meta-analyses concluded 1.0<ORs<2.0
	maternal SHS (1)	one meta-analysis concluded 1.0<OR<2.0
	paternal smoking (1)	one meta-analysis concluded 1.0<OR<2.0
	SHS (1)	one meta-analysis concluded 1.0<OR<2.0
	perfluorooctanoic acid exposure (1)	one meta-analysis concluded 1.0<OR<2.0
Nutritional disorder: obesity (14)	access to bike lanes (physical activity as outcome) (1)	one meta-analysis concluded 1.0<OR<2.0
	access to sidewalks (1)	one systematic review suggests conflicting evidence
	built and biophysical environment (1)	one systematic review suggests conflicting evidence
	screen time (1)	one meta-analysis concluded 1.0<OR<2.0
	street connectivity (1)	one systematic review suggests no explicit association
	hexaclorobenzene exposure (1)	one systematic review suggests positive association
	bisphenol A exposure (1)	one meta-analysis concluded 1.0<OR<2.0
	air pollution: nitrogen oxides exposure (1)	one systematic review suggests positive association
	traffic noise and proximity (1)	one systematic review suggests positive association
	SHS (postnatal) (2)	one meta-analysis concluded 1.0<OR<2.0, one concluded OR has no explicit association
	maternal SHS (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal smoking (2)	two meta-analyses concluded 1.0<ORs<2.0
	paternal smoking (1)	one meta-analysis concluded 1.0<OR<2.0
	SHS (1)	one meta-analysis concluded 1.0<OR<2.0
Nutritional disorder: obesity/ overweight (3)	screen time (2)	one meta-analysis concluded 1.0<OR<2.0, one systematic review suggests positive association

Health outcome	Environmental exposure	Summary of association from literature review results
Nutritional disorder: obesity/ overweight (3)	parental migration (1)	one meta-analysis concluded RR has no explicit association
Nutritional disorder: BMI/ BMI z-score (5)	phthalates exposure (2)	two pooled correlation coefficients: 0.12 (0.02–0.22), 0.08 (0.01–0.16) suggest positive association, one meta-analysis concluded OR has no explicit association
	pesticide exposure (DDT metabolite p,p'-DDE) (1)	β = 0.13 BMI z-score (95 percentage CI: 0.01, 0.25) per log increase of p,p'-DDE
	air pollution: nitrogen oxides exposure (1)	β : 0.05 (0.00-0.10)
	traffic flow (1)	β : 0.00 (0.00-0.01) (marginal correlation), one systematic review suggests positive association
	traffic noise (1)	one systematic review suggests positive association
	traffic pollution (1)	one systematic review suggests positive association
PERI/NEO disease: abortion	AAP (2)	one meta-analysis concluded 1.0<OR<2.0, one systematic review suggests no association
	IAP (1)	one systematic review suggests no agreement association
	phthalate (1)	one systematic review suggests no agreement association
	electronic waste (1)	one systematic review suggests positive association
	maternal electromagnetic field (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal SHS (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal anesthetic gases (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal arsenic (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal lithium (1)	one meta-analysis concluded 2.0<OR<4.0
	maternal medication: contraceptive (1)	one meta-analysis concluded 0.5<OR<1.0
	maternal medication: serotonin reuptake inhibitors (1)	one meta-analysis concluded 1.0<OR<2.0
PERI/NEO disease: abortion	maternal organic solvent (1)	one meta-analysis concluded 1.0<OR<2.0

Health outcome	Environmental exposure	Summary of association from literature review results
PERI/NEO disease: abortion	maternal smoke (1)	one systematic review suggests positive association
	maternal undefined chemicals (1)	one meta-analysis concluded 1.0<RR<1.1, one concluded 1.2<RR<1.4
PERI/NEO disease: BD: neural tube defects	AAP (1)	one systematic review suggests positive association
	SHS (1)	one meta-analysis concluded 1.0<OR<2.0
PERI/NEO disease: BD: anal atresia	maternal smoke (1)	one meta-analysis concluded 1.0<OR<2.0
PERI/NEO disease: BD: anencephalus	stagnant water (1)	one meta-analysis concluded 1.0<OR<2.0
PERI/NEO disease: BD: atrial septal defects	AAP: particulate (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal smoke (1)	one meta-analysis concluded 1.2<RR<1.4
	stagnant water (1)	one meta-analysis concluded 1.0<OR<2.0
PERI/NEO disease: BD: cerebral palsy	maternal magnesium (2)	two meta-analyses concluded 0.7<RRs<0.8
	traffic: noise (1)	one systematic review suggests no association
PERI/NEO disease: BD: cleft lip	maternal SHS (2)	two meta-analyses concluded 1.0<ORs<2.0, one concluded 2.0<OR<4.0
	maternal alcohol consumption (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal organic solvent (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal smoke (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal zinc (1)	one meta-analysis concluded 1.0<OR<2.0
	stagnant water (1)	one meta-analysis concluded 1.0<OR<2.0
PERI/NEO disease: BD: clubfoot	maternal smoke (1)	one meta-analysis concluded 1.0<OR<2.0
PERI/NEO disease: BD: congenital heart defect	AAP (6)	five meta-analyses concluded 1.0<ORs<2.0, one systematic review suggests positive association
	AAP: particulate (3)	one meta-analysis concluded 1.0<OR<2.0, one systematic review suggests no agreement association, one suggests positive association
	climate: temperature (2)	two meta-analyses concluded 1.0<ORs<2.0
	SHS (1)	one meta-analysis concluded 1.5<RR<2.9

Health outcome	Environmental exposure	Summary of association from literature review results
PERI/NEO disease: BD: congenital heart defect	dioxins (2)	two systematic reviews suggest no association
	maternal SHS (2)	one meta-analysis concluded 1.0<OR<2.0, one concluded 2.0<OR<4.0
	maternal alcohol consumption (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal lithium (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal organic solvent (1)	one meta-analysis concluded 1.0<OR<2.0
PERI/NEO disease: BD: congenital heart defect	maternal smoke (6)	three meta-analyses concluded 1.0<ORs<2.0, one concluded 1.2<RR<1.4, one concluded 1.5<RR<2.9, one concluded 2.0<OR<4.0
	maternal undefined chemicals (1)	one meta-analysis concluded 1.5<RR<2.9, one concluded 2.0<OR<4.0
	paternal alcohol consumption (3)	two meta-analyses concluded 1.0<ORs<2.0, one concluded 1.5<RR<2.9
	pesticide (1)	one meta-analysis concluded 4.0<OR<10.0
PERI/NEO disease: BD: craniosynostosis	maternal smoke (1)	one meta-analysis concluded 1.0<OR<2.0
PERI/NEO disease: BD: cryptorchidism	perfluoroalkyl and polyfluoroalkyl compounds (1)	one systematic review suggests no agreement association
PERI/NEO disease: BD: digestive malformation	maternal SHS (2)	two meta-analyses concluded 1.0<ORs<2.0
PERI/NEO disease: BD: eye defects	maternal smoke (1)	one meta-analysis concluded 1.0<OR<2.0
PERI/NEO disease: BD: face and neck defect	maternal SHS (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal smoke (1)	one meta-analysis concluded 1.0<OR<2.0
PERI/NEO disease: BD: gastrointestinal defects	maternal smoke (2)	two meta-analyses concluded 1.0<OR<2.0
PERI/NEO disease: BD: hernia	maternal smoke (1)	one meta-analysis concluded 1.0<OR<2.0
PERI/NEO disease: BD: hypospadias	perfluoroalkyl and polyfluoroalkyl compounds (1)	one systematic review suggests no agreement association
	maternal organic solvent (1)	one meta-analysis concluded 2.0<OR<4.0
	traffic: noise (1)	one meta-analysis concluded 1.2<RR<1.4

Health outcome	Environmental exposure	Summary of association from literature review results
PERI/NEO disease: BD: limb malformation	maternal smoke (1)	one meta-analysis concluded 1.0<OR<2.0
PERI/NEO disease: BD: musculoskeletal defect	maternal SHS (1)	one meta-analysis concluded 1.0<OR<2.0
PERI/NEO disease: BD: oral cleft	maternal smoke (1)	one meta-analysis concluded 1.0<OR<2.0
PERI/NEO disease: BD: orofacial cleft	dioxins (1)	one systematic review suggests no association
PERI/NEO disease: BD: other nervous system defect	maternal SHS (3)	three meta-analyses concluded 1.0<ORs<2.0
	maternal diet (1)	one meta-analysis concluded 1.0<RR<1.1
	maternal medication: citrate (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal organic solvent (1)	one meta-analysis concluded 1.0<OR<2.0
	water byproduct: trihalomethanes (1)	one meta-analysis concluded 1.0<OR<2.0
PERI/NEO disease: BD: undefined birth defect	AAP (2)	two systematic reviews suggest positive association
	AAP: particulate(1)	one systematic review suggests positive association
	persistent organic pollutants (1)	one systematic review suggests no association
	chemicals: mercury (1)	one meta-analysis concluded 1.5<RR<2.9
	dioxins (1)	one systematic review suggests no association
	maternal electromagnetic field (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal SHS (6)	four meta-analyses concluded 1.0<ORs<2.0, two systematic reviews suggest positive association
	maternal anesthetic gases (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal lithium (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal organic solvent (3)	two meta-analyses concluded 1.0<ORs<2.0, one systematic review suggests positive association
	maternal pesticide (1)	one systematic review suggests positive association

Health outcome	Environmental exposure	Summary of association from literature review results
PERI/NEO disease: BD: undefined birth defect	maternal smoke (1)	one systematic review suggests positive association
	maternal undefined chemicals (1)	one meta-analysis concluded 1.0<OR<2.0
	stagnant water (1)	one meta-analysis concluded 1.0<OR<2.0
	traffic: noise (1)	one meta-analysis concluded 1.5<RR<2.9, one systematic review suggests no association
	water byproduct: trihalomethanes (1)	one systematic review suggests positive association
PERI/NEO disease: BD: undescended testes	maternal smoke (1)	one meta-analysis concluded 1.0<OR<2.0
PERI/NEO disease: BD: urinary system defect	water byproduct: trihalomethanes (1)	one meta-analysis concluded 2.0<OR<4.0
PERI/NEO disease: birth asphyxia	IAP (1)	one meta-analysis concluded 0.5<OR<1.0
PERI/NEO disease: neonatal death	AAP (1)	one systematic review suggests positive association
	AAP: particulate (2)	two meta-analyses concluded 1.0<ORs<2.0
	IAP (1)	one meta-analysis concluded 0.7<RR<0.8
	maternal SHS (1)	one meta-analysis concluded 1.2<RR<1.4
	maternal lithium (1)	one meta-analysis concluded 1.0<OR<2.0
	stagnant water (1)	one meta-analysis concluded 0.4<RR<0.6
PERI/NEO disease: perinatal death	maternal SHS (2)	one meta-analysis concluded 1.0<OR<2.0, one concluded 1.2<RR<1.4
	maternal magnesium (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal undefined chemicals (1)	one meta-analysis concluded 1.0<OR<2.0
	microbe: RSV (1)	one systematic review suggests no association
PERI/NEO disease: sudden infant death syndrome	fungi (1)	one systematic review suggests positive association
	maternal SHS (1)	one systematic review suggests positive association
	maternal smoke (1)	one systematic review suggests no association

Health outcome	Environmental exposure	Summary of association from literature review results
PERI/NEO disease: birth weight	AAP (1)	one systematic review suggests positive association
	climate: temperature (1)	one systematic review suggests no association
	EDCs (1)	one systematic review suggests no agreement association
	PCBs (3)	three systematic reviews suggest positive association
	persistent organic pollutants (1)	one systematic review suggests no association
	maternal SHS (1)	one systematic review suggests positive association
PERI/NEO disease: large for gestational age	AAP (1)	one systematic review suggests positive association
	persistent organic pollutants (2)	two systematic reviews suggest positive association
	dioxins (1)	one systematic review suggests no association
	maternal diet (1)	one meta-analysis concluded 1.0<OR<2.0
	paternal alcohol consumption (1)	one systematic review suggests no association
	water byproduct: trihalomethanes (1)	one systematic review suggests no association
PERI/NEO disease: low birth weight	AAP (16)	one meta-analysis concluded 0.5<OR<1.0, nine concluded 1.0<ORs<2.0, one systematic review suggests no association, five suggest positive association
	AAP: particulate (16)	thirteen meta-analyses concluded 1.0<ORs<2.0, one systematic review suggests no agreement association, two suggest no association
	allergen (2)	one meta-analysis concluded 1.2<RR<1.4, one concluded 3.0<RR<10.0
	allergen: cat (1)	one meta-analysis concluded 1.0<OR<2.0
	climate: temperature (1)	one systematic review suggests no association
	EDCs (3)	two meta-analyses concluded 1.0<ORs<2.0, one systematic review suggests no association

Health outcome	Environmental exposure	Summary of association from literature review results
PERI/NEO disease: low birth weight	HAP: solid fuel (1)	one systematic review suggests positive association
	IAP (4)	one meta-analysis concluded 0.5<OR<1.0, three concluded 1.0<ORs<2.0
	maternal diets (2)	one systematic review suggests no agreement association, one systematic review suggests negative association
	PCBs (1)	one systematic review suggests no association
	chemicals: mercury (1)	one meta-analysis concluded 3.0<RR<10.0
	electronic waste (1)	one systematic review suggests positive association
	fungi (1)	one systematic review suggests positive association
	maternal electromagnetic field (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal SHS (8)	five meta-analyses concluded 1.0<ORs<2.0, one systematic review suggests no agreement association, one systematic review suggests no association, one systematic review suggests positive association
	maternal diets (4)	two meta-analyses concluded 0.5<ORs<1.0, one concluded 1.0<OR<2.0, one concluded 1.2<RR<1.4
	maternal drink (4)	two meta-analyses concluded 1.0<ORs<2.0, two concluded 1.2<RRs<1.4
	maternal iron (3)	one meta-analysis concluded 1.0<OR<2.0, one systematic review suggests no agreement association, one suggests negative association
	maternal medication: contraceptive (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal medication: corticosteroid (1)	one meta-analysis concluded 1.5<RR<2.9
	maternal smoke (6)	three meta-analyses concluded 1.0<ORs<2.0, one systematic review suggests no association, two suggest positive association
	maternal undefined chemicals (1)	one meta-analysis concluded 1.5<RR<2.9
	residence: greenness (1)	one meta-analysis concluded 0.5<OR<1.0
	traffic: noise (5)	three systematic reviews suggest no association, two suggest positive association

Health outcome	Environmental exposure	Summary of association from literature review results
	water byproduct: trihalomethanes (2)	one meta-analysis concluded 1.0<OR<2.0, one systematic review suggests no association
PERI/NEO disease: preterm	AAP (18)	three meta-analyses concluded 0.5<ORs<1.0, five concluded 1.0<ORs<2.0, one concluded 1.2<RR<1.4, three systematic reviews suggest no agreement association, two suggest no association, four suggest positive association
	AAP: particulate (18)	eleven meta-analyses concluded 1.0<ORs<2.0, one concluded 1.0<RR<1.1, one concluded 4.0<OR<10.0, three systematic reviews suggest no agreement association, two suggest positive association
	allergen (1)	one meta-analysis concluded 1.5<RR<2.9
	allergen: cat (1)	one systematic review suggests negative association
	climate: season (1)	one meta-analysis concluded 1.0<OR<2.0
	climate: temperature (2)	two systematic reviews suggest no association
	EDCs (2)	one systematic review suggests no agreement association, one systematic review suggests no association
	HAP: solid fuel (1)	one systematic review suggests positive association
	maternal diets (1)	one systematic review suggests no agreement association
	Magnesium sulfate heptahydrate (1)	one systematic review suggests no association
	persistent organic pollutants (1)	one systematic review suggests no agreement association
	phthalate (1)	one systematic review suggests no agreement association
	selenium (1)	one systematic review suggests negative association
	electronic waste (1)	one systematic review suggests positive association
	maternal electromagnetic field (3)	three meta-analyses concluded 1.0<ORs<2.0
	maternal SHS (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal diets (2)	one meta-analysis concluded 3.0<RR<10.0, one concluded RR>10.0

Health outcome	Environmental exposure	Summary of association from literature review results
PERI/NEO disease: preterm	maternal iron (2)	one meta-analysis concluded 1.0<OR<2.0, one systematic review suggests positive association
	maternal magnesium (2)	one meta-analysis concluded 0.4<RR<0.6, one concluded 0.7<RR<0.8
	maternal medication: contraceptive (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal medication: corticosteroid (2)	one meta-analysis concluded 1.5<RR<2.9, one systematic review suggests positive association
	maternal smoke (4)	one meta-analysis concluded 1.0<OR<2.0, one systematic review suggests no association, two suggest positive association
	maternal undefined chemicals (1)	one meta-analysis concluded 1.0<OR<2.0
	traffic: noise (5)	one meta-analysis concluded 1.0<OR<2.0, three systematic reviews suggest no association, one suggests positive association
	water byproduct: trihalomethanes (2)	one meta-analysis concluded 0.5<OR<1.0, one systematic review suggests no association
Respiratory disease: coughing	AAP: particulate (1)	one meta-analysis concluded 1.0<OR<2.0
	IAP (2)	two meta-analyses concluded 1.0<ORs<2.0
	maternal SHS (1)	one systematic review suggests positive association
Respiratory disease: lower respiratory tract infections	AAP (1)	one systematic review suggests positive association
	maternal zinc (1)	one systematic review suggests no agreement association
	microbe: RSV (1)	one systematic review suggests positive association
Respiratory disease: pneumonia	AAP (5)	four meta-analyses concluded ORs<0.5, one systematic review suggests no agreement association
	AAP: particulate (3)	one meta-analysis concluded 1.0<OR<2.0, two concluded ORs<0.5
	IAP (3)	one meta-analysis concluded 0.9<RR<1.0, one concluded 1.0<OR<2.0, one concluded 2.0<OR<4.0
	microbe: RSV (1)	one systematic review suggests positive association

Health outcome	Environmental exposure	Summary of association from literature review results
Respiratory disease: respiratory infections	AAP (2)	two meta-analyses concluded OR<0.5
	AAP: particulate (2)	two meta-analyses concluded OR<0.5
	climate: season (1)	one systematic review suggests no association
	SHS (3)	two meta-analyses concluded 1.0<ORs<2.0, one concluded 2.0<OR<4.0
	maternal SHS (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal smoke (4)	four meta-analyses concluded 1.0<ORs<2.0
	microbe: RSV (2)	one meta-analysis concluded 4.0<OR<10.0, one systematic review suggests no agreement association
	paternal smoking (1)	one systematic review suggests positive association
Respiratory disease: respiratory syncytial virus disease	SHS (1)	one systematic review suggests positive association
Respiratory disease: seasonal influenza	maternal SHS (1)	one systematic review suggests no agreement association
Respiratory disease: sinusitis	maternal SHS (1)	one systematic review suggests positive association
Respiratory disease: tuberculosis	SHS (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal SHS (1)	one systematic review suggests no association
Traffic accident: pedestrian injury	built roadway characteristics (2)	one meta-analysis concluded 1<OR<2, one systematic review suggests positive association
	traffic calming (1)	one systematic review suggests positive association
	presence of playgrounds/ recreation areas (1)	one systematic review suggests positive association
PERI/NEO disease: small for gestational age	AAP (3)	two meta-analyses concluded 1.0<ORs<2.0, one systematic review suggests positive association

Health outcome	Environmental exposure	Summary of association from literature review results
PERI/NEO disease: small for gestational age	AAP: particulate (5)	three meta-analyses concluded 1.0<ORs<2.0, two systematic reviews suggest no agreement association
	allergen (1)	one meta-analysis concluded 1.2<RR<1.4
	maternal diets (2)	one systematic review suggests no agreement association, one suggests negative association
	dioxins (1)	one systematic review suggests no association
	maternal electromagnetic field (2)	two meta-analyses concluded 1.0<ORs<2.0
	maternal SHS (5)	three meta-analyses concluded 1.0<ORs<2.0, one concluded 2.0<OR<4.0, one systematic review suggests positive association
	maternal TRP (2)	two meta-analyses concluded 1.0<ORs<2.0
	maternal diet (3)	two meta-analyses concluded 0.5<ORs<1.0, one concluded 2.0<OR<4.0
	maternal iron (1)	one systematic review suggests negative association
	maternal smoke (3)	one meta-analysis concluded 1.0<OR<2.0, one concluded 2.0<OR<4.0, one systematic review suggests no association
	residence: greenness (1)	one meta-analysis concluded 0.5<OR<1.0
	traffic: noise (4)	one meta-analysis concluded 1.0<OR<2.0, one concluded 1.2<RR<1.4, one systematic review suggests no association, one suggests positive association
	water byproduct: trihalomethanes (4)	two meta-analyses concluded 1.0<ORs<2.0, one systematic review suggests no association, one suggests positive association
PERI/NEO disease: stillbirth	AAP (1)	one systematic review suggests positive association
	AAP: particulate (1)	one meta-analysis concluded 1.0<OR<2.0
	climate: temperature (1)	one systematic review suggests no association
	HAP: solid fuel (1)	one systematic review suggests positive association
	IAP (4)	three meta-analyses concluded 1.0<ORs<2.0, one systematic review suggests no agreement association

Health outcome	Environmental exposure	Summary of association from literature review results
PERI/NEO disease: stillbirth	chemicals: mercury (1)	one meta-analysis concluded 1.5<RR<2.9
	dioxins (1)	one systematic review suggests no association
	electronic waste (1)	one systematic review suggests positive association
	maternal SHS (5)	three meta-analyses concluded 1.0<ORs<2.0, one concluded 1.5<RR<2.9, one systematic review suggests positive association
	maternal pesticide (1)	one meta-analysis concluded 1.5<RR<2.9
	maternal smoke (1)	one systematic review suggests no association
	water byproduct: trihalomethanes (1)	one systematic review suggests positive association
Respiratory disease: acute lower respiratory infections	AAP (1)	one systematic review suggests positive association
	IAP (4)	one meta-analysis concluded 1.0<RR<1.1, two concluded 1.0<ORs<2.0, one concluded 2.0<OR<4.0
	maternal SHS (1)	one meta-analysis concluded 1.0<OR<2.0
	maternal arsenic (1)	one systematic review suggests no agreement association
	maternal zinc (1)	one meta-analysis concluded 0.5<OR<1.0
	microbe: RSV (4)	one meta-analysis concluded 1.0<OR<2.0, one systematic review suggests no association, two suggest positive association
Respiratory disease: irreversible airway obstruction	maternal smoke (1)	one meta-analysis concluded 1.0<OR<2.0
Respiratory disease: viral respiratory infections	climate change (1)	one systematic review suggests no agreement association
Respiratory disease: pneumonia	poultry (1)	one systematic review suggests positive association

* The review that identifies the given relationship did not specifically review studies with children as the study population.

Annex H: Literature Review Results for Each Indicator Candidates

ID	Measure	Proposed indicator	Literature review results – from strongest to weakest association with environmental factors
18	Ambient air pollution exposure	Annual mean concentration of ambient $PM_{2.5}$	Abundant strong evidence suggests an association between environmental exposures and children's health or the specific health outcome
20	concentration of PM2.5 Annual mean concentration of PM2.5	Number of children under 18 years of age living in households in which at least one adult smokes on a regular basis	
62	Smoking environment	Number of children aged 0-17 years living in households in which at least one adult smokes on a regular basis	
79	Chronic respiratory illness	Prevalence of asthma among children aged 0-17 years	
87	Children's cancer	Prevalence of leukemia among children aged 0-17 years	
31	Diarrhea	Incidence of diarrhea among children aged 0-4 years	
9	Congenital malformations	Incidence of congenital malformations in children under 1 year of age	Abundant medium-to-strong evidence suggests an association between environmental exposures and children's health or the specific health outcome
110	Preterm birth	Incidence of preterm birth	
13	Low birth weight	Incidence of low birth weight (<2,500 grams)	
27	Water	Percentage of drinking water supplies failing national water quality standards	Abundant medium-strength evidence suggests an association between WASH and children's health
85	Hygiene	Percentage of population with basic handwashing facility	

ID	Measure	Proposed indicator	Literature review results – from strongest to weakest association with environmental factors
109	Sanitation	Percentage of schools with safely managed toilet	Abundant medium-strength evidence suggests an association between WASH and children's health
84	Sanitation	Percentage of population using safely managed toilet	
108	Hygiene	Percentage of schools with handwashing facility	
29	Water	Number of people living in households with piped water	
107	Water	Percentage of schools with piped water	
7	Perinatal mortality rate	Number of perinatal deaths per 1,000 births	Medium-strength evidence suggests an association between environmental exposures and children's health or the specific health outcome
19	Indoor air pollution exposure	Percentage of children aged 0-17 years living in households where solid fuels are used for cooking and heating	
80	Pesticide exposure	Percentage of soil failing national organochlorine pesticide standard	
22	Acute respiratory illness	Incidence of acute respiratory disease among children aged 0-4 years	
41	Prevalence of insect-borne diseases	Incidence of dengue fever among children aged 0-17 years	

ID	Measure	Proposed indicator	Literature review results – from strongest to weakest association with environmental factors
89	Noise	Percentage of cities failing national noise standard	Medium-to-weak evidence suggests an association between environmental exposures and children's health or the specific health outcome
12	Malnutrition	Prevalence (percentage) of stunting (<-2 SDs HAZ score) in children aged 0-4 years	
81	Overnutrition	Percentage of children aged 0-17 years who are overweight	
49	Heat wave	Number of days having heat wave	Weak evidence suggests an association between environmental exposures and children's health or the specific health outcome
98	Extreme weather event	Number of people affected by disasters	
83	Cold wave	Number of days having cold wave	
102	Mental illness	Prevalence of anxiety among children aged 0-17 years	
57	Flooding vulnerability	Number of floods	Weak evidence suggests an association between environmental exposures and children's health or the specific health outcome
103	Prevalence of insect-borne diseases	Incidence of encephalitis B among children aged 0-17 years	
82	Road traffic injury	Incidence of road traffic injury among children aged 0-17 years	Weak evidence of its association with environmental exposures
46	Drowning	Incidence of drowning among children aged 0-17 years	
76	Children aged 0-14 years excessively using electronic devices	Percentage of children aged 0-4 years excessively using electronic devices (aged 0-1 years: more than 0 hours; aged 2-4 years: more than 1 hour/day)	A few evidence suggests no association with children's health

ID	Measure	Proposed indicator	Literature review results – from strongest to weakest association with environmental factors
97	Safe products for children	Percentage of children's products failing national standards	No systematic review found
68	Exposure to contaminated water	Percentage of lakes and rivers whose water quality index is below national standard level III	
86	Soil contamination	Percentage of soil failing national heavy metal standard (mercury, cadmium, lead, chromium, copper, nickel, zinc, arsenic)	
106	Food safety	Percentage of infants' and young children's food products failing national food safety standards	
105	Hazardous school building	Percentage of schools evaluated as dilapidated buildings	
34	Food safety	Percentage of food products failing national food safety standards	
39	Children living in areas of endemic insect-borne diseases	Number of children aged 0-17 years living in areas of endemic insect-borne diseases	
104	Children living in areas of endemic insect-borne diseases	Mosquito density	
8	Intrauterine growth restriction in newborn children	Percentage of babies born before 37 weeks completed gestation	

Annex I: Indicators That Were Ranked and Prioritized in the Final Exercise

ID	Measure	Indicator	Domain	Recommendation
1	Ambient air pollution exposure	Annual mean concentration of ambient $PM_{2.5}$	Environmental exposure	Core
2	Indoor air pollution exposure	Percentage of children aged 0-17 years living in households where solid fuels are used for cooking and heating	Environmental exposure	Core
3	Industrial waste gas emission	Volume of industrial waste gas emission	Environmental exposure	Core
4	Smoking environment	Number of children aged 0-17 years living in households in which at least one adult smokes on a regular basis	Environmental exposure	Core
5	Pesticide exposure	Percentage of soil failing national organochlorine pesticide standard	Environmental exposure	Core
6	Soil contamination	Percentage of soil failing national heavy metal standard (mercury, cadmium, lead, chromium, copper, nickel, zinc, arsenic)	Environmental exposure	Core
7	Water	Percentage of drinking water supplies failing national water quality standards	Environmental exposure	Core
8	Extreme weather event	Number of children aged 0-17 years affected by disasters	Environmental exposure	Core
9	Exposure to contaminated water	Percentage of lakes and rivers whose water quality index is below national standard level III	Environmental exposure	Core
10	Safe products for children	Percentage of children's products failing national standards	Environmental exposure	Core
11	Blood Lead	Average blood lead level among children aged 0-17 years	Environmental exposure	Core
12	Chronic respiratory illness	Prevalence of asthma among children aged 0-17 years	Health outcome	Core
13	Acute respiratory illness	Incidence of acute respiratory disease among children aged 0-4 years	Health outcome	Core
14	Diarrhea	Incidence of diarrhea among children aged 0-4 years	Health outcome	Core

ID	Measure	Indicator	Domain	Recommendation
15	Congenital malformations	Incidence of congenital malformations in children under 1 year of age	Health outcome	Core
16	Preterm birth	Incidence of preterm birth	Health outcome	Core
17	Children's cancer	Prevalence of leukemia among children aged 0-17 years	Health outcome	Core
18	Road traffic injury	Incidence of road traffic injury among children aged 0-17 years	Health outcome	Core
19	Prevalence of insect-borne diseases	Incidence of dengue fever among children aged 0-17 years	Health outcome	Core
20	Governments' environmental health plans	Percentage of local governments that have implemented an environmental health plan that reduces the risks of disasters and climate change	Action	Core
21	Industrial pollution	Percentage of "key pollutant discharge units" that monitor and report their pollution status	Action	Core
22	Government spending on environmental health	Annual government budget spent on environmental health	Action	Core
23	Hygiene city/village	Percentage of cities/villages designated "national hygiene city/village"	Action	Core
24	Children's poverty	Percentage of households falling under 50% of the median household income in that province	Context	Core
25	Maternal malnutrition	Percentage of women of childbearing age (15-49 years) who are malnourished (BMI <18.5)	Context	Core
26	Children's education	Percentage of children aged 12-14 years who completed primary school	Context	Core
27	Maternal education	Percentage of women aged 18-49 years who completed tertiary education	Context	Core
28	Migrant/left-behind children	Percentage of children aged 0-17 years who are migrant or left behind	Context	Core

ID	Measure	Indicator	Domain	Recommendation
29	Hygiene	Percentage of population with basic handwashing facility	Environmental exposure	Keep
30	Sanitation	Percentage of schools with safely managed toilet	Environmental exposure	Keep
31	Sanitation	Percentage of population using safely managed toilet	Environmental exposure	Keep
32	Food safety	Percentage of infants' and young children's food products failing national food safety standards	Environmental exposure	Keep
33	Hygiene	Percentage of schools with handwashing facility	Environmental exposure	Keep
34	Hazardous school building	Percentage of schools evaluated as dilapidated buildings	Environmental exposure	Keep
35	Noise	Percentage of cities failing national noise standard	Environmental exposure	Keep
36	Food safety	Percentage of food products failing national food safety standards	Environmental exposure	Keep
37	Flooding vulnerability	Number of flooding events	Environmental exposure	Keep
38	Children living in areas of endemic insect-borne diseases	Number of children aged 0-17 years living in areas of endemic insect-borne diseases	Environmental exposure	Keep
39	Heat wave	Number of days of heat wave	Environmental exposure	Keep
40	Perinatal mortality rate	Number of perinatal deaths per 1,000 births	Health outcome	Keep
41	Low birth weight	Incidence of low birth weight (<2,500 grams)	Health outcome	Keep
42	Drowning	Incidence of drowning among children aged 0-17 years	Health outcome	Keep
43	Mental illness	Prevalence of anxiety among children 0-17 years	Health outcome	Keep
44	Malnutrition	Percentage of stunting (<-2 SDs HAZ score) in children aged 0-4 years	Health outcome	Keep

ID	Measure	Indicator	Domain	Recommendation
45	Overweight	Percentage of children aged 0-17 years who are overweight (as defined by China CDC)	Health outcome	Keep
46	Climate change risk assessments	Percentage of local governments that conduct regular climate change risk assessments including actions to address the needs of children	Action	Keep
47	Environmental health literacy	Percentage of people who pass the national government's environmental health literacy test	Action	Keep
48	Garbage management	Percentage of rural villages implementing a waste management system	Action	Remove
49	Smoking environment	Percentage of children aged 0-17 years smoking	Exposure	Remove
50	Children aged 0-4 years excessively using electronic devices	Percentage of children aged 0-4 years excessively using electronic devices (aged 0-1 years: more than 0 hours; aged 2-4 years: more than 1 hour/day)	Exposure	Remove
51	Water	Number of people living in households with piped water	Exposure	Remove
52	Children living in areas of endemic insect-borne diseases	Mosquito density	Exposure	Remove
53	Cold wave	Number of days having cold wave	Exposure	Remove
54	Intrauterine growth restriction in newborn children	Percentage of babies born before 37 weeks completed gestation	Health outcome	Remove
55	Prevalence of insect-borne diseases	Incidence of encephalitis B among children aged 0-17 years	Health outcome	Remove
56	Chronic respiratory illness	Prevalence of chronic respiratory illness in children aged 0-17 years	Health outcome	Remove
57	Prevalence of insect-borne diseases	Incidence of dengue fever among children aged 0-17 years	Health outcome	Remove

Annex J: Final Exercise to Prioritize Indicators

We conducted a final prioritization exercise to systematically rank the 57 remaining indicators as core and secondary, as well as sieve out indicators that did not belong on the priority list because of perceived overlap or low scores. We recommend that our counterparts in government collect data on all recommended indicators when they have the capacity; but when resources are limited, core indicators are the ones that should be prioritized for data collection and monitoring.
The reviewers for the final prioritization exercise were:

- Douglas Noble, Deputy Representative, UNICEF, China
- Seonmi Choi, Regional Advisor for Climate and Environment, UNICEF, East Asia and Pacific Regional Office
- Anuradha Narayan, Chief of Health, Nutrition, and WASH, UNICEF, China
- Hui Sun, WASH Officer, UNICEF, China
- Qiang Wang, Division Director, National Institute of Environmental Health, Chinese Center for Disease Control and Prevention
- Jiansheng Wang, Division Director, Policy Research Center for Environment and Economy, Ministry of Ecology and Environment
- Dan Kass, Senior Vice President, Environmental Health, Vital Strategies
- Russell Dowling, Technical Advisor, Environmental Health, Vital Strategies
- Yue Zhang, Consultant, Environmental Health, Vital Strategies

We asked reviewers to score the indicator criteria from 1 to 4 based on their personal knowledge as well as additional information we provided for each indicator, such as results from the systematic literature review, disease burden and prevalence of the exposure.[d]

The two tables below list the criteria and additional information that we provided to reviewers for the health outcome and environmental exposure indicators.

For action indicators, there were no criteria. Instead, we asked reviewers to score from 1 to 4 indicating how useful they think the given indicator is in tracking local efforts to promote children's environmental health in China. For context indicators, we did not seek scoring but welcomed suggestions from reviewers.

[d] The final recommended list of core and secondary indicators is offered within the confines of this project. It is not a definitive list by any means and remains open for scrutiny and improvement. We fully acknowledge that this list is subjective and dependent on the combined opinions and knowledge of the reviewers who are all affiliated with the project's primary stakeholders—the National Institute of Environmental Health at the Chinese Center for Disease Control and Prevention, the Policy Research Center for Environment and Economy at the Ministry of Ecology and Environment, UNICEF and Vital Strategies.

Four criteria for HEALTH OUTCOME indicators	
Criterion	**Additional information for reviewer**
Literature review 1: Little 2: Low 3: Medium 4: High	The working group has done a systematic literature review of 7,527 systematic reviews and meta-analyses that examine the association between any environmental exposures and the most burdensome diseases for Chinese children. We will provide a narrative that summarizes our findings from the systematic literature review about a given health outcome—this will be a summary describing the amount and strength of evidence that shows any environmental factors' influence on the given health outcome. In addition to the narrative, we will also provide an appendix of the full literature review results table, which summarizes all associations we identified. Reviewers can refer to the appendix for more information if they feel the narrative does not give sufficient information. Reviewers should score from 1 to 4 indicating how confident they are about the association between environmental exposures and the given health outcome.
Environmental contribution 1: Little 2: Low 3: Medium 4: High	Reviewers should score from 1 to 4 based on their perception of the extent to which the environmental factors contribute to the given health outcome among the many other factors that cause it.
Burden of disease 1: Little 2: Low 3: Medium 4: High	We will provide the ranking of the given health outcome's burden of disease (measured in disability-adjusted life years) in Chinese children. There are some diseases for which we don't have information about disease burden, in which case reviewers will need to score based on their own knowledge and experience. Reviewers should score from 1 to 4 how burdensome they think the disease is for Chinese children.
Ability to attract attention 1: Little 2: Low 3: Medium 4: High	Reviewers should score from 1 to 4 based on how interested they think Chinese policymakers, citizens, public and private enterprises, and multilateral organizations will be in the given health outcome. Reviewers currently residing outside of China should score based on their knowledge of the global context, and the working group will discount the weight of their scores by 50%.

Four criteria for ENVIRONMENTAL EXPOSURE indicators	
Criterion	**Additional information for reviewer**
Literature review 1: Little 2: Low 3: Medium 4: High	The working group has done a systematic literature review of 7,527 systematic reviews and meta-analyses that examine the association between any environmental exposures and the most burdensome diseases for Chinese children. We will provide a narrative that summarizes our findings from the systematic literature review about a given environmental exposure—this will be a summary describing the amount and strength of evidence that shows the given environmental exposure's influence on any children's health outcomes. In addition to the narrative, we will also provide an appendix of the full literature review results table, which summarizes all associations we identified. Reviewers can refer to the appendix for more information if they feel the narrative does not give sufficient information. Reviewers should score from 1 to 4 indicating how confident they are about the association between the given environmental exposure and children's health outcomes.
Prevalence in China 1: Little 2: Low 3: Medium 4: High	Reviewers should score from 1 to 4 based on the prevalence of the environmental exposure in China. We will provide as much information as we can find on the prevalence of the given exposure in China. For exposures without prevalence data provided upfront, please score based on their perceived effect. If you have limited knowledge about the China context, feel free to indicate "not applicable" or "N/A."
Precautionary principle 1: Little 2: Low 3: Medium 4: High	In an environmental context, the precautionary principle can be defined as: "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically."* The precautionary principle enables decision-makers to adopt precautionary measures when scientific evidence about an environmental or human health hazard is uncertain and the stakes are high. For example, warming and more extreme weather have clearly begun to alter marine life and affect infectious disease vectors and hosts. Even though uncertainty exists about how these weather changes affect human health, the unprecedented scale of this hazard justifies reexamination of environmental monitoring systems and paradigms. Reviewers should score from 1 to 4 based on how much they think this exposure has the potential to lead to serious health issues if the current prevalence continues to increase. This is despite the fact that we now have little or no certain population-level evidence linking the exposure to health outcomes.

Four criteria for ENVIRONMENTAL EXPOSURE indicators	
Criterion	**Additional information for reviewer**
Ability to attract attention 1: Little 2: Low 3: Medium 4: High	Reviewers should score from 1 to 4 based on how interested they think Chinese policymakers, citizens, public and private enterprises, and multilateral organizations will be in the given environmental exposure. Reviewers currently residing outside of China should score based on their knowledge of the global context, and the working group will discount the weight of their scores by 50%.

[*] Dembe, Allard E., 'Protecting Public Health and the Environment: Implementing the Precautionary Principle', Journal of Public Health Policy, Vol. 22, 2001, pp. 236-238.

Report

PRIORITIZING CHILDREN: Environmental Health Indicators for China