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REACH Framework

Applying Behavioural Science to Address Environmental Health Threats Affecting Children

Acknowledgements

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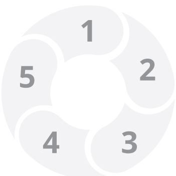

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Healthy Environments for Healthy Children

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Acronyms and abbreviations

AJPH	American Journal of Public Health
CCT	Cultural Cognition Theory
COM-B	capability, opportunity, motivation – behaviour model
ECO	ecological-social model
EPA	Environmental Protection Agency
HBM	health belief model
HEPA	high-efficiency particulate air
HAP	heat action plan
HAPIN	Household Air Pollution Intervention Network
IAP	indoor air pollution
LPG	liquefied petroleum gas
NO_2	nitrogen dioxide
ORS	oral rehydration solution
$PM_{2.5}$	particulate matter ≤2.5 micrometres
PMT	protection motivation theory
PMUY	Pradhan Mantri Ujjwala Yojana (India LPG Programme)
PPE	personal protective equipment
SBC	social and behaviour change
SMS	short message service
TSCA	Toxic Substances Control Act
UNICEF	United Nations Children’s Fund
WHO	World Health Organization
XRF	X-ray fluorescence

Executive summary

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Environmental health threats are exposures and conditions where children live, learn and play that increase the risk of disease, injury or impaired development. They include air pollution from household cooking fuels, traffic, industry and waste-burning; lead and other toxic substances in food, water, soil and consumer products; extreme heat and climate-driven hazards such as floods and wildfires; and chemical contaminants from pesticides, industrial processes and informal recycling.

Children face disproportionate risk because they have a higher metabolic rate than adults and eat more than adults relative to body weight, some of their detoxification systems may be immature, and their bodies and brains are undergoing rapid development when environmental exposures can cause irreversible damage. Nearly 92 per cent of pollution-related child deaths occur in low- and middle-income countries, and the populations most heavily exposed are often those with the fewest resources to respond.

Despite their diversity, these threats share key characteristics:

- imperceptibility
- delayed effects (months or years)
- indirect causal pathways
- perceived lack of individual control
- competition with immediate daily pressures

These factors make them systematically difficult to respond to from a behavioural perspective.

Protective responses fall into two categories:

- **monitoring** (detecting and tracking threats through environmental measurement, biological testing, and symptom recognition)
- **protective action** (reducing contact with hazards through avoidance behaviours, physical barriers and, ideally, through regulatory interventions).

These are components of a feedback system rather than independent activities: monitoring generates the information that guides protective action, and the outcomes of protective action can be assessed through ongoing monitoring.

When exposure occurs, health-seeking behaviours become necessary. Because many environmental health harms are irreversible once they occur, upstream action to reduce exposure takes precedence.

A persistent gap exists between the availability of protective behaviours and their successful, sustained adoption. Regulations exist to reduce lead exposure, but enforcement is inconsistent and industries continue to pollute. Programmes subsidize clean cookstoves, but some families prefer traditional methods for culturally valued dishes.[1,2] Workers understand the risks of heat exposure but cannot prioritize rest breaks when income depends on continuous labour. This guide provides a structured approach to diagnosing the behavioural and structural barriers that produce these gaps, and to designing interventions that address them. It draws examples from across environmental health challenges, including air pollution, lead contamination, extreme heat, pesticide exposure and water contamination.

The approach is organized around the REACH Framework:

Recognize addresses the detection, understanding and interpretation of invisible threats through sensory enhancement, causal understanding and risk calibration.

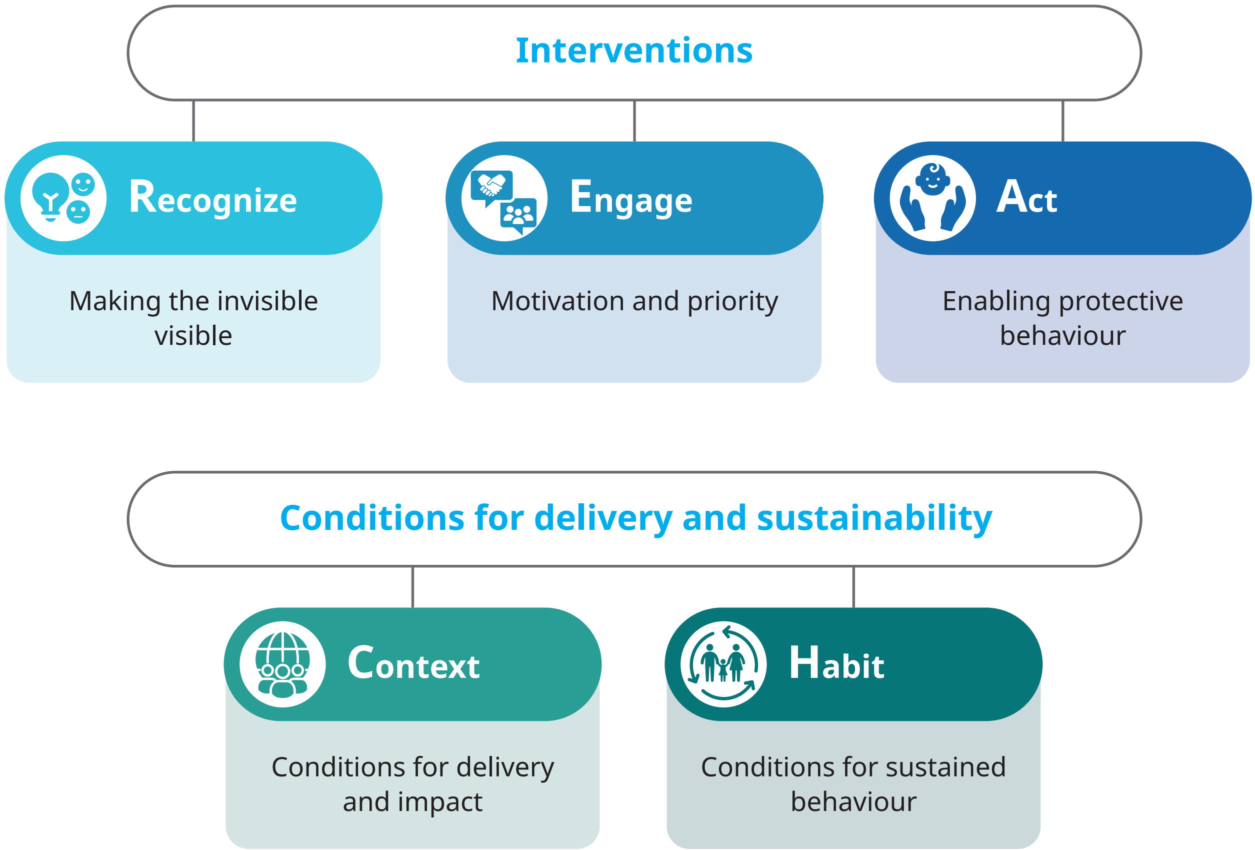
Engage creates personal relevance and emotional connection for environmental health protection through competing daily priorities using personalization, value-aligned framing and social influence.

Act enables consistent protective behaviour through capability-building, confidence and collective efficacy.

Context addresses the structural and contextual conditions that determine intervention effectiveness.

Habit ensures protective behaviour persists through routines, cues and environmental design that sustain automatic responses.

Figure 1 The REACH Framework



The guide concludes with a three-phase application process:

1. understanding the situation through a diagnostic assessment of each REACH component
2. deciding where to focus, based on the severity of barriers and the leverage available
3. designing an integrated intervention that sequences individual-facing and structural approaches.

A worked example (lead contamination near a battery recycling site) illustrates the process throughout. The framework does not prescribe a fixed sequence. The entry point and emphasis depend on the specific pattern of barriers in each context, and the guide is designed to support that judgment rather than replace it.

1. The challenge

1.1 Environmental health threats as a crisis for children

Environmental health threats are exposures and conditions in the environments where children live, learn and play that increase the risk of disease, injury or impaired development. They range from pollutants circulating invisibly through air, water, soil, food and consumer products, to climate-driven hazards such as extreme heat, floods and wildfires. These threats are not evenly distributed: nearly 92 per cent of pollution-related child deaths occur in low- and middle-income countries, and the populations most heavily exposed are often those with the fewest resources to respond.

The Children's Environmental Health Collaborative provides comprehensive information on the full landscape of risks. The categories below establish the scope and character of the threats addressed in this guide and the behavioural challenges they pose.

Pollution

Air pollution is the single greatest environmental health threat to children. Two thousand children aged under five years die each day from air pollution-related health impacts, accounting for 15 per cent of all global child deaths.[3] Sources include polluting household cooking fuels, traffic and industrial emissions, waste-burning (including plastics), and wildfires and dust storms. Fine particulate matter penetrates deep into developing lungs and crosses into the bloodstream, with exposure during pregnancy linked to preterm birth and stillbirth, and early childhood exposure linked to lasting cognitive, behavioural and social impairments.

Lead, toxic substances and chemical contaminants represent a second major pollution pathway. Around one in three children globally has blood lead levels high enough to cause harm,[4] with exposure entering through contaminated food, spices, cosmetics, cookware and poorly regulated waste and recycling operations, including informal battery or e-waste processing near residential areas. Lead is one of a broader set of hazards, including mercury, arsenic, pesticides and industrial chemicals, whose effects are cumulative, often invisible, and may only become apparent years after exposure. Housing conditions such as deteriorating lead paint, inadequate sanitation and proximity to industrial sites further shape children's baseline exposure.

Climate change

Climate change is intensifying hazards that directly threaten children's health. Extreme heat is an escalating risk: young children generate more internal heat relative to body mass, and depend on caregivers to manage their exposure, making them susceptible to dehydration, heat exhaustion and heatstroke.[5] Wildfires, floods and extreme weather are increasing in frequency and severity, destroying critical infrastructure, contaminating water supplies and producing dangerous air pollution far from the event itself. Weather-related disasters have displaced at least 43 million children over a six-year period.[6] Unlike most forms of pollution, many climate-driven threats are sudden-onset and time limited, demanding rapid preparedness and response rather than sustained avoidance.

Why children are uniquely vulnerable

Across both categories, children face disproportionate risk. Young children have a higher metabolic rate than adults and inhale a greater amount of air relative to their body weight, meaning that, for a given concentration of airborne pollutant, a child's effective dose is higher.[7] They eat and drink more per kilogram of body mass than adults, amplifying ingestion of contaminants in food and water. Hand-to-mouth behaviour in early childhood, a normal and necessary part of sensory exploration, can be a direct route of exposure when dust, soil or household surfaces carry toxic residues. A young child in a lead-contaminated environment may ingest soil and dust dozens of times per day, each instance delivering a small but cumulative dose.[8]

Children's bodies process toxicants differently than adults' bodies. Some detoxification enzymes in the liver are functionally immature in the first years of life, reducing the body's capacity to metabolize and excrete certain substances.[9] The blood-brain barrier, which in adults provides partial protection against some toxicants, is not fully matured and more fragile in infants with different permeability properties. The gastrointestinal tract absorbs a greater fraction of ingested metals; children absorb approximately 40 to 50 per cent of dietary lead, compared with 3 to 10 per cent in adults.[10]

The most consequential vulnerability, however, is developmental. More than 90 per cent of brain architecture is established in the first five years of life, a period of rapid neuronal proliferation, migration and synapse formation. Environmental exposures during these critical windows can redirect developmental trajectories entirely. Lead exposure in early childhood provides an illustration. There is no safe level of lead exposure for children.[11] Blood lead concentrations as low as 5 µg/dL are associated with measurable reductions in IQ, and each additional microgram of exposure can cause greater harm at lower concentrations than at higher ones.[12] Some cognitive deficits can persist into adulthood, affecting educational attainment, earning potential and impulse regulation decades after the original exposure.

The lungs tell a similar story. Children's airways are narrower and still developing alveolar structures well into adolescence. Prenatal exposure to fine particulate matter ($PM_{2.5}$) is associated with reduced forced expiratory volume in the first second of life, a deficit of approximately 55 millilitres per 10 micrograms per cubic metre of exposure.[13] Postnatal exposure during the first years compounds this: children growing up in highly polluted areas show measurably stunted lung growth, a deficit they carry into adulthood as reduced respiratory reserve.[14] Ambient air pollution contributes to an estimated 15.6 per cent of low-birth-weight deliveries globally,[15] with consequences that cascade through infancy and beyond.

What makes these vulnerabilities urgent rather than merely concerning is their irreversibility. Unlike many adult health effects, for which the body can partially compensate once exposure ceases, developmental damage sustained in the early years may be permanent. A child whose neural development is disrupted by lead at age two does not recover that lost capacity at age 10. A child whose lungs fail to reach full growth potential by adolescence, enters adulthood with diminished respiratory function that no subsequent intervention can fully restore. This is the fundamental asymmetry that distinguishes environmental health threats to children from those facing adults: the damage may not be proportional to the dose, sometimes it is not reversible, and it is not confined to the period of exposure. It can shape an entire life.

2. Characteristics of environmental threats that inhibit responses

Environmental health threats affecting children are shaped by common characteristics that make effective responses particularly challenging. Understanding these characteristics explains why awareness campaigns and conventional health messaging frequently fail to produce protective behaviour. Where a visible, immediate and clearly caused threat like a venomous snake triggers automatic protective instincts, environmental health threats systematically undermine the psychological foundations on which protective behaviour depends.

2.1 Threat characteristics

Sensory imperceptibility and normalization

Many of the most dangerous environmental health threats cannot be detected by human senses. Fine particulate matter ($PM_{2.5}$) is invisible to the naked eye. Lead contamination in water, soil, food and consumer products is tasteless, odourless and invisible. Many toxic chemicals in household products and building materials give no sensory warning. Even threats that produce some sensory signal often fail to communicate their true danger: air that smells clean may carry dangerous concentrations of pollutants, and water that appears clear may contain harmful levels of dissolved metals.

This imperceptibility creates a fundamental behavioural problem. Human protective instincts evolved to respond to perceivable dangers. Threats that cannot be seen, smelled, tasted or felt do not trigger the automatic alarm responses that drive the avoidance of visible hazards. Without sensory evidence of danger, people systematically underestimate risk. This means that, even where people are aware in principle that a threat exists, they lack the moment-to-moment perceptual feedback needed to guide protective decisions.

A related but distinct problem affects threats that are perceptible but constant. Extreme heat, persistent smog or chronic noise pollution may be experienced daily, yet their very ubiquity can cause them to fade into the background of ordinary life. When a whole community shares the same exposure, as during a prolonged heat wave or in a neighbourhood with persistently poor air quality, there is no contrast against which to recognize the abnormality of the situation. The threat becomes normalized: acknowledged in the abstract but no longer treated as something requiring a response. This normalization differs from invisibility but produces a similar behavioural outcome. People may not act on dangers they have come to regard as part of the fabric of daily life and may struggle to take appropriate precautions when conditions have crossed from uncomfortable to genuinely dangerous.

Temporal disconnection

For many environmental health threats, the interval between exposure and harm is measured in months, years or decades. Lead exposure in early childhood produces neurodevelopmental damage that may not become apparent until a child reaches school age. Chronic air pollution exposure contributes to respiratory and cardiovascular disease that develops over years. Accumulated exposure to pesticides or industrial chemicals may only manifest as illness long after the period of contact.

This temporal gap breaks the feedback loop that normally sustains health-protective behaviour. When a person touches a hot surface, the immediate pain teaches them to avoid it in future. When exposure to a pollutant produces no perceptible consequence for years, the connection between action and outcome becomes invisible. This disconnection undermines motivation for sustained protective effort, because it is difficult to maintain vigilance against a danger that produces no immediate evidence of harm.

The temporal dimension also operates in reverse. Some threats, such as extreme heat events, wildfires or acute pollution episodes are sudden-onset and require rapid response. The challenge in these cases is the compressed decision-time rather than delayed consequences; preparedness and response behaviours must already be in place before the event occurs, because the window for action is narrow.

Causal complexity and uncertainty

The pathways from environmental exposure to health outcome are often indirect, multi-causal and difficult to verify from personal experience. A child's developmental delay may have multiple contributing factors, of which lead exposure is only one. A respiratory illness may reflect the combined effects of indoor air pollution, outdoor air quality, occupational exposure and individual vulnerability. This causal complexity makes it difficult for individuals to attribute health problems to environmental causes, even when the epidemiological evidence is clear.

Uncertainty operates at multiple levels. At an individual level, exposure does not produce identical outcomes in all people, and this is especially the case for children at different ages. Some individuals and children exposed to the same concentration of a pollutant will develop illness while others will not, making it easy to dismiss the risk as inapplicable. In particular, younger children are at higher risk due to their immature body systems and rapid development. At community level, the uneven and unpredictable (probabilistic) nature of environmental health harm means that even well-documented tragedies, such as mass lead poisoning events, have only become apparent when entire populations showed disproportionate rates of illness or developmental problems. Moreover, conflicting messages from different sources about the severity of threats can create confusion that is easily resolved by inaction.

Perceived controllability

Many environmental health threats appear to originate from sources beyond the control of individuals and households. Air pollution comes from many sources, such as traffic, industry and waste-burning. Water contamination may reflect infrastructure failures or upstream industrial discharge. Chemical exposures may stem from unregulated manufacturing or supply-chain contamination. When the source of a threat seems systemic, people may conclude that personal or household action is futile, leading to a sense of helplessness that suppresses protective behaviour even where meaningful individual-level actions exist.

This perception has some basis. Some environmental health challenges require policy, regulatory or infrastructure responses that individuals cannot provide. A household cannot regulate factory emissions or reform a contaminated water supply. But the conclusion that personal action is therefore pointless is a behavioural trap. Household and individual actions, such as using water filters, choosing safer products, timing outdoor activities or wearing protective equipment, can meaningfully reduce exposure even while systemic problems persist. The challenge for intervention design is to support individual protective action without implying that systemic change is unnecessary, or that the burden of protection should fall on those least responsible for the hazard. Additionally, in some circumstances, citizen action can also be an effective way to move towards obtaining government regulations to deal with polluters.

Competing priorities

Environmental health threats rarely exist in isolation from other pressures. Households facing poverty, food insecurity or lack of employment must allocate scarce time, money and attention across competing demands. An invisible, slow-acting environmental hazard will almost always lose this competition against visible, immediate needs. A mother may understand that indoor smoke from cooking harms her children. If the alternative fuel is unaffordable or unavailable, that knowledge cannot translate into action. A family living near an informal recycling operation recognizes the health risks while depending on that income for their livelihood.

This competition reflects structural conditions (poverty, inadequate infrastructure, weak regulation, gender dynamics and limited access to alternatives) that constrain available choices, not only individual prioritization. The populations most heavily exposed to environmental health threats are often those with the fewest resources to respond. Communities in informal settlements near industrial sites, workers in hazardous occupations without adequate protection, and families relying on contaminated water supplies face disproportionate exposure and disproportionate barriers to action. Where exposure is highest, the conditions for behaviour change are most often absent.

2.2 From characteristics to response

These characteristics interact and compound the problem. A threat that is both imperceptible and temporally disconnected is harder to respond to than one that is merely invisible but produces immediate symptoms. A hazard that appears uncontrollable and competes with more pressing survival needs generates even less protective motivation than one that is invisible but within perceived control. The cumulative effect is a set of threats that are systematically biased against behavioural response; the features that would normally trigger and sustain protective action are absent.

These characteristics also explain why conventional health communication approaches are often insufficient. Awareness campaigns that inform people about the existence of a threat do not solve the perception problem if the threat remains invisible or normalized in daily experience. Messaging that emphasizes severity can produce fatalism rather than action if people feel unable to control the source. Information about protective behaviours is ineffective if structural barriers make those behaviours inaccessible.

The following section describes some categories of protective behaviour that can reduce harm from environmental health threats: monitoring (detecting and tracking threats) and protective action (reducing contact with hazards). The REACH Framework in Section 4 then provides a structured approach to designing interventions that address the behavioural and structural barriers to adopting and maintaining these behaviours.

Figure 2 **Environmental threats: Why they are so difficult to tackle**

Five characteristics that systematically suppress protective behaviour – compared with acute, visible threats where protective instincts work naturally.

	Acute visible threat	Environmental health threat
1 Sensory imperceptibility	**Visible and triggering** You see the snake. Fear response is automatic. No technology or training needed to detect the danger.	**Invisible or normalized** $PM_{2.5}$ is invisible. Lead in water is tasteless. Persistent smog becomes 'just how things are.' No sensory alarm fires.
2 Temporal disconnection	**Immediate feedback** A snakebite causes instant pain. The cause-effect link is unmissable. Avoidance learning is rapid.	**Months to decades** Lead exposure in childhood may not show effects until school age. No immediate signal that today's exposure is causing harm.
3 Causal complexity	**Single, clear cause** Snake ▶ bite ▶ pain ▶ illness. One cause, one pathway, no ambiguity.	**Indirect and multi-causal** A child's developmental delay may reflect lead, nutrition, genetics and stimulation combined. Easy to dismiss any single cause.
4 Perceived controllability	**Action feels effective** Move away from the snake. The protective action is obvious, immediate, and clearly within your control.	**Source feels systemic** Air pollution comes from traffic and industry and water contamination from infrastructure failures. 'What can I possibly do?' suppresses action.
5 Competing priorities	**Overrides everything** A snake demands immediate full attention. No competing priority wins.	**Crowded out daily** An invisible, slow-acting hazard loses to food, income and shelter needs every time – especially for those with the fewest resources.

3. Responses to environmental health threats

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Prevention takes precedence because many environmental health harms are irreversible once they occur. Two fundamental categories, monitoring (detecting and tracking threats) and protective action (reducing contact with hazards) form a feedback system; monitoring generates information that guides protective action, while outcomes are assessed through ongoing monitoring.

When exposure does occur despite protective efforts, health-seeking behaviours become necessary, including accessing medical consultation, adhering to treatment and ongoing health management. While important, these responses are inherently reactive. The primary focus of this guide is therefore on the behaviours that reduce exposure before harm occurs.

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3.1 Monitoring

Effective protection against environmental health threats begins with detection. Many of the most dangerous environmental hazards are invisible to ordinary human perception. You cannot see particulate matter, taste dissolved metals, smell many toxic gases or feel radiation. This invisibility creates a fundamental behavioural challenge: threats that cannot be seen or felt tend not to command attention or motivate action. Monitoring behaviours bridge this gap by translating imperceptible risks into information that can guide decision-making.

Monitoring operates across two complementary domains. Environmental monitoring encompasses measurements that detect, measure or track hazards in one's surroundings, including air, water, soil, food and consumer products. This ranges from passive monitoring (checking air quality indices, heeding heat wave warnings, reviewing water quality reports) to active monitoring (using home test kits for lead in water, portable sensors for indoor air quality) to participatory monitoring, where communities collectively gather data about local hazards (for example, pooling personal air quality sensor readings to create neighbourhood-level exposure maps). These participatory efforts can reveal local patterns that centralized monitoring systems miss, and they connect directly to the collective efficacy approaches discussed in the Act component of the REACH Framework.

A particularly important form of environmental monitoring is product testing. Items entering the home, including cookware, cosmetics, toys, building materials and food products, may contain hazardous substances. A study testing consumer products across 25 low- and middle-income countries found that 51 per cent of metal cookware, 45 per cent of ceramics, and 41 per cent of paints exceeded safety thresholds for lead.[16] Product monitoring and transparent labelling can transform purchasing decisions into protective opportunities.

Biological monitoring measures the presence or effects of hazards within the body. This matters because environmental exposure does not translate uniformly into bodily harm. Biological monitoring provides confirmation that contact with a hazard has occurred (which may not be apparent from environmental data alone, particularly when exposure pathways are occupational, dietary or historical) and can help to assess whether current protective strategies are working. For some threats, symptom recognition functions as a form of biological monitoring. During heat exposure, recognizing early warning signs like dizziness, nausea or cessation of sweating can signal that physiological limits are being approached before a medical emergency develops.

From monitoring to action

Monitoring alone does not produce behaviour change. Effective intervention design must address the full chain from detection to understanding to accessible action.

3.2 Protective action

Where monitoring detects threats, protective action reduces contact with them. Protective behaviours fall into two broad categories:

- avoidance (preventing contact through choices)
- barriers (blocking hazards from reaching the body)

This distinction matters for intervention design because the two categories involve different psychological processes, face different adoption challenges and require different kinds of support.

Avoidance

Avoidance behaviours prevent hazard contact through choices about timing, location, products and responses to changing conditions. Selection and decision-making create protection: the hazard never reaches the person because of choices that create separation.

Avoidance operates across four dimensions, each involving distinct decision types and behavioural patterns. The four dimensions overlap, with each reinforcing the others. Effective protection typically combines multiple types.

Table 1 Avoidance behaviour types, decision types, examples and behavioural insights

Type	Decision type	Example	Key behavioural insight
Temporal	**When to act:** Timing activities around predictable risk periods	Scheduling children's outdoor play and school break times for morning hours when ground-level ozone is lowest, rather than peak afternoon pollution. During heat waves, shifting physically active lessons to cooler parts of the day.	Highly amenable to habit formation. Once timing adjustments are established they can become routine, but initial disruption to school and family schedules requires coordination with others.
Spatial	**Where to go:** Choosing locations and routes that reduce exposure	A parent directing children to play on grassy areas rather than bare soil that may be contaminated with lead from historical industrial activity. Choosing a walking route to school through quieter streets or green corridors rather than along congested roads. Relocating play areas away from informal e-waste processing sites.	Often involves trade-offs with cost, convenience and proximity. More accessible to those with economic flexibility. For the most vulnerable (informal settlements near industrial sites), structural intervention such as relocation support may be needed.
Source	**What generates the hazard:** Choosing products and practices that do not create risk	Transitioning from solid fuels to cleaner cooking alternatives, reducing indoor air pollution that children breathe during meal preparation. Replacing traditional cookware or ceramic dishes with certified lead-free alternatives for children's meals. Choosing lead-free paints and toys, or avoiding cosmetics containing toxic metals applied to children's skin.	One effective form of protection as it addresses threats at their origin. Depends on knowledge that products pose risks, access to safer alternatives, and affordability. Structural interventions (regulation, subsidy, market development) can substantially expand reach.
Situational	**Responding to current conditions:** Adjustments triggered by monitoring information	Keeping children indoors when air quality alerts indicate dangerous pollution levels. Cancelling outdoor sports or school activities during a heat wave warning. Avoiding a playground near a construction site that is disturbing contaminated soil. Switching to bottled water after a contamination alert.	Requires sustained attention to threat information, competing with other demands on cognitive resources. Unlike temporal avoidance, cannot become fully routine as it depends on variable conditions and willingness to disrupt plans. Monitoring enables this behavioural response.

Barriers

Where avoidance prevents contact through choices, barriers block hazards that exist in one's environment from reaching the body or causing harm. Barriers can be understood along a spectrum from the individual body to the built environment.

This spectrum matters because different positions along it involve different behavioural requirements, including different frequencies of action, different types of decisions and different maintenance demands.

Table 2 **Protective barrier types from personal protection to physical separation**

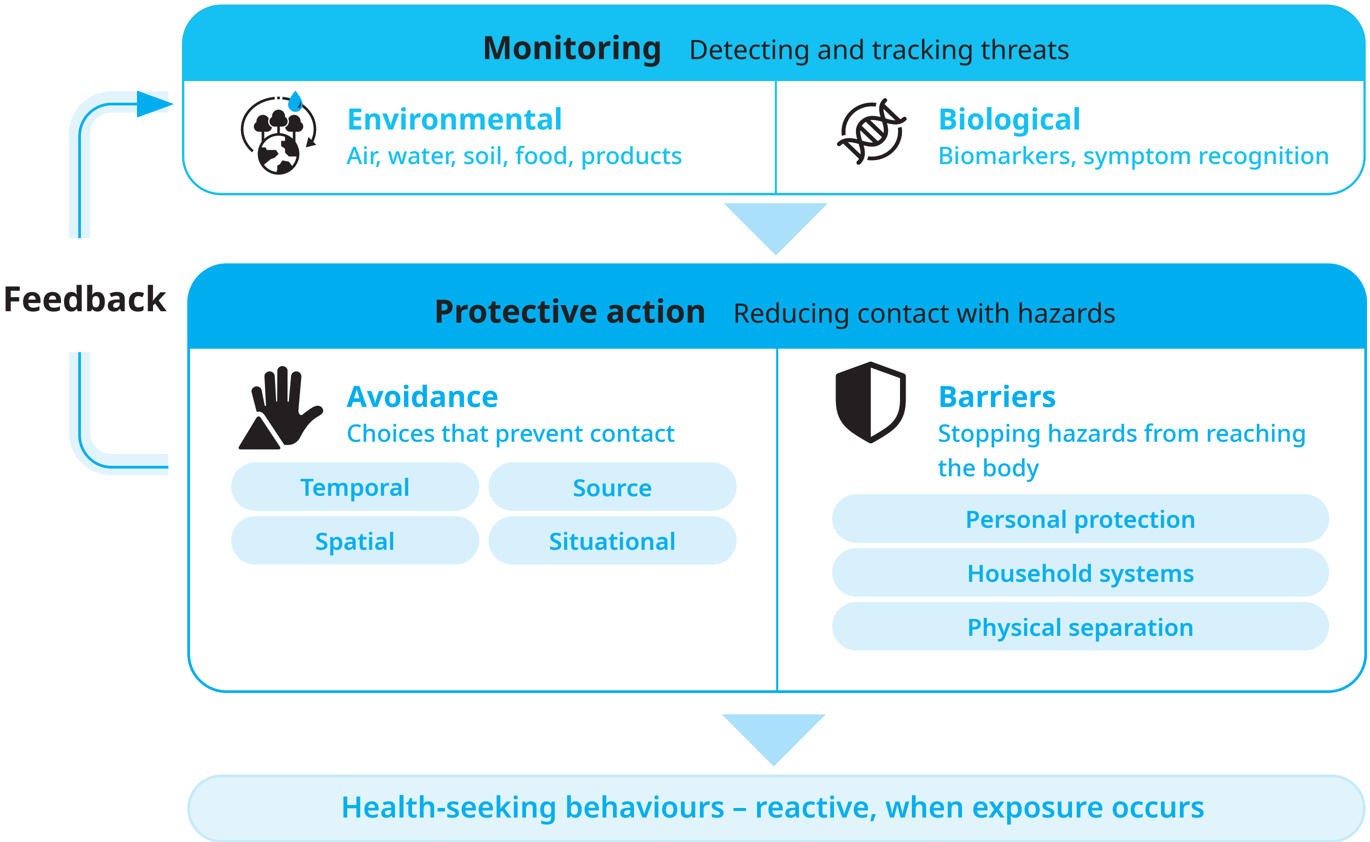
Type	Frequency of action	Example	Key consideration
Personal protection	Each exposure event	Wearing appropriate masks during high pollution days or in dusty environments. Protective clothing for adolescents working in agriculture or around pesticides. Nutritional barriers: diets adequate in calcium and iron reduce lead absorption in children because these nutrients compete with lead for the same uptake pathways. Adequate hydration for children during heat exposure.	Requires ongoing, repeated compliance, creating vulnerability to lapses. May carry psychological burden of visible difference for children (stigma from mask-wearing). Nutritional protection requires sustained dietary patterns rather than single actions.
Household systems	Periodic maintenance	Water filters certified to remove lead, arsenic and microbial pathogens from drinking water used to prepare children's food and formula. Air purifiers in children's bedrooms or play areas to reduce indoor particulate matter. Protective window screens that filter outdoor pollution while maintaining ventilation in nurseries.	Once installed, these provide continuous protection with relatively little ongoing action. Adoption barriers include upfront cost, effort to research and select, and ongoing costs such as filter replacement. Effectiveness depends on appropriate selection: a filter not rated for the relevant contaminant provides false reassurance.
Physical separation	One-time or infrequent decisions	Separating cooking areas from children's sleeping and play spaces to limit exposure to combustion pollutants. A caregiver with occupational exposure to toxicants (mining, battery recycling, painting) establishing routines for changing clothes and showering before contact with children, and laundering work clothes separately. Encapsulating or removing lead paint in children's rooms.	Protection persists without sustained motivation, but requires control over one's environment and resources to implement changes. May not be available to renters, those in shared housing, or those in informal settlements.

The relationship between monitoring and protective action

Monitoring and protective action form a feedback system; monitoring can guide decisions, and protective outcomes can be assessed through ongoing monitoring.

The REACH Framework that follows provides a structured approach to designing interventions that support both monitoring and protective action, addressing the full chain from detection through to sustained behaviour change.

Figure 3 Responses to environmental health threats



4. REACH Framework: A behavioural lens for message re-design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Environmental health threats are difficult to respond to for reasons that are behavioural, not informational. The hazards are largely imperceptible; the harm is delayed; the exposure is often normalized within communities that have lived with it for generations. These characteristics suppress the ordinary psychological processes (threat detection, risk appraisal, self-protective response) that drive behaviour change in acute emergencies. Providing information about the threat, or guidelines on how to respond, addresses only a fraction of the problem.

REACH organizes the conditions required for protective behaviour into five components, each addressing a distinct point where the behavioural response to environmental health threats typically breaks down.

Recognize. Environmental health hazards are often undetectable. Fine particulate matter is invisible, lead in water is tasteless, and chronic exposures that are perceptible (e.g., persistent smog or industrial odour) are subject to habituation. Recognition programmes translate monitoring data into forms that restore salience: making air quality visible on a screen, making contamination legible on a test strip, making the connection between a substance and a symptom concrete enough to act on.

Engage. A caregiver who recognizes a threat may still not respond to it. Competing demands for income, food, safety and childcare absorb attention and resources. Engagement programmes use personal relevance, emotional connection, and social influence to move environmental health protection from a background concern to one that competes successfully with immediate priorities.

Act. Motivation to protect is insufficient without the means to do so. Action programmes build technical skills, provide access to resources, and develop collective support systems that allow individuals and communities to carry out protective behaviour in their specific circumstances.

Context. Individual behaviour operates within economic, infrastructural, regulatory and cultural systems. A caregiver who is motivated, informed and skilled will still fail to adopt a protective behaviour if the product needed is unaffordable, the infrastructure is absent, or the regulatory environment permits ongoing contamination. Context programmes address these structural determinants.

Habit. Protective behaviours that require deliberate effort in each instance gradually erode. Habit programmes embed protective actions into environmental cues, daily routines and reinforcement systems so that they persist without ongoing conscious decision-making.

These components operate concurrently rather than sequentially. Recognition may not precede engagement; context constraints can block action regardless of motivation. Most environmental health programmes will need to address several components in parallel. The sections that follow examine each in turn: theoretical foundations, supporting evidence and practical guidance for application, with case studies from programmes in low- and middle-income settings.

4.1 Recognize

Making the invisible visible

4.1.1 Definition

Recognition involves the ability to detect, understand and correctly interpret environmental health threats that are typically invisible, odourless or have become normalized in daily life.

4.1.2 Why recognition matters

The recognition gap is substantial: perception of threats like air quality correlates poorly with actual measurements,[17] and people struggle to connect exposures to delayed health outcomes. A 62 per cent awareness rate among plastic-burning households still failed to prevent exposure,[18] showing that recognition alone is insufficient without causal understanding and a belief in protective efficacy. Recognition must address both perceptibility and the causal connection between exposure and health harm.

4.1.3 Theoretical foundations

Risk perception depends on threat characteristics such as dread, familiarity and perceived controllability,[19] but fundamentally requires the threat to be perceptible. Multiple behavioural models, including Protection Motivation Theory,[20,21] the Health Belief Model,[22] converge on this finding; recognition failure cascades into failures of motivation and action.

Even when people know a threat exists, they must link it to the health outcomes they observe. Research on causal judgment identifies the conditions for successful cause-effect learning. Einhorn and Hogarth's model[23] identifies critical cues: temporal contiguity (cause and effect close in time), spatial contiguity (close in space), covariation (the effect occurs with the cause and not without it), and plausible alternative causes. Environmental health threats fail on all these criteria; causes are invisible, temporally distant, and constant exposure masks covariation. Research on causal learning shows that delays impair this detection,[24] and organisms lack biological preparedness for novel environmental threats.[25] Causal learning about environmental health threats will not happen naturally; it requires deliberate intervention that reconstructs the conditions for causal reasoning, whether by making threats visible, demonstrating covariation through monitoring, or reducing temporal gaps through real-time measurement.

4.1.4 Approach for gaining recognition

Recognition of environmental risks develop through three pathways:

1. sensory detection enhancement
2. building causal understanding
3. risk calibration

Each of these can catalyse corresponding individual or collective level interventions.

Sensory detection enhancement

Sensory detection enhancement refers to making invisible threats visible through direct senses, sensory proxies (e.g., traffic density as a proxy for air pollution), or technological aids such as monitors and apps.

Table 3 Risk calibration tools and case studies by environmental threat

Environmental threat	Sensory enhancement	Case example
Air pollution	Direct sensing	City residents in Beijing learned to recognize dangerous $PM_{2.5}$, distinguishing it from mere 'fog' through visibility distances, the smell of burning, and respiratory irritation as proxy indicators for excess air pollution during the 2013 'Airpocalypse'[26]
Lead contamination	Technology aids	In Kenya, surface soil testing near a Mombasa lead smelter used portable X-ray fluorescence (XRF) analysers to map contamination zones, finding mean levels of 224 mg/kg. This is more than five times the lead concentration commonly used as an international safety benchmark for children's play areas (often ~40 mg/kg)[27]
Chemical pollution	Mobile app	The 'Smell Pittsburgh' programme,[28,29] demonstrates how communities can use smell as a pollution detection tool. Residents use a mobile app to report unusual odours, creating a community-generated map of pollution events. The programme found that collective smell reporting correlated strongly with industrial emissions, empowering communities to document pollution that monitoring stations might miss

In Bangladesh, researchers deployed portable XRF analysers to detect lead chromate adulteration in turmeric, an invisible contaminant added during processing to enhance colour. Coupled with televised enforcement raids and mobile court fines, the proportion of market turmeric containing detectable lead dropped from 47 per cent to zero.[30] The technology made an undetectable hazard testable at the point of sale, extending the same principle demonstrated by the Mombasa soil testing to a consumer product that enters millions of homes.

Personalized testing can also bridge the gap between general awareness and individual action. In rural Bangladesh, households whose tubewells were tested for arsenic and labelled safe or unsafe were 37 per cent more likely to switch to a safer water source within one year, with roughly 60 per cent of affected households switching. General media campaigns about arsenic risk, by contrast, did not induce behaviour change; only well-specific test results triggered action.[31] This pattern, in which personalized risk information outperforms general awareness, recurs across the evidence base for environmental health interventions.

Finally, some health signs and symptoms can indicate exposure or over-exposure to certain threats. UNICEF has identified different signs and symptoms for heat exhaustion and heat stroke in babies and children. Examples include dizziness, a heat rash which can have small, raised spots and mild swelling, or cramps in legs, stomach or arms for heat exhaustion.[32]

Causal understanding

Causal understanding refers to awareness of exposure pathways, cumulative effects and vulnerability to long-term harm. Educational interventions using visualization tools can emphasize the severity of health outcomes. When communicating uncertainty about probabilistic risk, honesty about exposure-to-outcome pathways being multi-causal (reflecting combined factors like nutrition and genetics) strengthens credibility and supports sustained action.

Table 4 Building causal understanding: Illustrative examples by environmental threat

Threat	How causal understanding is established
Indoor air pollution	A household receives a simple indoor air quality monitor that spikes visibly every time they cook with solid fuel. For the first time, the family can see that their cooking routine produces the same pollutants they have been warned about in health messages. The monitor makes the causal link between a specific daily behaviour and an otherwise invisible exposure, helping the family understand which activities create the most risk and when ventilation matters most.
Extreme heat	A child develops muscle cramps and dizziness after playing outside on a hot afternoon. A community health worker explains that these symptoms are early signs of heat exhaustion, that young children may overheat faster than adults, and that the symptoms the caregiver observed are directly connected to heat exposure rather than being an unrelated illness. The caregiver now has a mental model that links observable symptoms to an environmental cause.

Community health workers can serve as a particularly effective channel for building causal understanding at the household level. In rural Bangladesh, community health workers delivered an intervention using a 'making the invisible visible' framing, which linked lead contamination in turmeric, food storage cans and soil, to child cognitive development. Lead awareness rose by 52 per cent in the intervention group and safe turmeric consumption and food storage practices shifted significantly.[33] The intervention succeeded because it connected an invisible contaminant to a deeply valued outcome (children's brain development) through a trusted, face-to-face channel.

Risk calibration

Risk calibration refers to enabling people to more accurately assess when an exposure level is severe or dangerous. For people to assess their own respective vulnerability, they need to understand how important the duration of exposure is and how it may compare to other threats. This can be done using digital tools that more precisely measure invisible risks, simpler visualization tools that draw on heuristics, interactive educational methods and mental models, and pairing monitoring with cultural activities (youth clubs or structuring monitoring around prayer times in religious communities). Such engagement can enable individuals to respond in real time when the threat goes beyond a pre-established threshold.

Table 5 Sensory detection enhancement approaches and case examples by environmental threat

Environmental threat	Calibration tool	Case examples
Indoor air pollution (IAP)	Indoor air quality monitors	Providing families with simple air quality monitors may help them to identify when air quality passes an unsafe threshold more easily. In the UK, providing real-time feedback led to a 17% decrease in $PM_{2.5}$ concentrations and increased residents' recognition of where their IAP was significantly higher than they originally perceived.[34]
Outdoor air pollution	Wearable sensors	HazeDose System:[35] Wearable sensors showing personal $PM_{2.5}$ exposure varied 300% from area estimates. Real-time feedback led participants to reduce exposure by 23% through route changes and timing adjustments.
Lead contamination	Blood lead level testing with tiered action thresholds	Blood lead levels are invisible without testing but can be translated into clear action categories. The US CDC's tiered reference system links specific blood lead levels to escalating responses: below 3.5 µg/dL requires ongoing prevention education, 3.5–9.9 µg/dL triggers environmental investigation and follow-up testing, and higher levels prompt increasingly urgent medical and remediation interventions. This calibration structure turns an otherwise uninterpretable number into a clear signal for action.
Extreme heat	Colour-coded heat warning systems	After the 2010 heatwave, Ahmedabad developed a colour-coded heat warning system (green, yellow, orange, red) broadcast through media and community outreach. The system translates temperature and humidity forecasts into action categories that residents can act on without needing to interpret raw meteorological data. Evaluations showed heat-related fatalities remained low during a 2015 heatwave while thousands died elsewhere across India.[36]

4.2 Engage
Motivation and priority

4.2.1 Definition

Engagement creates personal relevance and emotional connection that elevates environmental health protection among competing daily priorities and survival needs.

4.2.2 Why engagement matters

Awareness alone does not produce protective behaviour. Households who understand the health risks of indoor smoke frequently continue using traditional fuels.[37] In many cities with publicly available air quality monitoring, parents can check pollution levels on their phones at any time, yet few adjust their children's outdoor activities in response. Families living in areas with well-documented lead contamination may acknowledge the hazard when asked about it, but not maintain the daily hygiene routines (such as removing work clothes prior to playing with children) that would meaningfully reduce their children's exposure.

In each of these cases, the barrier is neither ignorance nor inability to act. The missing ingredient is motivation: the threat has not become emotionally real or personally urgent enough to compete with other demands on attention and resources. The mother using a traditional stove knows about the smoke but is thinking about the meal she needs to prepare. Parents with air quality data often do not check it, regarding pollution as background noise rather than something requiring a daily decision. The family near a lead site have heard the health messages but the threat remains abstract, something that affects 'children in this area' rather than their own child in front of them.

4.2.3 Theoretical foundation

Three theoretical frameworks from behavioural science inform the approach to engagement.

Value-Belief-Norm Theory[38] proposes that values, beliefs about consequences, and a sense of personal responsibility together activate moral norms that motivate action. For environmental health, the same threat may need framing differently for different audiences depending on their core values. Messages emphasizing children's cognitive development engage parents focused on family welfare; messages about community stewardship resonate where collective identity is strong; messages about economic costs of illness motivate those focused on household livelihoods. A single 'correct' framing is unlikely to work across diverse populations.

Risk as Feelings Theory[39] emphasizes that emotional reactions drive decision-making through a pathway separate from cognitive evaluation. People may understand a risk intellectually without feeling the urgency to respond. Emotional responsiveness depends on vividness of imagined consequences, immediacy, background mood and personal experience. For environmental health hazards that are delayed, invisible, or probabilistic, engagement requires making risks emotionally salient rather than relying on information alone.

Construal Level Theory[40] explains how psychological distance shapes thinking and response. Distant or abstract events favour general attitudes ('pollution is bad') but not specific action. Environmental health threats are typically distant on multiple dimensions: consequences lie in the future, causal mechanisms are invisible, and affected populations feel statistically abstract. Reducing this distance by connecting threats to a specific child, location or immediate time frame shifts construal from abstract to concrete and increases likelihood of behavioural response.

These three frameworks converge on a shared insight: engagement depends on changing the emotional and psychological relationship between the person and the threat, not on providing additional information.

4.2.4 Approach for engagement

The four approaches below address distinct aspects of the engagement challenge. Personal relevance and emotional connection work to make the threat feel real and immediate to the individual. Social influence establishes protective behaviour as normatively expected within a reference group. Priority elevation addresses whether environmental health protection can compete with other demands on attention and resources.

1. personal relevance
2. emotional connection
3. social influence
4. priority elevation

Personal relevance

Human emotional systems evolved to respond to specific, identifiable individuals rather than abstract categories. When a caregiver hears about one child's experience with lead poisoning, they automatically simulate that experience, activating empathy and protective instincts. Statistics, by contrast, tend to trigger analytical processing, which can suppress rather than enhance emotional response.[41] Personalization therefore involves framing risks in terms of individual stories ('your child') rather than collective figures ('10,000 children'). By helping a caregiver visualize their specific child's vulnerability, personalization closes the psychological distance between the threat and the listener, making the threat more salient.

Personalization can operate at different levels of specificity. At the most direct level, it involves individual-level information such as a name, a health result or a family circumstance. But it can also be achieved through subgroup matching: connecting messages to characteristics that a listener shares with others in their reference group. This follows from Value-Belief-Norm theory's recognition that interventions should connect to people's existing values, which may differ across groups. In the case of a cookstove adoption campaign that initially saw poor uptake in Ethiopia, the groups that saw improved uptake included female-headed households and those owning their own homes.[42] In the UK, a large randomized trial of text messages for smoking cessation ('txt2stop') found that effectiveness increased substantially when messages were tailored to concerns participants had identified, such as potential weight gain.[43]

Subgroup characteristics that can guide personalization include:

- Family-specific risks: 'your daughter's asthma...'
- Local connections: 'in our neighbourhood...', 'whenever you pass by X factory...'
- Cultural values or societal roles: 'as good mothers and fathers...'
- Life goals: 'for your children's future...'

Biomonitoring can function as a particularly direct form of personalization, because it translates an abstract environmental threat into a number attached to a specific child. In Dong Mai village, Viet Nam, blood lead testing revealed that 28 per cent of children under the age of six had levels exceeding 45 µg/dL, making the invisible contamination from decades of battery recycling personally real to each family.[44] In Guiyu, China, serial population-based blood lead studies spanning 2004–2019 documented children's mean levels of 15.3 µg/dL, a finding that galvanized the Government's investment of US$233 million in an industrial park to relocate e-waste processing away from residential areas.[45,46,47] In both cases, biomonitoring served a dual function: it measured the problem and simultaneously made it emotionally real to families and policymakers, illustrating how monitoring can itself be an engagement intervention.

Visualization can also strengthen personalized connections, with illustrations that model a recognizable figure. For air pollutants, for example, a message could state and show, 'This is what happens in your lungs when you are exposed to pollution repeatedly'.

Emotional connection

Protective emotions (fear, hope, pride) drive behaviour more effectively than cognitive calculations. Risk as Feelings Theory explains these as fast intuitive drivers, arising when threats feel serious and personally relevant, working in conjunction with values and moral obligation.

Message framing activates different emotions: gain framing ('protect potential') outperforms loss framing for prevention behaviours.

For detection behaviours (testing water, checking air quality, blood lead tests), loss framing ('find out before it's too late') may be more effective than gain framing.

Prevention behaviours feel more certain when framed as preserving something good. Detection behaviours benefit from the urgency of potential loss. Gain framing empowers; loss framing without agency produces paralysis.

Figure 4 **Message framing**

Gain framing
For protective action (prevention)

Air pollution
Protect your child's brilliant, developing mind.

Lead exposure
Keep your child's growing brain safe with simple daily steps.

Heat
Keep your family cool, healthy, and active all summer.

Loss framing
For monitoring (detection)

Air pollution
Don't let invisible pollution go unchecked – find out what's in your air.

Blood lead testing
Find out before it's too late – get your child tested.

Water quality
You can't see what's in your water. Test it.

Social influence

Social norms approaches are widely used in health promotion because they draw on a fundamental human tendency: people adjust their behaviour to match what they believe others like them are doing. When protective behaviours are seen as typical within a reference group, individuals are more likely to follow suit. But norms alone do not explain how people interpret risk information. Cultural Cognition Theory suggests that individuals assess evidence through the lens of their existing values and group identities.[48] Information that aligns with those values is more likely to be accepted; information that appears to threaten them may be discounted, regardless of its scientific strength.

For environmental health, this implies that protective behaviours should be framed in ways that resonate with what communities already prioritize. Rather than presenting prevention as a separate health agenda, it can be positioned as supporting goals such as children's educational achievement, religious responsibility, family honour or economic stability. Aligning messages with these values reduces resistance and makes future risks feel relevant to present identity and social standing, helping to counter present bias.

Priority elevation

Environmental health threats compete with immediate pressures (food, income, shelter). Temporal reframing using sensitive developmental periods ('your child's brain is building now') creates urgency without alarm. Demonstrating co-benefits (that protective actions serve multiple goals, such as handwashing to remove lead dust and reduce infection, or timing activities to avoid heat while freeing productive hours) elevates priority by aligning environmental protection with household-valued goals.

CASE STUDY

Reducing women's consumption of rice contaminated with toxic metals in Iran through social reinforcement[49]

In Iran, a study compared two education approaches for reducing women's consumption of rice contaminated with toxic metals. A health belief model (HBM) approach focused on individual knowledge, risk perception and self-efficacy. An ecological-social (ECO) model added social support, community norms and group cooking activities. Both improved safe rice consumption, but the ECO group consumed safe rice 27.5 per cent more than the HBM group, with greater persistence at six months.

Social and environmental support, including shared norms and community reinforcement, sustained the behaviour more effectively than individual-level education alone.[50]

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4.3 Act
Enabling protective behaviour

4.3.1 Definition

Action encompasses the capabilities, skills and support systems needed to translate motivation into effective protective behaviour in real-world contexts.

4.3.2 Why action matters

Even where recognition and motivation are established, protective behaviour may not follow. Households may understand the risks but lack practical capability: how exactly to act, whether their actions will make a real difference, or whether they can sustain the effort. Act addresses this by building the practical capability to convert commitment into behaviour. Without it, motivation remains stranded: people want to protect their children but do not act, because they lack the means, not the motivation.

4.3.3 Theoretical foundations

Capability is a necessary condition for behaviour, independent of knowledge and motivation. This finding appears consistently across behavioural science frameworks, including COM-B,[51] Protection Motivation Theory (PMT),[52,53] and Social Cognitive Theory.[54] Even where motivation is strong and structural conditions are favourable, behaviour will not occur if the person lacks the capability to perform it.

Three dimensions of capability emerge consistently as relevant to environmental health protection: whether the person believes the action will work, whether they believe they can do it, and whether they have a concrete plan for when and how to act.

Response efficacy is the belief that a recommended protective action will actually reduce the threat. In PMT's coping appraisal framework, it sits alongside self-efficacy as one of two components that determine whether a person acts on their motivation.[55] Response efficacy presents a particular challenge for environmental health threats. Where effects are delayed by months or years and multiple causal factors contribute to health outcomes, people receive little natural feedback that protective actions are working. Without this feedback, response efficacy erodes. Intervention design must therefore actively demonstrate that protective actions produce measurable results, whether through biological monitoring, environmental monitoring or epidemiological evidence communicated at community level. This is why it is crucial to invest in monitoring capabilities of environmental health threats in communities.

Self-efficacy is the belief that one can successfully perform the protective behaviour. Self-efficacy develops through mastery experience (the strongest source), vicarious experience, verbal persuasion and physiological states.[56,57] Graduated approaches beginning with simpler protective actions tend to be more effective than programmes introducing the full behavioural repertoire at once. If performing a protective action feels confusing or exhausting, confidence drops regardless of technical success. This explains why design of protective equipment and tools matters for sustained adoption.

Implementation intentions address the gap between general motivation and specific behaviour. Gollwitzer's theory[58] explains the mechanism: an implementation intention ('when situation Y arises, I will perform behaviour Z') specifies in advance the situational cue and the exact response, reducing cognitive load at the moment of action. Meta-analytic evidence shows that forming implementation intentions produces a medium-to-large effect on goal attainment across behavioural domains.[59] For environmental health behaviours, where the appropriate response often depends on variable conditions, implementation intentions are particularly valuable because they convert complex situational judgments into manageable 'if-then' rules.

These three dimensions of capability are complementary. Interventions that build skills without demonstrating effectiveness (neglecting response efficacy), or provide action plans without building confidence (neglecting self-efficacy), or demonstrate effectiveness without helping people plan when and how to act (neglecting implementation), leave parts of the capability gap unaddressed.

4.3.4 Approach for enabling action

Environmental health protection encompasses behaviours with very different capability requirements. Avoidance behaviours such as timing outdoor activities or choosing walking routes require different skills from barrier behaviours such as operating a water filter or maintaining an air purifier. Monitoring behaviours that involve interpreting data or recognizing symptoms demand yet another set of competencies. The approaches below apply across these categories, but the specific skills and confidence-building strategies will vary depending on which type of protective behaviour is being supported.

Building capability for protective behaviour involves four aspects, each addressing a limitation of the one before it. Technical capability provides the skill to perform a behaviour. Self-efficacy provides the confidence to persist with it. Implementation support provides a concrete plan for when and how to act in daily life. Collective efficacy sustains individual capability within a social context. Together, they form a progression from knowing how, to believing one can, to acting consistently, to acting as part of a group.

1. technical capability
2. self-efficacy
3. implementation support
4. collective efficacy

Figure 5 **Act: Building capability for protective behaviour**

Four dimensions of capability, each addressing a limitation of the one before it – from knowing how, to believing one can, to acting consistently, to acting as part of a group.

Act | Enabling protective behaviour

1. Technical capability | Do I know how to do this?

The skill to perform the protective behaviour correctly – from operating a clean cookstove to interpreting an air quality index to fitting a mask properly.

Evidence In California's Salinas Valley, community health workers taught farmworker families specific take-home pesticide reduction practices – producing a 51% decrease in children's urinary pesticide metabolites.

2. Self-efficacy | Do I believe I can do this?

Confidence that one can successfully perform and maintain the behaviour. Built through mastery experience (start simple, succeed, then progress), vicarious experience (seeing peers succeed), and feasible design.

Evidence In Antwerp, personalized lower-pollution walking routes to school were constrained to only marginally longer distances – making adoption feel achievable rather than burdensome.

3. Implementation support | When and how does this fit my life?

Concrete action plans that specify when, where and how. Anchoring new behaviours to existing routines. Anticipating obstacles before they arise. Converting general capability into reliable daily practice.

Evidence In Bangladesh, pairing arsenic test results with specific information about nearby safer water sources produced a 60% reduction in household arsenic exposure.

4. Collective efficacy | Are we doing this together?

A group's shared belief in its capacity to achieve protective outcomes. Some behaviours are inherently collective (community water testing, coordinated school responses). Others are individually performed but collectively reinforced.

Evidence In Zamfara State, Nigeria, community agreements to ban ore processing inside residential areas required collective capability that individual interventions could never have achieved.

Sources: Ahmed et al. 2020. Madajewicz et al. 2007. Salvatore et al. 2015. Tirima et al. 2016.

Design principle

These four dimensions are complementary. Interventions that build skills without demonstrating effectiveness (neglecting response efficacy), or provide action plans without building confidence (neglecting self-efficacy), leave parts of the capability gap unaddressed. Technical capability alone does not guarantee practice change when economic barriers persist – Act cannot be separated from Context.

Technical capability

Protective behaviours vary in technical demands from simple (closing windows) to complex (operating cookstoves, fitting masks, maintaining filtration systems). Technical capability requires both knowing how, and understanding why, each step matters for protection.

FRESH AIR's clean cookstove programme in Uganda, Viet Nam and Kyrgyzstan succeeded by offering stove choices matching locally available fuels and existing routines,[60] illustrating that technical capability builds more readily when behaviours integrate with existing practices rather than disrupt them.

Decision skills, such as matching responses to varying conditions (heat action plans with tiered responses for different severity levels), are equally important as executing any single behaviour.

Pesticide training in California's Salinas Valley (51 per cent reduction in children's pesticide metabolites)[61] and in northern Thailand (biomarker-verified reductions)[62] succeeded through concrete instructions delivered by trusted community workers in practice settings.

However, technical capability alone cannot overcome economic barriers. A Ugandan trial found that a pesticide workshop plus eight months of SMS nudges produced knowledge without practice change; workers understood but could not afford the necessary protective equipment,[63] reinforcing that Act and Context cannot be separated.

Self-efficacy

The practical question is how to activate the sources of self-efficacy in intervention design.

Mastery experience, the strongest source, explains the effectiveness of graduated approaches. When people begin with a protective action that is simple enough to grasp, each success reinforces their confidence to attempt more demanding behaviours. A concerned family member working in an informal lead battery recycling facility might start by remembering to remove their work clothing prior to entering their home (simple, immediately achievable), then add wet-mopping routines for floors and surfaces, then incorporate dietary adjustments that reduce lead absorption. Each step is manageable on its own, and each success reinforces the confidence needed to attempt the next.

Vicarious experience, the second most influential source, operates through social comparison. In a study of cookstove adoption across nearly 6,000 households in northwest Ethiopia, positive social interaction with neighbours who had already adopted an improved stove and had previous experience of a live demonstration were both independently associated with uptake.[64] The effectiveness of these demonstrations depended not on the technical content, which could have been delivered through printed materials, but on the social proof they provided: families could see someone like them successfully performing the behaviour.

Feasibility reinforces self-efficacy from a different angle. Where self-efficacy concerns whether a person believes they can perform a behaviour, feasibility concerns whether the behaviour is reasonable to attempt given real-world constraints. In Antwerp, Belgium, an intervention to reduce children's air pollution exposure provided parents with personalized alternative walking routes to school that involved lower traffic-related pollution.[65] The suggested alternatives were limited to routes only marginally longer than existing ones, requiring no additional equipment or changes in travel mode. When people can see that a protective action fits within their existing circumstances, a significant psychological barrier to adoption is removed.

Implementation support

A person who has the skill and the confidence to act may still fail to do so consistently, because general capability does not automatically translate into reliable daily behaviour. The challenge at this stage is no longer 'can I do this?' but 'when and how does this fit into my life?' This is particularly true for environmental health behaviours that must be performed repeatedly under varying conditions, where each occasion requires a decision about whether and how to act.

Implementation support addresses this by converting general capability into situation-specific plans. Action plans that specify when, where and how a behaviour will be performed function as pre-made implementation intentions, reducing the cognitive load of decision-making at the moment of action. Anchoring new behaviours to existing routines exploits the cue-response structure that makes implementation intentions effective: checking an air quality index as part of a morning routine that already includes checking the weather, or establishing a surface-wiping practice for lead dust-control at the same time as an existing after-school routine of unpacking bags and preparing snacks.

The Smoke Sense citizen science project in the United States illustrates how implementation support works for dynamic environmental threats.[66] Real-time and forecast air quality data are paired with clearly specified protective actions, converting complex environmental information into actionable 'if-then' decisions: if air quality reaches a given threshold, then perform this specific set of behaviours. Digital reminders keep protective behaviours a high priority during intermittent adverse air quality events. The intervention bridges the gap between awareness of a variable threat and consistent situational response.

The Bangladesh arsenic example (described in Section 4.2, Personalized information) demonstrates how specific, actionable guidance paired with risk information produces sustained behaviour change; a 60 per cent average reduction in household arsenic exposure with one-third of households proactively requesting testing of additional sources.[67]

Identifying likely points of failure (running out of replacement filters, social pressure against mask-wearing, disruption during travel) and providing planned responses in advance of those obstacles further strengthens implementation.

Collective efficacy

Individual capability, even when supported by concrete plans, exists within a social context that can sustain or erode it. A family maintaining protective routines in isolation faces a different challenge from one whose neighbours are doing the same. Collective efficacy, defined as a group's shared belief in its capacity to achieve desired outcomes,[68] extends the logic of self-efficacy from the individual to the group level. Research on collective climate action has shown that people's willingness to engage in protective behaviour increases when they believe their participation contributes to a meaningful collective effort.[69]

Some protective behaviours are inherently collective: community water quality testing, coordinated school responses to air quality alerts, or collective advocacy for industrial emission controls require groups to act together. Others are individually performed but collectively reinforced: a family is more likely to maintain daily protective routines when their neighbours are doing the same, and they can share practical knowledge about what works.

CASE STUDY
The community-led response to lead poisoning in Zamfara State, Nigeria

Illustrates how collective efficacy operates in practice. Following the discovery that artisanal processing of gold ore had caused mass lead poisoning among children, with 97 per cent of children under the age of 5 showing blood lead levels above 45 µg/dL, the response required not only structural remediation but the rapid development of collective capability.[70] Community agreements to ban ore processing inside residential areas, combined with structural soil remediation, produced significant reductions in children's blood lead levels.[71,72]

Context and Habit

Recognize, Engage and Act address the psychological work of getting people to perceive a threat, care about it, and develop the capability to respond. They are the intervention. Context and Habit sit on the other side of that work.

Context concerns the conditions under which an intervention is delivered: will it land in this setting?

Habit concerns the conditions under which its effects are sustained: will the behaviours it produces last after the programme ends?

They serve a common purpose (ensuring that REA interventions achieve lasting impact) but operate through different mechanisms and require different design responses.

The reason they sit together in REACH is that the most common failure mode in environmental health programming involves both. A landmark randomized controlled trial in rural Orissa, India, distributed improved cookstoves at heavily subsidized prices. In the first year, households showed meaningful reductions in smoke inhalation. But gradually, the effect disappeared. Take-up was only 60 per cent higher in treatment households despite a near-full subsidy. Of those who adopted the stoves, only 36 per cent maintained them in good condition, and 40 per cent of those did not use them properly.[73] The stoves were well-designed. The health messaging was sound. What the programme lacked was both the contextual conditions for successful delivery (maintenance infrastructure, cultural compatibility with cooking practices) and the conditions for sustained adoption (routine integration, reinforcement and resilience to disruption).

The sections that follow treat Context and Habit separately, because they are separate challenges requiring separate analysis. Where they connect, particularly where social norms sustain behaviour, or where infrastructure design creates automatic protection, the text notes the connection.

4.4 Context
Conditions for delivery and impact

4.4.1 Definition

Context encompasses the cultural, social, economic and infrastructural conditions that shape whether a well-designed intervention achieves its intended effect in a specific setting.

4.4.2 Why context matters

The Bangladesh cookstove experience illustrates this directly. A trial of 3,000 households found that marketing focused on the health effects of indoor air pollution missed the mark. Consumers were already largely aware of the hazards. Women had stronger preferences for healthier stoves but lacked authority to make household purchases.[74,75] The binding constraint was the gendered power dynamics of household decision-making. The social context was the bottleneck, and no amount of improved messaging on environmental hazards could have unblocked it.

Context can be accounted for and leveraged. Accounting for context means identifying the conditions that could prevent an otherwise well-designed intervention from landing: economic barriers that make protective behaviours unaffordable, infrastructure gaps that make them impractical, cultural dynamics that make them unwelcome, or social structures that direct programme inputs to the wrong people. Leveraging context means using existing social structures, trusted institutions and cultural practices as delivery platforms that amplify the intervention's reach and credibility.

4.4.3 Approach for delivering interventions in context

The approaches below address the contextual dimensions that most frequently determine whether environmental health interventions succeed or fail. In COM-B terms, these are the physical and social opportunity conditions that must be present for behaviour to occur alongside capability and motivation.[76] Social and cultural conditions receive the most depth, because they are where programmes most frequently go wrong and where behavioural science thinking adds the most value beyond common sense.

Social and cultural conditions

Of the contextual dimensions that shape programme outcomes, social and cultural conditions warrant the most careful attention. Economic barriers are tangible and, when resources permit, addressable through subsidies or microfinance. Infrastructure gaps are visible and amenable to supply chain solutions. But social and cultural conditions operate through mechanisms that are less visible and more resistant to standardized responses: trust, gender dynamics, identity, community governance and the social meaning of protective behaviour. Programmes that fail to account for these conditions can produce outcomes opposite to those intended.

Gender dynamics and household decision-making. Protective behaviours in households are rarely individual decisions. They take place within structures of authority, negotiation and role expectation that vary across cultures but are pervasive in their influence. The Bangladesh cookstove study described above illustrates this: the women who bore the health burden and preferred cleaner cooking lacked the household authority to make purchasing decisions.[77,78]

This pattern recurs across environmental health domains. Decisions about household expenditure, technology adoption, children's activities and home modifications typically involve negotiation between household members whose priorities, exposure levels and decision-making power differ. Interventions that direct capability-building at the person who performs the behaviour while ignoring the person who controls the resources or grants permission will encounter a ceiling that REA alone cannot lift. Effective programmes identify who decides, who performs, and who controls resources, and design engagement and delivery strategies that address each role.

Cultural identity and the social meaning of behaviour. Protective behaviours are not performed in a cultural vacuum. They carry social meaning, and that meaning can support or undermine adoption. Studies of fuel switching in Kenya and Rwanda found that households with access to cleaner fuels still relied on charcoal for certain traditional dishes. Kerosene was considered unsuitable for grilling particular meats. Electric coil stoves were seen as producing unacceptable taste and appearance for staples.[79,80] The economic and infrastructure barriers had been addressed; the constraint was cultural. Cooking practices were tied to food identity, family tradition and the social expectations of a proper meal. The clean fuel was rejected because using it for certain dishes would mean serving food that did not meet cultural standards.

The FRESH AIR study (described in Section 4.3) addressed this by matching stove models to locally available fuels and existing cooking routines, removing a cultural barrier unrelated to awareness, motivation or skill.[81]

The implication for programme design is that cultural adaptation is not a surface-level exercise in translating materials into local languages. It requires understanding which aspects of a protective behaviour conflict with culturally valued practices, and designing interventions that work within those practices rather than asking people to override them. Programmes that force a choice between health protection and cultural identity tend to produce resistance rather than adoption.

Trust, credibility and the social infrastructure of delivery. Environmental health interventions depend on people accepting information and adopting practices recommended by external actors. The success of this process depends less on the quality of the information than on the social relationship between the source and the audience. Trust is specific to institutions, individuals and social roles.

The FRESH AIR study (described in Section 4.3) delivered interventions through existing women's savings groups with trusted peer educators, achieving $PM_{2.5}$ reductions of 31–65 per cent and improving respiratory outcomes.[82]

Religious and traditional institutions function similarly. The Zamfara community-led response to mass lead poisoning (described in Section 4.3, Collective efficacy) illustrates how mosques, community governance and traditional authority structures created the conditions for collective action that individual capability-building could never have achieved.

Social norms and collective reinforcement. Social conditions do not only shape whether an intervention is initially accepted. They also determine whether behaviour persists, creating an area where context connects directly to the sustainability concerns addressed in Habit (Section 4.5). When protective behaviours are performed by isolated individuals, they depend entirely on personal motivation, which is subject to erosion. When the same behaviours are performed within a social group that reinforces them, the desire to conform to group expectations and maintain social standing sustains them.

The Iran rice consumption study (described in Section 4.2, Social influence) demonstrated this directly: adding social support, community norms and group activities to individual health education produced 27.5 per cent higher safe consumption, with the difference persisting over six months.[83]

A community-level intervention in Uganda used social competition between neighbourhoods to reduce informal waste-burning without material incentives. Community leaders served as focal points for collective action. The threat of waste-burning was already recognized, and individual engagement techniques had not shifted behaviour because the practice was normalized. The social intervention reframed waste-burning from something everyone does to something the neighbourhood was moving past. The mechanism was social identity and collective pride.[84]

These examples illustrate a principle: social structures are among the strongest reinforcement systems available for sustained behaviour. When a behaviour becomes normative within a reference group, the same social forces that sustain all normative behaviour maintain it, rather than individual willpower. This makes social context both a delivery condition and, as discussed in Section 4.5, a form of habit infrastructure.

Economic conditions

Economic conditions determine whether motivation and capability translate into action. Where protective behaviours impose costs, whether in money, time or foregone income, affordability becomes the binding constraint regardless of what people know or feel about the threat.

In Kenya, a microloan programme for liquefied petroleum gas (LPG) equipment addressed the upfront cost barrier that prevented households from switching away from biomass fuels. Households that received the loans reduced their biomass use by 4.8 hours per week.[85] The motivation to switch already existed; what the programme provided was a financing structure that made the switch affordable. Similarly, in northwest Ethiopia, households who perceived improved cookstoves as affordable were 2.48 times more likely to adopt them than those who did not, independent of their awareness of the health risks.[86] In both cases, economic access converted existing motivation into action.

The reverse is equally instructive. At the Agbogbloshie e-waste site in Accra, Ghana, workers continued to burn cables to extract copper despite training on safer mechanical alternatives, because open burning yielded what they described as '100 per cent profit' with no equipment costs.[87] The economic incentive structure made the hazardous practice rational from the worker's perspective. Capability and motivation were both present; the economic logic of the situation overrode them. Effective economic interventions restructure these choices rather than asking people to act against their material interests. For outdoor workers exposed to extreme heat in India, employer-provided rest breaks, water and shading removed the trade-off between income and health protection, allowing workers to activate heat-protective behaviours that they had previously been unable to prioritize.[88]

Infrastructure and technology design

Infrastructure determines whether the action that REA makes psychologically possible is physically possible. A family persuaded to switch to cleaner fuel cannot do so without a supply chain. A community motivated to test blood lead levels cannot act without testing services. A household that wants to monitor indoor air quality needs access to monitoring equipment. Where infrastructure is absent, the gap between intention and behaviour is material, not psychological.

London home air quality monitors revealed $PM_{2.5}$ exceeded standards and triggered a 17 per cent decrease in pollutants as residents adapted behaviours upon seeing threats,[89] showing how infrastructure amplifies recognition and engagement.

Technology design is a contextual factor. As the FRESH AIR study showed (Section 4.3), matching stove models to local fuels and cooking practices improves adoption.[90]

Dong Mai's clothes-changing facility[91] combined with soil remediation (3,940 to below 100 mg/kg) produced 67 per cent blood lead reductions, demonstrating how environmental remediation plus behavioural infrastructure can protect informal recycling communities.

Free chlorine dispensers in Kenya at water sources increased chlorine use by 53 per cent, which was sustained for 30 months, by removing price barriers, creating visual cues and simplifying dosing.[92,93]

The most effective infrastructure makes protection automatic. Cool roof retrofits in Ahmedabad reduced temperatures by 2-5 degrees without any behavioural requirement.[94] For vulnerable populations, designing protection into the physical environment is more effective than behaviour-dependent interventions: a one-time modification provides continuous, passive protection.

Regulation and policy

Regulatory and policy environments shape the structural conditions within which all of the above operates. Effective regulation can eliminate the need for individual behaviour change entirely; congestion charges reduce traffic-related air pollution through price signals rather than health messaging,[95] and token charges for single-use plastics reduce the feedstock available for informal waste-burning.[96]

Policy environments can also actively enable behavioural interventions. Bogotá's Barrios Vitales programme redesigned a high-traffic neighbourhood by introducing pedestrian zones, replacing roads with bike lanes, and adding green spaces. Public transit use and cycling and scooter use increased by over 80 per cent.[97] The policy changes did not rely on health messaging to shift transport behaviour; they restructured the physical and economic environment so that lower-emission choices became the most convenient options available. This is policy as context intervention; creating conditions in which the behaviours that REA promotes become the path of least resistance.

Regulatory enforcement can eliminate the need for individual behaviour change by restructuring the conditions under which hazardous exposures occur. Case study: the Bangladesh turmeric enforcement campaign (described in Section 4.1, Sensory Detection Enhancement) achieved this at an estimated cost of approximately US$1 per disability-adjusted life year averted.[98] In Guiyu, China, the mandatory relocation of all e-waste workshops to an industrial park with exhaust hoods, filtration and physical separation from residential areas produced sustained declines in children's blood lead levels, from a mean of 15.3 µg/dL in 2004 to 7.06 µg/dL by 2013.[99,100,101] Both cases demonstrate how regulatory action can achieve population-level protection that individual behaviour-change programmes cannot. The evidence base for behavioural approaches to e-waste exposure remains extremely thin and represents a priority for future research.

Changing policy is typically beyond the scope of behavioural programming, but understanding the policy environment is not. Programmes should assess whether existing regulation supports or undermines the behaviours they promote, identify opportunities where modest policy shifts could amplify programme impact, and be realistic about the gap between regulation on paper and enforcement in practice.

Advocacy as a contextual lever

The contextual barriers described above, absent infrastructure, weak regulation, misaligned economic incentives, are not fixed features of a setting. They can be shifted through organized advocacy. When nine-year-old Ella Adoo-Kissi-Debrah, who lived 25 metres from the South Circular road in London, died from acute respiratory failure in 2013, the original coroner's verdict made no mention of air pollution. Her mother campaigned for seven years to secure a second inquest. In December 2020, the coroner ruled that air pollution was a cause of death, finding that Ella had been exposed to levels of nitrogen dioxide and particulate matter exceeding World Health Organization guidelines, principally from traffic emissions, and that her family had never been provided with information about the health risks.[102] The ruling was the first anywhere in the world to name air pollution as a direct contributor to a death. It catalysed the expansion of London's Ultra Low Emission Zone to cover the entire city, and Ella's Law, a Clean Air (Human Rights) Bill that would establish legally binding air quality limits aligned with WHO standards, is now progressing through Parliament. In Flint, Michigan, a paediatrician who gathered blood lead data from local hospitals and a resident who had her household water independently tested forced a national reckoning with lead in drinking water infrastructure. Community pressure produced a US$97 million settlement for pipe replacement and a state-wide mandate requiring removal of all lead service lines over 20 years.[103] In both cases, the structural conditions that permitted harm did not change until affected communities made them politically untenable.

These examples illustrate a recurring pattern: community advocacy operates on context by converting individual experience into collective evidence, directing that evidence at decision-makers, and sustaining pressure until structural conditions shift. For practitioners designing environmental health interventions, this has a practical implication. Where contextual barriers are rooted in policy failure or institutional neglect, building the capacity for advocacy may be as important as building the capacity for individual protective behaviour. This connects to the collective efficacy described in Act (Section 4.3), but the objective differs. Collective efficacy in Act concerns groups performing protective behaviours together. Advocacy concerns groups changing the conditions that make those behaviours necessary, difficult or impossible. Both are needed. An intervention that helps families filter contaminated water addresses immediate exposure. An intervention that builds the community's capacity to demand clean water infrastructure addresses the reason the filters are needed. The most effective programmes pair immediate protection with longer-term structural change, ensuring that individual-level behavioural support does not become a substitute for the systemic action that would make it unnecessary.

4.5 Habit
Conditions for sustained behaviour

4.5.1 Definition

Habit encompasses the routines, environmental cues, reinforcement systems and design choices that determine whether protective behaviour persists once established.

4.5.2 Why habit matters

Environmental health threats are chronic and require sustained behaviour change over years. Initial motivation is insufficient; what sustains protective behaviours is habit: the shift from conscious decision to automatic response triggered by context rather than deliberation.

Habit is the mechanism by which the intervention's effects are preserved after programme resources are withdrawn.

4.5.3 Approach for sustaining protective behaviour

Sustaining protective behaviour requires four conditions. The behaviour must be cued by the environment so that it is triggered without conscious deliberation. It must be easy enough that friction does not erode compliance. It must be reinforced through feedback, social norms or visible results so that the person has a reason to continue. And it must be resilient to the disruptions that inevitably occur in daily life. The approaches below address each of these conditions, beginning with the design of the physical environment and moving through routine integration, reinforcement and resilience.

Figure 6 Conditions for sustained behaviour

Habit | Conditions for sustained behaviour

Four conditions that determine whether protective behaviour persists once established.

Condition 1

Cued Place cues at the moment and location of decision. Link new behaviours to existing routines.

Air quality monitor in the kitchen – visible at the point where cooking decisions are made.

If absent: behaviour depends on memory, which decays under competing demands.

Condition 2

Easy Reduce friction. Design protective actions to fit existing constraints. Make the default protective.

Alternative walking routes should only be marginally longer than original polluted routes to encourage uptake (Antwerp).

If absent: motivated people abandon behaviours that require too much effort.

Condition 3

Reinforced Provide feedback through monitoring. Leverage social norms and group identity. Make progress visible.

Real-time $PM_{2.5}$ data showing behaviour reduces exposure. Social competition reducing waste burning (Uganda).

If absent: perceived value erodes when effects are delayed and invisible.

Condition 4

Resilient Build flexibility. Teach principles, not just procedures. Integrate behaviour into identity.

Understanding that wet cleaning captures lead dust (principle) allows adaptation when supplies change.

If absent: habits break on first disruption and are not recovered.

Environmental design and automaticity

The shift from deliberate to automatic behaviour depends on the consistency of the context in which the behaviour is performed. A behaviour triggered by the same cue, performed in the same setting, and followed by a consistent outcome develops into a habit more rapidly than one performed in variable conditions.[104] Choice architecture extends this logic to the design of environments: rather than relying on people to remember and choose protective behaviour every day, the environment can be structured so that protection is the path of least resistance.[105] For environmental health, this has a direct design implication: the physical environments in which protective behaviours must occur, homes, schools, workplaces and community spaces, can be structured to provide the cues and reduce the friction that make those behaviours automatic.

Cue design. In communities affected by lead contamination, a handwashing station positioned at the entrance to a dwelling, where it is visible and unavoidable, cues the handwashing behaviour that removes lead dust from children's hands before they eat or touch their faces. A basin kept under a shelf in another room does not. The placement of the station is itself an intervention: it creates a cue-response association between arriving home and washing hands that, with repetition, reduces the need for a conscious decision. Similarly, an indoor air quality monitor placed in the kitchen, where cooking decisions are made, provides a context-specific cue that connects real-time pollution data to the point of action. The Smoke Sense wildfire app paired real-time air quality data with specific 'if-then' action rules, converting variable environmental conditions into consistent situational cues: when the app signals a threshold, the response is pre-determined.[106] In each case, the cue is designed to appear at the moment and location where the decision is made, not at a point removed from it.

Friction reduction. Protective behaviours that require preparation or additional effort are more vulnerable to abandonment than those designed to be easy. The personalized walking route intervention in Antwerp illustrates this: suggested alternatives were constrained to routes only marginally longer than existing ones, requiring no additional equipment or changes in travel mode.[107] Had the programme recommended routes that added 20 minutes or required crossing a busy road, the same parents who adopted the low-friction alternative would likely have reverted. For household air pollution, cookstove programmes that require families to source unfamiliar fuels or learn entirely new cooking techniques impose friction that undermines adoption, whereas programmes that match stove design to existing fuel availability and cooking routines, as the FRESH AIR study did, reduce the friction of daily use.[108] Friction reduction is not about making behaviour mindless; it is about removing the logistical obstacles that cause motivated people to give up.

Default design. The strongest form of environmental shaping occurs when the default state of the environment is itself protective. Water filtration systems that treat water at the point of entry provide protection regardless of whether the household remembers to act. Building ventilation designs that maximize airflow without occupant intervention reduce indoor air pollution passively. The cool roof retrofits described in Section 4.4 illustrate the principle at its most direct: a one-time modification that provides continuous, passive heat protection without any ongoing behavioural requirement. Where it is possible to design the default state as protective, doing so is both more effective and more equitable than relying on individuals to consistently choose the right option, because it protects those with the least capacity for sustained deliberate behaviour, including young children, the elderly and households under the greatest economic pressure.

Routine integration

New behaviours are more readily maintained when they are anchored to existing routines rather than requiring the establishment of entirely new ones. This exploits the cue-response structure that underpins habit formation: an established behaviour serves as the cue for a new one. Checking an air quality index as part of a morning routine that already includes checking the weather requires less cognitive effort than establishing a stand-alone monitoring practice. Incorporating surface-wiping for lead dust-control into an existing after-school routine of unpacking bags and preparing snacks attaches the new behaviour to a stable contextual cue.

This transition occurs naturally through repetition of the same behaviour in the same context, provided the contextual conditions described in Section 4.4 remain stable.

Several of the interventions described in earlier sections illustrate how contextual and infrastructure design can create the conditions for habit formation. The Kenya chlorine dispensers (Section 4.4) achieved sustained uptake at approximately 50 per cent for more than 30 months because the dispenser placement created a consistent cue-behaviour loop at the point of water collection: the same location, the same action, the same moment in the daily routine. Case study: The Dong Mai clothes-changing facility (Section 4.4) institutionalized a new hygiene routine by providing a physical space that made the behaviour automatic rather than discretionary. In Uganda, SMS nudges following a pesticide safety workshop attempted to sustain behaviour through digital reinforcement, though practice change remained constrained by economic barriers (see Section 4.3).[109] These cases suggest that the most durable habits are those anchored to physical infrastructure that provides the cue, reduces the friction, and makes the protective behaviour the path of least resistance.

Reinforcement and maintenance

Automaticity alone does not guarantee persistence. Habits can be disrupted by changes in routine (travel, illness, household changes), by shifts in the environment (supply-chain failures, seasonal variation), or simply by the absence of any signal that the behaviour is working. Environmental health behaviours are particularly vulnerable to disruption because they protect against threats whose effects are delayed and invisible. A family maintaining dust-control practices for lead cannot see whether blood lead levels are declining. A household timing outdoor activities to avoid peak air pollution cannot perceive whether their actions have reduced cumulative respiratory harm. Without feedback, the perceived value of the effort erodes.

Feedback and monitoring as reinforcement. Monitoring infrastructure serves a dual function in the REACH Framework. As discussed in Recognize (Section 4.1), it makes threats visible and supports risk calibration. But it also functions as a reinforcement system for sustained behaviour. When a family can see that their indoor air quality readings have declined since switching fuels, or that their child's blood lead level has dropped following dust-control practices, the monitoring data reinforces the behaviour by making its benefits visible.

Where individual monitoring is not feasible, community-level feedback can serve a similar function. The Smell Pittsburgh programme transformed individual, fleeting sensory experiences into a collective data set. Residents discovered that their collective smell reports correlated with industrial emissions data.[110,111] The community monitoring system provided ongoing collective feedback that validated and reinforced individual protective behaviours.

Digital feedback loops. Three mechanisms are particularly relevant: threshold alerts for discrete action cues; personal exposure tracking (personal $PM_{2.5}$ exposure varied by up to 300 per cent from area-level estimates);[112] and longitudinal tracking to make progress visible.

Digital tools are not a substitute for the social and environmental conditions described above. An air quality app is useless to a household without a smartphone, and personalized data is ineffective where the recommended actions are unaffordable or impractical. But where the contextual conditions described in Section 4.4 are in place, technology-enabled feedback can provide the reinforcement mechanism that keeps behaviour going after initial motivation fades.

Social reinforcement operates through conformity to group norms, shared routines and mutual accountability. Families maintain protective behaviours more readily when neighbours do the same, and peer educators modelling behaviours within existing social structures provide ongoing reinforcement without requiring dedicated resources.

Resilience to disruption. Habits break. Routines are interrupted by illness, travel, seasonal changes, economic shocks or changes in household composition. The question is not whether disruption will occur but whether the conditions for recovery are in place. Interventions that build flexibility into protective behaviour, offering multiple ways to achieve the same protective outcome rather than a single prescribed routine, are more resilient to disruption. A family that understands the principle behind dust-control (wet cleaning captures particles; dry cleaning disperses them) can adapt when their usual supplies are unavailable, in a way that a family trained only in a specific sequence of steps cannot.

Identity integration provides a further source of resilience. When protective behaviour becomes part of how a person understands themselves ('I am someone who protects my children from this threat'), lapses are experienced as inconsistencies to be corrected rather than as evidence that they have abandoned the behaviour. This connects to the engagement work described in Section 4.2: the emotional commitment and personal relevance built through engagement become the identity foundation on which habit resilience rests.

5. How to use the REACH Framework


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This section supports the move from understanding the REACH components to applying them: identifying the barriers in your context, deciding where to focus, and sequencing interventions.

Environmental health challenges are too varied for a single procedure to substitute for judgment. The process is qualitative and meant to be adapted to every context and hazard. The process below structures the thinking into three phases:

- understand your situation
- decide where to focus
- design your intervention

A worked example (lead contamination near a battery recycling site) illustrates the process, with contrasting examples from other threats.

EXAMPLE
Lead contamination near a battery recycling site

To illustrate how these questions work in practice, consider a community living adjacent to an informal battery recycling operation in a low-income peri-urban area.

Recognize. Families know the site produces fumes but don't connect it to lead contamination or see children's illness as preventable. No monitoring or testing exists.

Engage. Parents care about health but frame illness as medical rather than environmental. The recycling operation provides livelihoods, creating income-health trade-offs. No organized community voice exists on lead exposure.

Act. Families don't know protective actions: wet cleaning versus sweeping, work-clothes management, dietary interventions. Workers lack equipment and carry contamination home.

Context. The operation is informal and unregulated; no employer equipment or site remediation exists. No testing infrastructure. Opportunities: active health workers and interested NGO partners.

Habit. No protective habits exist. Workers change clothes at home, carrying contamination indoors. Children play freely in contaminated areas. No cues or routines for lead reduction.

This picture reveals a pattern across components: recognition is partial (people see symptoms but not causes), engagement is misdirected (concern exists but is channelled towards treatment rather than prevention), action capability is almost entirely absent, context presents serious barriers alongside genuine entry points, and habit has no foundation to build on.

A different threat would produce a different picture. For a community experiencing extreme heat during agricultural work, Recognition might be strong (people feel the heat and know it is dangerous) but Context might be the binding constraint, because workers cannot afford to stop during peak hours. The reflective questions are the same; what they surface is different.

Phase 1 Understand your situation

Before designing any intervention, you need a clear picture of where the barriers lie. This means examining your context through each of the five REACH components to understand what is and is not working, and why.

For each component, Figure 7 offers reflective questions to guide this process. Some you will be able to answer from existing data or programme experience. Others may require conversation with communities, front-line workers or local stakeholders. The aim is not to complete a checklist but to surface the specific nature of the challenge within each component. A 'recognition gap', for instance, can mean very different things: people may be entirely unaware that a threat exists, or they may be aware in principle but unable to detect it in their own environment, or they may detect it but have normalized it to the point where it no longer prompts concern. Each calls for a different response.

Figure 7 **Phase 1: Situational diagnostic**

Work through each REACH component to surface the specific barriers in your context. The core question frames the assessment; the checklist items guide what to investigate. These questions are illustrative, not exhaustive. Add your own based on what you know about your setting.

Recognize

Can people perceive the threat and understand how it connects to their health?

- How do people explain the health problems they observe?
- Is the threat invisible, normalized, or both?
- Can they identify sources of exposure in their environment?
- Do they have access to monitoring tools or test results?

Engage

Does the threat register as something that matters enough to act on?

- Where does this threat sit among daily concerns and priorities?
- What emotional response does the threat provoke: fear, fatalism, indifference?
- Do people feel it is personally relevant to their family?
- Are there existing social norms around protective behaviour?

Act

Do people know what to do and feel capable of doing it?

- Can people name specific protective actions they could take?
- Are there existing practices that already offer some protection?
- Have they tried and abandoned protective behaviours before? Why?
- Could collective action succeed where individual action feels insufficient?

Context

Does the surrounding environment support or undermine protective behaviour?

- Are materials and infrastructure available and affordable?
- Do existing policies support or hinder protective action?
- Who holds decision-making power in the household and community?
- What institutions or platforms could deliver the intervention?

Habit

Are protective behaviours, where they exist, sustained over time?

- Are behaviours occurring automatically or requiring constant reminders?
- Have previous programmes established behaviours that later faded?
- Are there environmental cues embedded in daily routines?
- Do people identify as protecting their family from this?

NEXT STEP Once you have assessed each component, identify which barriers are most severe and where you have the most leverage. This determines your entry point and emphasis, see Phase 2.

Phase 2 Decide where to focus

Understanding your situation is necessary but not sufficient. You also need to decide where to direct your limited resources. Three considerations should inform this decision.

Where are the barriers most severe? Your reflections from Phase 1 will have surfaced the components where the gaps are widest. These are where the need is greatest, and where progress would make the most difference to health outcomes.

Where do you have genuine leverage? Not every barrier is equally amenable to intervention. Some require policy change, institutional reform, or infrastructure investment that may be beyond your programme's reach. Others require community trust that takes years to build. Be honest about what you can realistically influence given your time, funding, partnerships and relationship with the community.

Where would progress unlock movement elsewhere? REACH components interact: progress in one often enables progress in others, while neglecting one can constrain the rest.

The point of intersection between these three considerations (greatest need, greatest leverage, and greatest potential for knock-on effects) is where you should focus first. Sequence your effort so that early investments create the conditions for later ones.

The structural change tension

Structural change (bans, regulations, infrastructure) is most effective but often beyond individual programmes' control and requires years to materialize. This creates a dilemma: behaviour-only focus burdens victims; reform-only focus leaves communities unprotected during waiting periods. The practical approach is dual-track: pursue structural changes you can influence (evidence generation, advocacy, coalition-building) while providing interim protective actions with clear messaging: 'these steps reduce exposure while we address the source.' The REACH components (Recognize, Engage, Act, Habit) are not alternatives to Context but what you do while pursuing contextual change.

Returning to the worked example

For the battery recycling community, the programme team might reason as follows. Recognition is partial, but the deeper problem is that the community lacks any way to see the threat. There is no monitoring, no testing, no data. Without this, engagement will remain misdirected and action will have no foundation. The team has a partnership with a regional NGO that could support a blood lead testing campaign, which would simultaneously build recognition (making an invisible threat visible through personal health data) and catalyse engagement (transforming abstract concern into specific, personal urgency). This suggests that recognition is the right starting point, not because it scored lowest, but because it is the component where progress would most effectively unlock movement across the others.

On the structural track, the team begins documenting contamination levels and health impacts to build an evidence base for regulatory action, while working with the health worker programme to establish soil covering in children's play areas and change-stations where workers can remove contaminated clothing before entering the home.

Contrast this with the heat-exposed agricultural community, where recognition is already strong. There, the bottleneck is context: workers know the danger but cannot avoid it without changes to work schedules, employer expectations or shade infrastructure. Starting with more awareness-raising would be redundant. The focus should be on advocacy and structural change, with individual-level action strategies (hydration, rest-seeking, recognizing early symptoms) offered as interim protection while longer-term contextual shifts are pursued.

Phase 3 Design your intervention

With a clear understanding of your situation and a focus for your effort, you are ready to design. Five considerations should guide this process.

1. Select evidence-based strategies. For each priority component, identify strategies from the relevant guide section (Sections 4.1 to 4.5) that have worked in comparable contexts. Treat them as materials to adapt, not templates to copy. No strategy transfers wholesale from one setting to another.

2. Centre the design in local context. Consider who holds decision-making power, what cultural values can be leveraged, what practices already offer partial protection, and what social dynamics might support or undermine your intervention. Section 4.4 addresses these questions in depth. For the battery recycling community, this might mean recognizing that the mothers' group is a more trusted platform than formal institutions, and that framing protection as an extension of existing maternal care practices may be more effective than framing it as a response to industrial pollution.

3. Plan the sequence. Recognition and engagement typically precede action-focused interventions, and habits require a clear protective behaviour to anchor to. Crisis situations may require immediate action first; community-led programmes may start with engagement. Sequence based on your situation, not a pre-determined order.

4. Coordinate individual and structural interventions. Where your design spans multiple levels, plan how they reinforce each other. Be transparent with communities about what individual action can and cannot achieve. Frame household behaviours as meaningful steps that reduce exposure, not as substitutes for the structural changes that are also needed.

5. Build in evaluation and iteration. Include monitoring checkpoints to assess whether each component is shifting as intended. Expect to revisit your Phase 1 reflections, as interventions frequently reveal that initial understandings were incomplete. A recognition campaign may surface the fact that engagement is lower than expected. A context modification may reveal that the habit challenge is different from what you assumed. Treat these discoveries as information, not failures. REACH is an iterative process. The three phases described here are a first pass, not a final plan.

Quality check: Common integration mistakes

Before finalizing your design, review it against the following failure modes. Each recurs across environmental health programmes and is often visible only in hindsight.

Table 6 Common integration mistakes, warning signs and check questions

Mistake	What it looks like	Check question
Action without context	Encouraging protective behaviours that the surrounding environment makes impractical. E.g., advising families to use LPG where it is unaffordable or supply is unreliable. The likely result is frustration, disengagement or blame directed at individuals.	Does your intervention ask people to do things that the current context allows them to do?
Engagement without recognition	Triggering concern without ensuring people understand the hazard well enough to act on it, e.g., telling parents lead harms brain development when they do not know where lead is found or how to avoid it. The result is confusion, fatalism or misplaced fear.	Will the people you are trying to engage have a clear enough understanding of the threat to know what their concern should lead them to do?
Habit without foundation	Attempting to establish sustained routines without the preconditions: understanding, motivation and feasible action, e.g., promoting daily water filtration without ensuring households understand contamination risks or have affordable filters.	If you removed all programme support tomorrow, would the target behaviours have enough foundation to continue?
Context without community	Imposing structural changes without community involvement, e.g., banning kohl (a traditional cosmetic containing lead) without engaging the communities that use it. Regulation without legitimacy invites workarounds rather than compliance.	Have the communities affected by your structural interventions been involved in shaping them?
Recognition without solutions	Raising awareness without offering feasible actions, e.g., publicizing high blood lead levels without offering remediation or guidance. Awareness without agency increases helplessness and erodes trust.	For every piece of risk information you communicate, is there a corresponding action people can realistically take?

6. Conclusion

The process described in this section (understanding your situation, deciding where to focus, and designing an integrated intervention) is a starting framework, not a finished methodology. It helps you think systematically about a class of problems that resist simple solutions, and to use the REACH components as a lens for identifying what is missing and what is possible in your specific context.

Two principles are worth holding onto throughout. The first is that environmental health protection depends on progress, not perfection. Cumulative exposure drives health harm, and even partial reductions, sustained through habit formation and supported by enabling environments, can meaningfully improve outcomes. Modest, sustained changes produce greater cumulative benefit than ambitious changes that are not maintained.

The second is that the most effective interventions are those that communities come to own. External programmes can catalyse recognition, build capabilities and improve structural conditions. But lasting protection depends on communities internalizing the motivation, knowledge and practices that the REACH Framework describes, so that protective behaviour continues because it has become part of how people understand and respond to the threats in their environment.

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