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An independent academic psychologist, based in England, who has written extensively on different areas of psychology with an emphasis on the critical stance towards traditional ideas.

A complete listing of his writings at <http://psychologywritings.synthasite.com/>. See also material at <https://archive.org/details/orsett-psych>.

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1. PLASTIC AND MICRO-PLASTICS

- 1.1. Plastics
- 1.2. Micro-plastics
- 1.3. References

1.1. PLASTICS

Abu Noman et al (2025) viewed plastic production and waste as a key issue. They stated: "About 99% of plastics are derived from fossil fuels, and each stage of the plastic life cycle releases greenhouse gases. The estimated 450 million tonnes of plastic produced per year account for about 12% of global oil extraction and 8.5% of gas extraction. Under a business-as-usual trajectory, plastic production will likely triple by 2050, with each additional tonne produced from fossil fuels generating 1.89 to 2.3 tonnes of carbon dioxide (CO₂) emissions. The plastic life cycle contributes roughly 3 to 8% of total global greenhouse gas emissions currently and will likely consume 15% of the global carbon budget by 2050" (Abu Noman et al 2025 p1048).

It has been estimated that only around one-sixth of collected plastic waste is recycled, and the collected plastic waste for recycling is about one-quarter of the total plastic waste (Cuff 2025). Consumer packaging makes up about half of the waste. "Consumer packaging is cheap and discarded quickly, often used only once before being thrown away. It is expensive to for recycling companies to collect and sort, and the sheer variety of plastic types and additives used in packaging makes it tricky to distinguish between what can be recycled and what can't" (Cuff 2025 p11).

This view has led some countries to burn plastic waste instead of recycling it. But "we shouldn't rush to abandon recycling completely", Cuff (2005) advised (quoting Andrew Dove of the University of Birmingham), "the key is to get the right mix of regulations, public behaviour and policies in place" (p11). New technologies to sort plastics, and to break them down will help (Cuff 2025).

1.2. MICRO-PLASTICS

Micro-plastics (ie: less than 5 mm in size) have been found in human bodies in studies. They form as larger pieces of plastic break down, and enter the body

through food, water, and air (Wade 2024). Are micro-plastics impacting human health?

One claim is that 10 grams of plastics can be isolated from a post-mortem human brain (Kozlov 2025). Nihart et al (2025) reported 50% higher levels of micro-plastics in post-mortem brain samples from 2024 than from 2016.

In terms of live human studies, for example, a correlation has been found between the presence of micro-plastics in the arteries and the likelihood of heart attack or stroke in adults (Marfella et al 2024).

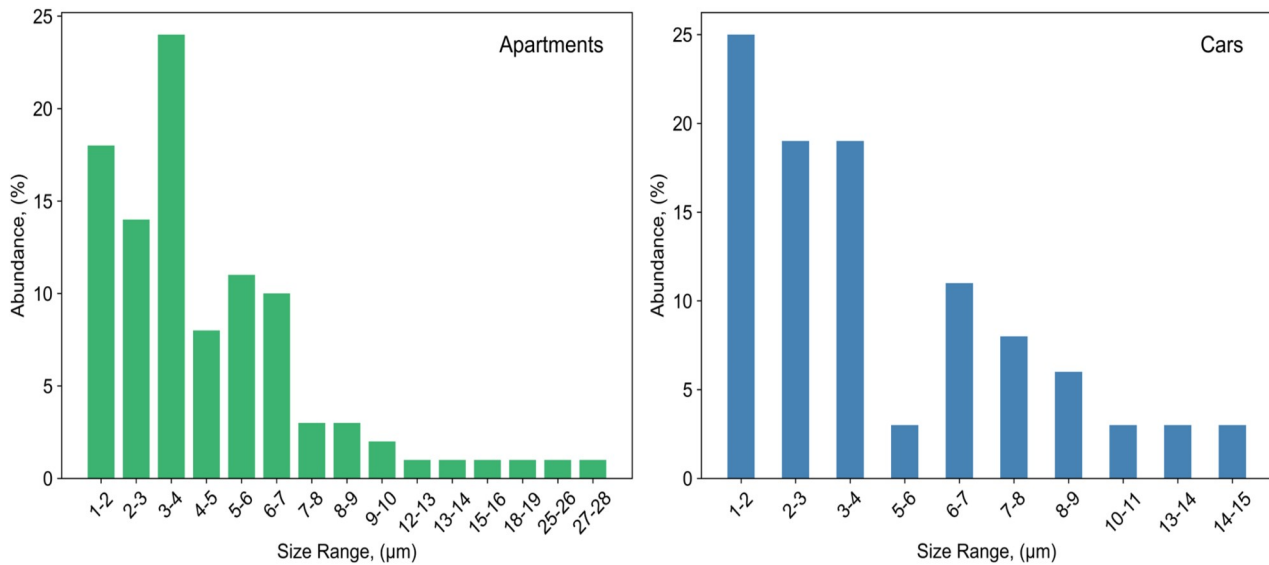
Direct causation tends to be based on animal studies (eg: Chartres et al 2024; Huang et al 2025), which show detrimental effects. But such experiments use much higher concentrations of micro-plastics than humans experience (Wade 2024).

Thompson et al (2024) have pointed out another set of problems - namely that micro-plastics come in a range of shapes, sizes, and materials, whereas most studies use polystyrene or polyethylene, and spherical (rather than irregular) shapes, for instance (Wade 2024). There is "no one 'micro-plastic'" (Kozlov 2025 p311). Other methodological issues include the analytical approach to detect and characterise micro-plastics, the use of pristine micro-plastics in experiments, dosage, and mode of ingestion (Kozlov 2025).

Airborne micro-plastics (MPs) in indoor air is a risk. In fact, the concentration may be higher than in outdoor air (eg: Liao et al 2021). "Given that people in developed nations spend approximately 90% of their time indoors, including 5% in cars, the potential for inhalation exposure to MPs in indoor environments is significantly higher and warrants attention" (Yakovenko et al 2025 p2).

Yakovenko et al (2025) sampled the air in three different indoor environments - bedrooms, home offices, and living rooms - in three apartments in Toulouse, France, and inside two different cars in 2023. MPs suspended in the air were collected by vacuum pumps for analysis.

The dominant fragment type in the residential environments was polyethylene, and inside the cars polyamide. It was estimated that adult indoor MP inhalation was between 3000 to 68 000 MPs per day. These figures were 100-fold higher than previous research because Yakovenko et al (2025) collected smaller MPs (eg: 1-10 μm) (figure 1.1).



(Source: Yakovenko et al 2025 figure 3)

Figure 1.1 - Size distribution of MPs (μm) found in seven apartments and five cars.

“Finding micro-plastics in marine species is now unfortunately a norm” (Nina Wootton of the University of Adelaide in Australia quoted in Woodford 2024). Dziobak et al (2024) found micro-plastics in the exhaled breath of eleven bottlenose dolphins tested off Florida and Louisiana in 2023. The most common particle was polyethylene terephthalate (figure 1.2).

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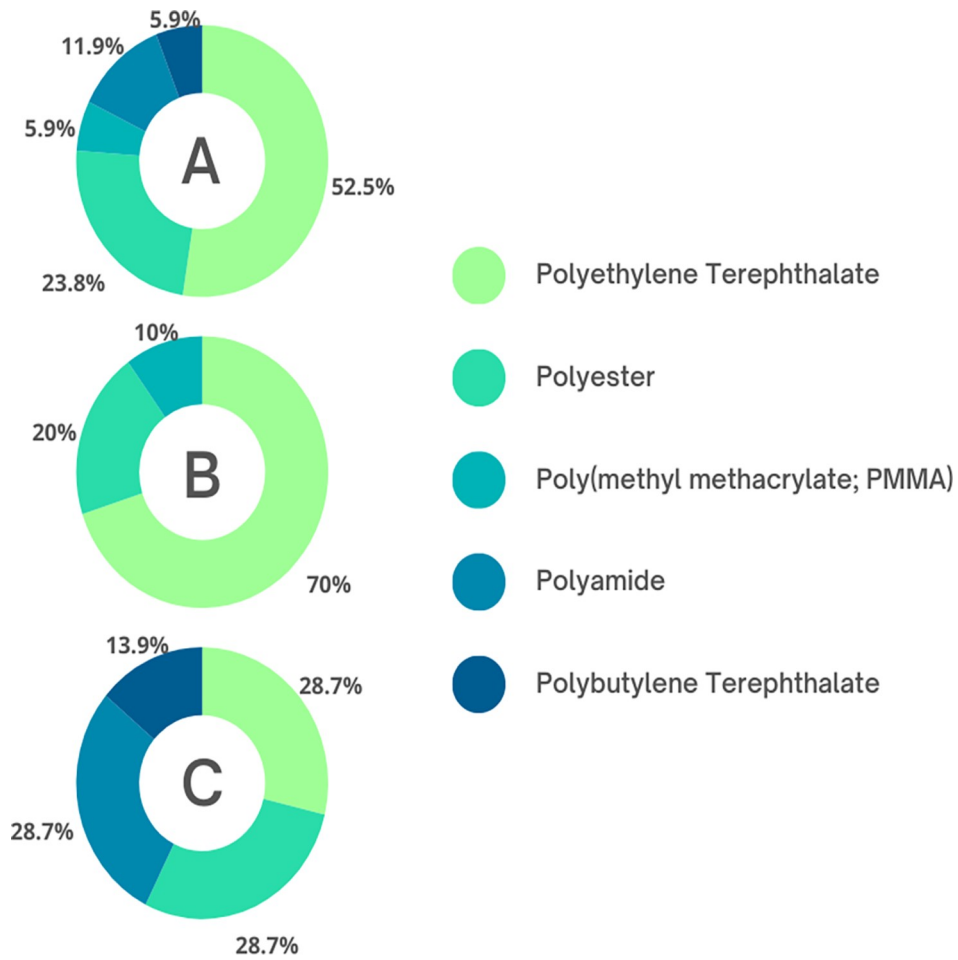
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(A = whole sample; B = Sarasota Bay, Florida; C = Barataria Bay, Louisiana)

(Source: Dziobak et al 2024 figure 3)

Figure 1.2 - Types of micro-plastics found in exhalation of dolphins.

2. HUMAN IMPACTS

- 2.1. Anthropogenic noise
- 2.2. Heat
 - 2.2.1. Urban heat island
- 2.3. Cleaner energy and health
- 2.4. References

2.1. ANTHROPOGENIC NOISE

“Human-induced rapid environmental change” (HIREC) (Sih et al 2016) is “a modern-day phenomenon, arising from population growth, urbanisation, and industrialisation. Under the umbrella of HIREC, habitat loss and fragmentation, climate change and various forms of pollution can compromise the fitness and behaviour of animals at a greater rate than they have previously experienced or have the cognitive flexibility to overcome... Anthropogenic (human-generated) noise, defined as unwanted, unpleasant, or non-functional sound..., is an integral part of HIREC... that can negatively affect the health and well-being of humans... and other animals” (Steinbrecher et al 2023 p1).

Steinbrecher et al (2023) studied anthropogenic noise and captive individuals, specifically pied tamarins at Jersey Zoo, British Channel Islands. Recorded gardening machinery noise was played to ten pairs of tamarins in a wooden box (380 x 240 x 55 mm) containing food. Foraging (ie: number of waxworms eaten out of fourteen hidden in wood shavings), and vigilance¹ were measured in ten-minute bouts.

There was significantly less foraging frequency in the noise versus non-noise condition (ie: looking into the wooden box), but no difference in foraging success or vigilance. There were individual differences in the impact of the noise.

There was the possibility that as zoo housed animals the impact of noise was less than if in the wild, admitted the researchers. Cronin et al (2018), for example, had found that three species of zoo housed primates that had lived longer in such environments were less affected by the noise.

Noise impacts human child’s cognitive development. “It is suggested that noise may impact cognitive

¹ Defined as “Visually scanning the surroundings, head pointed horizontal, upwards or onto the ground” (Steinbrecher et al 2023 p4).

abilities directly or lead to impaired attention, frustration, learned helplessness, arousal, or tuning out, which could impact performance and learning in the long term" (Foraster et al 2022 p3). Rodent experiments, for example, have shown differences in the brain with exposure to noise (eg: reduced dendrite numbers in the hippocampus; Foraster et al 2022).

Longitudinal studies of schoolchildren exposed to aircraft noise have been reported. "However, the available evidence for the association between exposure to road traffic noise and children's cognition is still limited and based only on cross-sectional studies. In specific, it is unclear how noise could affect working memory or attention, which are essential for learning and school attainment and which develop actively between 6 to 10 years of age as a result of cognitive maturation" (Foraster et al 2022 p4). Most of the studies have concentrated on home and/or outdoor exposure to road traffic noise. Foraster et al (2022) reported a longitudinal study of road traffic noise exposure at home and at school on working memory and attention.

It was part of the BREATHE (Brain Development and Air Pollution Ultra-fine Particles in School Children) project, which was undertaken in Barcelona, Spain, in 2011 to 2016. Noise pollution was included. Thirty-nine schools with nearly 3000 7-10 year-olds were involved. Average noise levels were sampled in classrooms and outdoors (playground and on local streets) at school at the beginning of the academic year, while noise levels at home were estimated from official data. Working memory and attention were measured by standardised tests at least four times.

Outdoor school noise exposure was associated with slower development in working memory, and poorer attention, while indoor school noise exposure level was associated with inattention only. Road traffic noise at home was not associated with the outcome measures.

2.2. HEAT

Extreme heat events (both dry and humid types) have a negative impact on human health. Matthews et al (2025) reviewed the mortality threat from increases in these events due to global warming.

Dry extreme heat is a higher temperature (eg: 50 °C), while humid heat extremes can occur at a lower temperature but with more moisture in the air. Extreme heat events are those historically rare or record setting

in an area. Fourteen heat events worldwide have involved more than 1000 deaths per event since the year 2000. For example, Europe in July-September 2023 over 47 000 deaths estimated as linked to the heat (Matthews et al 2025).

Mortality risk from heat is linked to certain factors like older age, health condition (eg: cardiovascular disease), behaviours and socio-economic status (eg: agricultural work during the day). Physiological acclimatisation (with behavioural and technological aids) is another variable (Matthews et al 2025). The focus is upon the direct impact of heat (ie: via heat stress), but there are indirect impacts (eg: crop failure and starvation).

Ballester et al (2023) analysed Eurostat mortality data for 2022. The data covered 35 European countries with a total population of over 543 million people. Heat-related deaths were estimated for the period 30th May to 4th September - 61 672 in total. Italy, Spain, Germany, Greece and Portugal had the highest rates. More heat-related mortality was observed for women than men (particularly older ones, 80 years and above).

The mean summer temperature in 2022 was 20.30 °C, which was the warmest on record to that point (eg: 2003: 20.20 °C). The mean temperature for the three months of summer (June, July and August) is obviously the average, so that the peak days were much higher. The highest mortality areas had peaks 2-3 °C above usual values for their area. That may not seem too bad on paper, but there was a prolonged period of heatwave in many areas.

2.2.1. Urban Heat Island

The "Urban Heat Island" (UHI) effect describes how urban areas are warmer than the surrounding rural areas. This can be mitigated with green spaces within, and particularly around the urban areas ("neighbouring rural land cover"; NRLC) as shown in a study of temperature data from thirty Chinese cities between 2000 and 2020 (Yang et al 2024). Put simply, an urban area would benefit from a clear "greenbelt" around it. The UHI could be reduced by up to 0.5 °C by NRLC within a 10-15 km radius of the urban boundary (Yang et al 2024).

2.3. CLEANER ENERGY AND HEALTH

The transition from fossil fuels to renewable energy

sources will have health benefits including a "rare win-win strategy" (p315) of healthier society and cleaner environment (Bell and Gillingham 2025).

Bell and Gillingham (2025) selected five examples:

i) More public transportation and less individual automobiles will lead to lower air, water, and noise pollution, and fewer deaths, including from vehicle accidents.

ii) A shift from cars to bicycles will see improvements in air and water quality, and in physical activity/exercise.

iii) Greener and more walkable cities will result in a reduced "urban heat island effect", and physical and mental health benefits.

iv) The move to electric appliances in buildings will mean lower emissions of air pollutants, and improved indoor and outdoor air quality.

v) From petrol-powered to electric vehicles will include air quality improvements, but increase mining for mineral components of batteries, and issues with their disposal and recycling.

Developing the theme of unintended consequences of "green" policies, "electric vehicles tend to weigh more than comparable-sized conventional vehicles, due to the heavy batteries. Thus, bringing the vehicle to a stop produces more wear on brakes, resulting in emissions of airborne particles rich in metals that can catalyse the production of reactive oxygen species (ROS), which can harm the respiratory system. The heavier weight of electric vehicles can also result in higher emissions from tyre wear. However, the difference in emissions of particulate matter between electric vehicles and gasoline vehicles depends on the type of brake pad; similar or lower emissions by electric vehicles have been found when low-metallic brake pads were used, and secondary particle emissions were much lower with electric vehicles" (Bell and Gillingham 2025 p321).

The positives and negatives of moving from fossil fuels are "not shared equally, with disproportionate impacts on the most vulnerable populations. Furthermore, the primary contributors to high GHG [greenhouse gases] emissions are typically those with the lowest risk of the associated adverse health burden, although everyone is

affected” (Bell and Gillingham 2025 pp322-323). This is an issue of environmental justice (and injustice). “Environmental injustice can be based on higher exposures to environmental harms (or lesser exposure to environmental goods such as green space), higher health responses to a given level of exposure (eg: more severe reaction), and other disparities such as procedural inequities (eg: differential responses to complaints of violations). Populations at risk include racial/ethnic minority populations, those with low socioeconomic positions, rural populations, and persons with disabilities, with growing evidence for higher risks for the LGBTQIA+ community. These very populations that currently, on average, suffer the highest environmental health burden in the present day are also often at the highest risk from the health burdens of climate change in the future and generally have the lowest capability to respond. Energy transitions have the potential to increase or decrease these disparities” (Bell and Gillingham 2025 p323).

Energy transitions have occurred throughout history, usually from one type of fossil fuel to another (eg: coal to oil), but the future shift to clean and renewable energy will be a “fundamental departure” (Bell and Gillingham 2025 p324). The full health benefits will depend upon individual choices (eg: to cycle instead of travel by vehicle), and policies (eg: to invest in cycle paths), and there will also be unforeseen or unintended consequences (both positive and negative) before achieving Bell and Gillingham’s (2025) “win-win” situation ².

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² Efforts to improve air quality may inadvertently warm the planet further. Sulphate particles released by burning fossil fuels cool the planet by reflecting sunlight back into space and influencing the development of whiter, longer-lived clouds (which also reflect sunlight). Removing these particles from the atmosphere eliminates the cooling effect (Cuff 2025).

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3. AIR POLLUTION

- 3.1. Nitrogen dioxide
- 3.2. Dementia
- 3.3. References

3.1. NITROGEN DIOXIDE

Nitrogen dioxide (NO₂) is an air pollutant from tailpipe emissions, factories, and agriculture, for instance. It is "a precursor to ground-level ozone and fine particulate matter (PM_{2.5}), the leading contributors to air pollution-related mortality" (Anenberg et al 2022 pe49).

There is an association between transportation-related air pollutants and childhood asthma onset. "Epidemiological studies are generally consistent in their finding that NO₂ is significantly associated with paediatric asthma incidence, whereas the evidence for other transportation-related air pollutants (eg: PM_{2.5}) is more mixed. Although the putative agent causing asthma in the traffic-related air pollution mixture is unknown, NO₂ could serve as a surrogate for other pollutants causing observed health effects" (Anenberg et al 2022 pe49). Achakulwisut et al (2019), for example, estimated that 13% of the global paediatric asthma burden was linked to NO₂, more so in large cities (Anenberg et al 2022).

Anenberg et al (2022) updated this estimate for over 13 000 urban areas globally in the 21st century. It was estimated that 1.85 million new paediatric asthma cases in 2019 were attributable to NO₂, two-thirds of these occurred in urban areas. The overall proportion of cases attributable to NO₂ in urban areas, however, had declined between 2000 and 2019, and in high-income countries, but had risen in south Asia, sub-Saharan Africa, and the Middle East. "Despite improvements in some regions, combustion-related NO₂ pollution continues to be an important contributor to paediatric asthma incidence globally, particularly in cities. Mitigating air pollution should be a crucial element of public health strategies for children" (Anenberg et al 2022 pe49).

3.2. DEMENTIA

The impact of exposure to air pollution upon cognition in later years can be studied by longitudinal research. The "1946 British Birth Cohort" (or National

Survey of Health and Development; NSHD) allows such research. The cohort was recruited at birth in a single week in March 1946, and followed since then.

Canning et al (2025) analysed the data in relation to air pollution and later life cognition. Specifically, exposure to air pollution in mid-life (45-64 years old) was calculated for different types (eg: nitrogen dioxide; particulate matter, PM₁₀) based on where the individual had lived, using official air quality monitoring data. Verbal memory (recall of fifteen items), and processing speed in a visual search task were measured, along with a whole brain scan at age 69 years. This analysis involved 453 individuals (from the original 5362 singleton births in the cohort, and over 13 000 total births in the week of March 1946).

Higher exposure to air pollution was associated with poorer cognition, and smaller brain volume.

This study had a follow-up period of 26 years, which was "one of the longest" for such research (Canning et al 2025 p2).

3.3. REFERENCES

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4. INDOOR ENVIRONMENT

- 4.1. Decor
- 4.2. Lighting
- 4.3. Pollution
- 4.4. References

4.1. DECOR

The importance of the interior design of a building on individual psychology comes from a field called "neuroaesthetics". This is the study of "brain processes underlying our sense of beauty in art and music" (Robson 2022 p44).

Then there is the application of evolution in the "biophilia hypothesis" - ie: "we are drawn to living things - such as the sight of foliage and fruit or the sound of birds - and that this tendency has, in part, a genetic basis... Consequently, our brains still find natural scenes effortlessly fascinating - they can capture our attention without us having to deliberately focus on them" (Robson 2022 pp44-45). What this means is that natural scenes can "recharge the mind when it is stressed" (p45) (known as the "attention restoration theory") (Robson 2022). Thus, homes and offices that incorporate natural elements will be beneficial to mental health.

Yin et al (2020) used virtual reality (VR) technology in their experiment on biophilic indoor environments and stress reduction. One hundred US adults were first exposed to stress using VR - a virtual office which was untidy and noisy while performing mental tasks - then participants experienced one of four VR environments: a book-filled room (non-biophilic), a room with plants ("indoor green"), a room with an outdoor view of nature, or a combination of all three. Stress reduction was assessed by physiological and psychological measures.

Compared to the non-biophilic VR environment, physiological measures like blood pressure were significantly reduced in the other three experimental conditions. All conditions led to reductions in psychological measures (eg: anxiety), though there were non-significantly greater reductions in the indoor green and room with a view conditions. Biophilic indoor environments were better for stress recovery was the conclusion.

Another idea from evolution is "habitat theory". "This is the idea that we have a preference for larger, open spaces dotted with smaller areas of cover because of the fundamental visual properties of our ancestral home, the savannah" (Robson 2022 p46).

The indoor environment can impact creativity. For example, Dul et al (2011) found twelve elements of the physical environment in a literature review that "increased knowledge workers' self-assessed performance" (Steidle and Werth 2013 p68) - furniture, natural plants, calming colours, inspiring colours, privacy, a view of nature, any window view, quantity of light, daylight, indoor physical climate, positive sound, and positive smell.

4.2. LIGHTING

Steidle and Werth (2013) studied darkness and dim illumination, and creativity in six experiments. Creative performance was improved in darkness or dim light (150 lux) compared to bright light (1500 lux). Creativity was measured by tasks like imagining what aliens look like on a distant planet, or the alternative uses task. The participants were mostly German university undergraduates (table 4.1).

The explanation for the findings appeared to be that "darkness elicits a feeling of being free from constraints and triggers a risky, explorative processing style" (Steidle and Werth 2013 p67).

The researchers explained further: "Generally, when entering a room, individuals automatically assess their environment and form expectations about what kind of behaviour and processing style is appropriate in the situation. The atmosphere and concomitant expectations that certain lighting conditions produce are referred to as the room's visual message (Boyce 2003). Accordingly, whether individuals adopt a creativity-supportive global and explorative or local, vigilant processing style is determined by their perception of the atmosphere in a certain situation. In a recent review, Friedman and Förster (2010) summarise that benign, safe, and comfortable environments elicit global processing and exploration, because, in this kind of atmosphere, individuals are more eager to take risks. In contrast, threatening and tense environments elicit local processing and vigilance, which helps individuals focus on the problems at hand and find concrete solutions"

(Steidle and Werth 2013 p68).

Study	Participants	Procedure	Outcome Measure	Main Finding
1	40 undergrads	5 mins to recall a bright or dark location	Structured imagination task: "imagine going to another galaxy in the universe and visiting a planet very different from earth", draw an alien. Scored by 2 independent judges for difference to animals on earth	Mean creative score (out of 5): 3.35 (dark) vs 2.60
2	113 students	Word task related to darkness or brightness	Alternative uses task: a brick. Scored by 3 independent judges for creativity (but feasible)	Mean score (out of 9): 2.33 (dark) vs 1.24
3	46 students	As Study 2	"Connecting-dots-task"	Darkness group faster (more dots joined in 1 min; mean 310 vs 295), but made more mistakes (mean: 8.17 vs 3.50). "This indicates that darkness induces a more explorative, less vigilant processing style than brightness..." (p72)
4	110 undergrads	3 lighting conditions: 150, 500, & 1500 lux	Solve 4 creative insight problems	More problems solved in darker condition
5	60 undergrads	3 lighting conditions (25, 150, & 1500 lux), but light appeared non-uniform	As Study 4	No differences
6	140 undergrads	As Study 4	Creativity as in Study 1 & 4, logical reasoning problems	Creativity score higher in dark room, but lowest score on logical (abstract) reasoning problems

Table 4.1 - The six experiments of Steidle and Werth (2013).

Subsequently, Steidle and Werth (2014) showed that bright light increased self-awareness, and the motivation

to make a good impression on others in five experiments. In one experiment, the participants completed a questionnaire about self-awareness after one hour in a room with lighting at 150 or 1500 lux. Those in the bright lighting reported higher public self-awareness (eg: "Right now, I am concerned about what others think of me"), but there was no difference in private self-awareness (eg: "Right now, I am conscious of my inner feelings").

4.3. POLLUTION

Corinne Mandin of the "Scientific and Technical Building Centre" in France made this disturbing observation: "People don't imagine that there is pollution indoors; it is perceived as a protective place. But there are more pollutants in buildings than in outdoor air" (quoted in Lawton 2023).

The main pollutants are tobacco smoke, and carbon monoxide (from poorly ventilated gas appliances) (where these occur), and volatile organic compounds (VOCs) (eg: trichloroethylene; TCE), and particles less than 2.5 micrometres (PM2.5) of organic chemicals, soot, metals, soil, and dust (Lawton 2023).

In terms of human behaviours, cooking is a key source of indoor pollution, particularly frying as compared to boiling and steaming food (Lawton 2023).

Household cleaning products (HCPs) are a source of potential pollutants with VOCs and metals. Consumers may face hazards including from "substances formed through interactions among product components, both before (inside the product) and after usage (outside the product)" (Kim et al 2024 p1).

It is not always clear about the substances in HCPs from their labels, and studies have found up to 36 VOCs, including benzene, phenol, and hexane, in one US study, and 37 VOCs, including benzene, toluene, and acetone, in a study in South Korea (Kim et al 2024). "All the VOCs and metals have been reported to be exposed to humans through the following possible exposure routes: inhalation, dermal, and oral (ingestion)" (Kim et al 2024 p2).

Kim et al (2024) analysed 75 HCPs available in South Korea in 2022 for 23 VOCs and nineteen metals. Spray-type products contained more of these pollutants, including benzene, nickel, and d-Limonene in particular. "The study discovered that the VOCs and metals varied by their spray

type and lacked sufficient harmful information" (Kim et al 2024 p1).

4.4. REFERENCES

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5. WATER

- 5.1. River microbiome
- 5.2. State of oceans
- 5.3. Litter in rivers
- 5.4. Water shortages

5.1. RIVER MICROBIOME

Rivers are crucial to ecosystems as they "(1) offer an important nexus of nutrient transport across terrestrial and aquatic interfaces; (2) are hotspots for biogeochemical processes that contribute substantially to global terrestrial carbon and nitrogen budgets, ultimately influencing global greenhouse gas emissions, eutrophication and acidification; and (3) have immediate societal impacts on sustainable energy, agriculture, environmental health and human health" (Borton et al 2025 p103).

The micro-organisms (or microbiome) govern the river biogeochemistry, but knowledge is limited. Borton et al (2025) reported the creation of the "Genome Resolved Open Watersheds database" (GROWdb) to increase knowledge about US rivers. It was crowdsourced from 163 samples of water at 106 sites with the resulting analytic data (eg: genomic; chemical).

Microbial lineages from 27 phyla were found overall, including new members of ten families and 128 genera ³. The dominant organisms in the water samples were members of the Actinobacteria, Proteobacteria, Bacteroidota, and Verrucomicrobiota.

In terms of contaminants, microbial genes related to antibiotics, disinfection by-products, fluorinated compounds, fertilisers, and micro-plastics were identified in the samples. Specifically, 1587 antibiotic-resistance genes were found.

Borton et al (2025) ended: "Changing climate impacts rivers through altered precipitation intensity, surface run-off, flooding, fires, sea level rise and droughts, and all of these have direct impacts on human health, agriculture, energy production and ecosystem resiliency. Moreover, two-thirds of drinking water in the United States comes from surface river waters. Consequently, river management is expected to be one of the most

³ The biological hierarchy of living organisms has "eight levels"(taxonomic ranks) beginning with species, which are part of a genus, which are part of a family, and families make up an order (then class, phylum, kingdom, and domain).

politically charged topics in decades to come. Micro-organisms are master orchestrators of nutrient and energy flows that will probably dictate water quality under current and future water scenarios" (p111).

Reference

Borton, M.A et al (2025) A functional microbiome catalogue crowdsourced from North American rivers Nature 637, 103-112

5.2. STATE OF OCEANS

The oceans are changing as a consequence of global warming and human activity, and this can be seen in four examples (Cuff 2024):

i) Warmer sea temperatures - eg: global average sea surface temperature rose by 0.42 °C per decade between 1993 and 2022. Coral bleaching is one particular consequence.

ii) Algal blooms, some producing toxins. "Ocean waters are naturally stratified into layers, with warmer, fresher, oxygen-rich water near the surface and cool, salty, nutrient-dense water further down. As the oceans heat up, there is less mixing between these layers, preventing nutrients from travelling to the surface and oxygen from sinking to the deep ocean. As well as setting the stage for algal blooms, this causes problems for phytoplankton, tiny, plant-like organisms that turn sunlight and carbon dioxide into sugars and oxygen" (Cuff 2024 p34).

iii) Disappearing "bottom water" in the Antarctic. Cold, dense, oxygen-rich water from the Antarctic drives global networks of ocean currents, but increased amounts as more ice melts, which is less salty, does not sink to the depths, leading to a slow down in Antarctic currents.

iv) Booms in certain species of fish - eg: bombay duck fish in East China Sea that thrive in warming and oxygen depleted waters.

Reference

Cuff, M (2024) Ocean chaos New Scientist 17th August, 32-35

5.3. LITTER IN RIVERS

“Urban development and population growth impose three distinct stressors on local rivers: degradation of water quality, depletion of water quantity and a sink for macro-pollution waste, thereby acting as threat multipliers for the riverine and marine environments. Macro-pollution is commonly referred to as litter. The nature of litter varies greatly, from cigarette ends (also known as butts or buds) to discarded food packaging” (Kachef et al 2025 p1).

The estimates of daily terrestrial litter in rivers range up to 4.2 million tonnes (Kachef et al 2025). “Floating Marine Macro Litter” (FMML) is a term for pieces of litter larger than 2.5 cm in length (Kachef et al 2025).

How does terrestrial litter get into rivers? Obviously, it can be directly dumped there, but “litter mobility” can be the result of wind and rain as well as human activity indirectly “through foot traffic, kicking, and sweeping of surfaces” (Kachef et al 2025 p2).

Kachef et al (2025) studied litter mobility during the Oxford and Cambridge Boat Race on the River Thames on Sunday 2nd April 2017. GPS trackers were placed within ten empty plastic bottles, which were left at equal intervals along the banks of the race course. Over 250 000 spectators attended the race.

Five bottles remained at the spot placed by the researchers, while the others travelled an average distance of 2.4 metres, with two bottles entering the river. Though this study was limited, it showed that large crowds cause litter mobility which can include terrestrial litter ending up in rivers. The researchers ended: “this study highlights that litter is not simply deposited; it flows. Litter is not restricted by boarders or confined to any singular environment, it travels long distances and can do so within, and between various systems” (Kachef et al 2025 p9).

Reference

Kachef, R.L et al (2025) Transfer dynamics of litter: Introduction to new vectors in the mobility of terrestrial litter Next Research 2, 100193

5.4. WATER SHORTAGES

One prediction is that water over-consumption and

global warming will leave three-quarters of people facing water shortages, contamination, or drought, according to the United Nations. For example, 70% of major aquifers are declining (ie: more water is being used than is being replenished by rainwater and snow melt) (Luhn 2026) ⁴.

Madani (2026) commented: "'Water crisis' has become the default label for almost any episode of water stress, from short-lived droughts to decades-long overuse of rivers and aquifers. Yet in many regions of the world, water problems no longer resemble a crisis in the conventional sense. They represent a post-crisis failure state in which human-water systems have exceeded their hydrological carrying capacities, and societies have spent beyond their sustainable hydrological budgets for so long that critical water assets are depleted, some ecosystem damages are irreversible on human time scales, and a return to 'normal' is infeasible even with prohibitive economic, social, and environmental costs" (p1).

This author called the situation "water bankruptcy" (Madani 2017 quoted in Madani 2026). A bank account analogy was used which "likens surface water to a checking [cheque-book or current] account and groundwater to a savings account..." (Madani 2026 p1).

"Water bankruptcy" is distinguished from "water stress" (a temporary over-demand compared to supply, but still within safe limits), and "water crisis" ("Shock-driven disruption (eg: droughts, floods, contamination) that temporarily pushes the system beyond capacity with no or little irreversible damage"; Madani 2026 p4).

Madani (2026) proposed some arguments as to why "water bankruptcy" is a better way to understand the situation than "water crisis", including:

a) Crisis suggests a temporary and reversible problem - "Repeatedly labelling a chronic water condition as a water crisis or water emergency obscures the reality that the system has failed and the pre-crisis baseline is no longer attainable" (Madani 2026 p3).

b) Repeatedly talking of crisis can "become background noise, creating fatigue rather than urgency" (Madani 2026 p3).

c) Bankruptcy suggests a need for transformation and a definitive change rather the restoration of the old.

⁴ Niazi et al (2024) modelled nine hundred future scenarios for 235 water basins, and found that one-third had passed "peak water limit".

d) "Crisis talk keeps systems in denial and delays the admission of defeat" (Madani 2026 p4).

River deltas are "among the most vital landforms on Earth", but "[A]s low-lying landforms, with extensive areas less than 2 m above sea level, deltas are acutely susceptible to rising sea level, storm surge, land subsidence, shifting temperature and rainfall patterns, and other environmental pressures, which are amplified by climate change. These pressures degrade agricultural land; disrupt freshwater availability; exacerbate coastal and fluvial flooding; promote wetland loss, saltwater intrusion and shoreline retreat; and threaten infrastructure in deltas" (Ohenhen et al 2026 p894).

River delta subsidence was the particular focus of Ohenhen et al (2026), and they studied forty deltas in 29 countries. The subsidence was estimated at between 2-4 mm per year. This increases the risk of flooding of urban areas nearby (and an estimated 350-500 million people worldwide live around deltas), and subsidence could be more influential than climate-induced sea-level rise. The using up of groundwater below the deltas was the strongest influence on subsidence in ten of the cases, while other causes included urban expansion, and sediment removal.

References

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Ohenhen, L.O et al (2026) Global subsidence of river deltas Nature 649, 894-901

6. HYBRID PARASITIC WORMS

- 6.1. Introduction
- 6.2. Treatment
- 6.3. Transmission and reservoir hosts
- 6.4. HUGS study
- 6.5. Genital schistosomiasis
- 6.6. A nuanced position
- 6.7. References

6.1. INTRODUCTION

The parasitic worm known today as *Schistosoma haematobium* was first observed in post-mortem blood samples in the early nineteenth century. Subsequent work over the years has distinguished this species from *Schistosoma mansoni* (Stothard et al 2026) ⁵.

However, even today, "there are still many gaps in understanding natural transmission cycles and how these worms progress within their developmental migration inside a host's body. Indeed, there appears to be a highly evolved developmental molecular cross-talk between male and female worms that stimulates each other to become sexually mature, not forgetting their responses to many host physiological and immunological cues. In brief, the maturing and adult male worms are morphologically adapted to closely interact anatomically with the more slender female, held within his muscular gynaecophoric canal and to carry her to their preferred egg-laying sites. At a molecular level, the ability of these worms to live for many years within the blood stream is in itself a marvel of host-parasite co-evolution, with many immunological processes present to modulate and fully evade the host's development of sterile immunity against either immature or adult worms themselves. Even so, mating within the population of adult male and female worms is not uniform through time, as aggressive competition between worms to exchange female partners is known, with an increasing ability for genetic outcrossing within a spectrum of polyandry, polygyny and polygynandry possibilities, as of yet poorly quantified" (Stothard et al 2026 pp2-3).

Schistosomes (now categorised as 23 species) continues to thrive in humans in Africa and Asia, in

⁵ "Urogenital schistosomiasis is primarily caused by the parasitic blood fluke *Schistosoma haematobium* (*S.haematobium*), while intestinal schistosomiasis is primarily caused by *Schistosoma mansoni* (*S.mansoni*)" (Cunningham et al 2026 p2).

particular. Specifically, 90% of current global human cases of schistosomiasis live in Africa (Stothard et al 2026).

Luviano Aparicio et al (2026) explained that schistomes are “parasitic blood flukes that develop and grow in the vascular system of mammal definitive hosts. They are responsible for causing bilharzia, or schistosomiasis, a neglected tropical disease and the second most important parasitic disease after malaria. There are over 230 million people requiring treatment, of which the majority live in Africa ⁶. Schistosomiasis is a waterborne disease. Schistosome parasites first infect at the miracidial stage an intermediate mollusc host in which the parasite asexually multiplies. Cercariae are then released and can infect the mammal definitive host when this later has contact with water. Sexual reproduction occurs in the definitive host and, depending on the schistosome species, eggs are released through urine or faeces in water so that the cycle can continue” (p2).

Stothard et al (2026) introduced a special issue on the journal “Philosophical Transactions of the Royal Society B” on the evolution of schistosomes, specifically hybrids, and their impact in Africa. Hybrids include combinations of species found in humans and non-humans (cattle) (eg: *S.haematobium* and *S.bovis* (from cattle) discovered in Senegal in the mid-2000s; *S.bovis* and *S.mattheei* (from humans) in Zanzibar in 2024) (Stothard et al 2026) ⁷.

“Since the early 2000s, hybrids between *S.haematobium* and *Schistosoma bovis* (*S.bovis*) have been widely reported from communities in West Africa. They have since been reported from further afield in East Africa and outside the typical transmission zone, such as in Corsica and Spain. Studies looking at the introgression of *S.haematobium* and the zoonotic species *S.bovis* have suggested that hybridisation events were rare and largely ancestral. In consideration of another veterinary schistosome species, *Schistosoma mattheei* (*S.mattheei*), another zoonotic species common in livestock, particularly cattle, hybridisation events have different introgression dynamics and appear more

⁶ Annual mortality is estimated at 13 000 people approximately (Cunningham et al 2026).

⁷ “While numerous schistosome species exist, their barriers are often maintained through differences in ecology, host specificity and evolutionary history. However, hybridisation between closely related species can happen when parasites infect the same host. For instance, hybrids between *Schistosoma haematobium* and *Schistosoma bovis* have been detected in humans across several African countries, including Benin, Ivory Coast, Mali, Niger and Senegal” (Luviano Aparicio et al 2026 p2).

contemporary as shown in the laboratory and nature. More importantly, meticulous laboratory studies carried out by Wright and Ross [1980] demonstrated that *S. haematobium* x *S. mattheei* hybrids exhibited heterosis in their ability to infect snails and experimental animals, as well as demonstrating increased growth rate and egg output" (Cunningham et al 2026 p2).

Hybrids highlight issues like zoonotic transmission⁸, which is a concern around many infections and diseases, and potential future pandemics, and "One Health" (an approach that sees human and non-human health as intertwined). In terms of medication, the oral anthelmintic treatment praziquantel (PZQ) is used for humans (and animals). Hybrid schistosomes could well become immune to this (Stothard et al 2026).

6.2. TREATMENT

Anderson (2026) was sanguine: "For the two most important schistosome infections of humans in Africa, *Schistosoma mansoni* and *Schistosoma haematobium*, control efforts over the past few decades based on repeated rounds of school-based or community-wide drug treatment have not been as successful as might have been expected given reported drug coverage levels. This may be in part owing to overly optimistic coverage levels reported by countries, but it may also be partly owing to the continued evolution of these parasites and the role played by livestock parasites in sustaining transmission via hybridisation, within human communities. The importance of hybridisation in this context is unclear at present, since it is uncertain whether the hybrids have greater transmission potential (as measured by the basic reproductive number) than the non-hybrid forms" (p1).

The World Health Organisation (WHO) has a target to eliminate schistosomiasis as a public health problem by 2030 using preventive drugs, but "mixed infections of *Schistosoma haematobium* with zoonotic species, inclusive of putative hybrids, present a potential challenge" (Cunningham et al 2026 p1). Cunningham et al's (2026) study over two years in two villages in Southern Malawi

⁸ Introgression is "the transfer of genetic material between species through hybridisation" (p1), and Luviano Aparicio et al (2026) found that the plasticity that it gave hybrid worms increased their zoonotic potential. Luviano Aparicio et al (2026) explained further: "Introgression can promote gene flow between two species, increasing the genetic variability and fitness of one or the other species and facilitating adaptation to new environments. Genomic studies have revealed that introgression is far from exceptional, one in every 10 mammalian species carries the imprint of past or ongoing hybridisation, and comparable proportions are reported for birds, fishes and many plant clades" (p2).

(with over 2000 participants) found evidence to support the view that "treatment alone will not be sufficient for control of zoonotic *S.mattheei*, but additional investment will be required" (p2).

There is concern that PZQ is used (and overused) by subsistence farmers in Sub-Saharan Africa who experience high livestock mortality from *Schistosoma* species. As PZQ is the sole drug available for humans, the WHO has advised its use with at-risk human populations only. Diaz et al (2026) reported a trial of a veterinary formula of PZQ with domestic ruminants in Northern Senegal. There were "acceptable efficacy levels within cattle infected with *S.bovis*, but near zero efficacies in goats and sheep infected with *S.curassoni* and/or hybrids. Furthermore, increased miracidial output [ie: number of parasite eggs] post-PZQ was observed among several individuals, particularly within sheep. There was a significant increase in body condition in both cattle and sheep post-PZQ" (Diaz et al 2026 p1).

In another study of PZQ in cattle (in Southern Malawi), Junasz et al (2026) reported reduced infection prevalence over twelve weeks, but with an infection rebound post-treatment (Stothard et al 2026). Two herds of fifteen in the study area were treated with PZQ. Hybrid worms were not identified in this study.

The treating of non-human animals with PZQ fits with the "One Health" approach, which the WHO and World Organisation for Animal Health defined as "integrating, unifying efforts to sustainably balance and optimise the health of people, animals and ecosystems" (quoted in Junasz et al 2026).

6.3. TRANSMISSION AND RESERVOIR HOSTS

Though cattle are important in the transmission of the parasites, including hybrids, rats and non-human primates (chimpanzees; green monkeys) also have a role. *S.mansoni*, for example, naturally infects 56 host species including thirty-one rodent and fourteen primate species. "It has therefore been suggested that rodents in Africa or in Brazil, and non-human primates in Africa, could serve as reservoir hosts for human schistosomiasis" (Savassi et al 2026 p2).

S.japonicum, recognised as a zoonotic parasite, has been linked to around 46 mammalian species as suspected or potential reservoir hosts, while genetic evidence of zoonotic transmission from water buffalo, cattle, pigs,

dogs, rats, and cats has been documented (Savassi et al 2026).

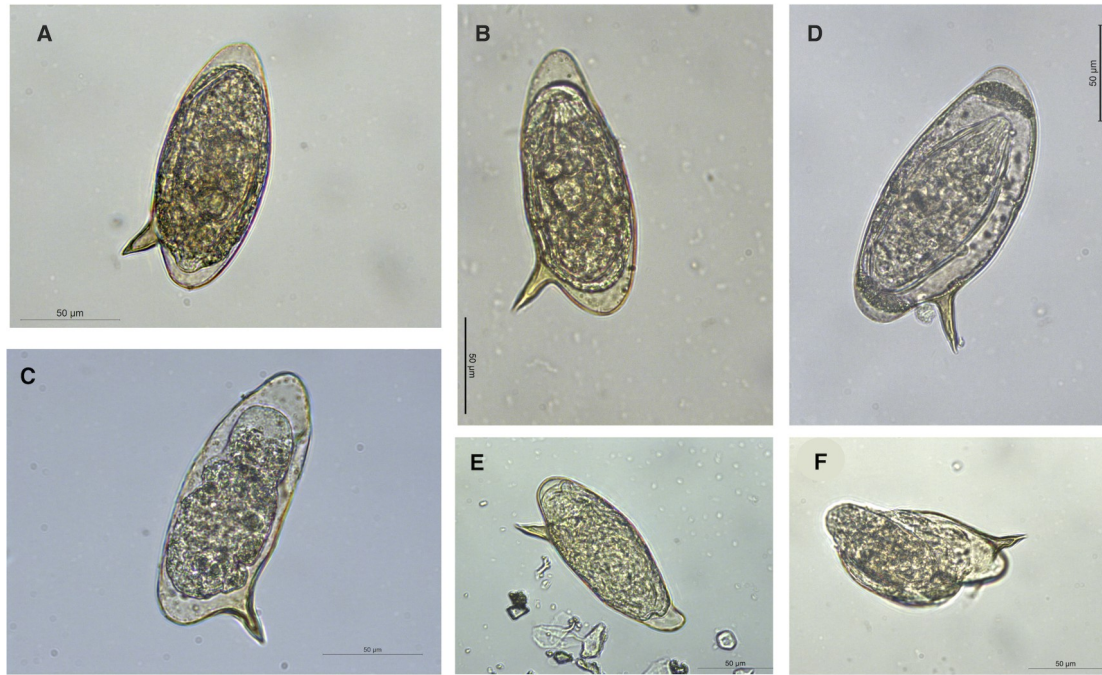
"Interestingly, the zoonotic transmission patterns of *S.japonicum* vary regionally. In the marshland region of Anhui province (China), water buffalo and cattle appear to play a more significant role as reservoirs than other domestic animals. However, in the hilly region of the same area, rodents and dogs are found to be the primary reservoirs, whereas in the province of Samar, the Philippines, dogs have been found to play a dominant role in *S.japonicum* transmission. Considering that the transmission of schistosomes is highly focal, these regional differences likely result from a specific selection of a given reservoir host (eg: dogs, water buffaloes or rodents), resulting in genetic adaptation of the parasite to a given host in specific areas" (Savassi et al 2026 p2).

Note, Savassi et al (2026) pointed out: "The mere presence of the same parasite species in both human and animal hosts does not necessarily indicate zoonotic transmission. A parasitic life cycle can function independently in humans and animals without the two encountering. For zoonotic transmission to occur, both the encounter filter (spatial and temporal overlap) and the compatibility filter (the parasite must be able to successfully infect the host and evade its defence) must be open. In the case of schistosomes, the encounter filter may be closed if humans and animals are exposed to infection in different water bodies or at different times, even when they share the same environment" (p2).

De Elias-Escribano et al (2026) reported a screening programme in Almeria, Spain of travellers, migrants, and visitors from areas where *Schistosoma* species are endemic. The fear is that hybrid species could adapt to European environments. A recent outbreak in Almeria (Salas-Coronas et al 2021) had prompted the screening programme.

De Elias-Escribano et al (2026) listed eleven different hybrids reported in Europe and confirmed by genetic analysis. France, Belgium, and Spain were the countries of diagnosis, and the main sources were attributed to Cote d'Ivoire, Senegal, and Mali. Eight of the cases were linked to non-EU immigrants, and the rest to EU travellers returning home.

De Elias-Escribano et al (2025) reported the presence of "pure" and hybrid eggs in the urine of a sample of migrants diagnosed in Spain (figure 6.1).



(Source: Figure 1 De Elias-Escribano et al 2025)

Figure 6.1 - Six photographs of *Schistosoma mansoni*-like eggs found in West African migrant urine samples by De Elias-Escribano et al (2025).

6.4. HUGS STUDY

The “hybridisation in urogenital schistosomiasis” (HUGS) study in Malawi confirmed the circulation of a hybrid of *S. haematobium* and *S. mattheei* in humans, livestock, and snails. The HUGS study lasted four years and involved around 2400 two to 45 year-olds, twelve snail collection sites, and multiple herds of cattle, goats, and sheep in the Mangochi and Nsanje districts. The general prevalence of urogenital was between 26-41% (Musaya et al 2026).

Key findings included that adults engaged in water-dependent occupations had a higher risk of infection due to infected waters, and that persistence and dispersal of hybrids was impacted by climate change, poor livestock management, and control of the vectors (eg: snails) (Musaya et al 2026).

Musaya et al (2026) recommended: “A One Health strategy would involve co-ordinated surveillance of human and animal infections, monitoring of snail populations and land-use planning that mitigates the creation of high-risk water contact zones. Such an approach also requires community engagement and behaviour change

communication tailored to local livelihoods, promoting safe water practices without disrupting essential economic activities" (p7).

A sub-study of the HUGS study with 701 participants investigated PZQ treatment with human and/or zoonotic schistosomiasis (Kayuni et al 2026). Of the sample at baseline, 42% had urinary *S.haematobium* egg infections, and 29 of these individuals were co-infected with *S.mansoni*, thirty-eight with *S.mattheei*, and six with both *mansoni* and *mattheei*. At follow-up one year later, 203 of the original participants were available, and 13% had urinary *S.haematobium* egg infections, and twelve individuals were co-infected in some way.

Portable ultrasonography of the bladder showed changes in the infected individuals (eg: abnormally thickened bladder walls).

"Overall, greater morbidity was observed in those with *S.haematobium* alone than in those with mixed species infections" (Kayuni et al 2026 p2).

Kayuni et al (2024) reported two cases in the HUGS sample in 2024 of concurrent zoonotic urogenital and intestinal schistosomiasis. "These cases showed that *S.haematobium* group species, rather than *S.mansoni*, can be the dominant contributors to *Schistosoma* ova excretion via the intestinal tract, signposting towards a potential broader shift in the landscape of intestinal schistosomiasis in southern Malawi towards multi-species infections" (O'Ferrall et al 2026 p2). O'Ferrall et al (2026) followed up these two cases, and also found ten children with triple-species infection.

6.5. GENITAL SCHISTOSOMIASIS

Genital schistosomiasis, caused by *S.haematobium* in the main, mimics "sexually transmitted infections in men and women, owing to inflammation in the genital organs caused by migrating and trapped parasite ova" (Rafferty and Bustinduy 2026 p1).

Rafferty and Bustinduy (2026) explained in more detail: "Symptoms result from the inflammation around eggs migrating through the genital tissue. In women, this can present as abnormal bleeding, genital lesions, genital itch, abnormal discharge and dyspareunia. There are links to sub-fertility and infertility, ectopic pregnancy and stillbirth. In addition, female genital schistosomiasis (FGS) is associated with increased

risk of HIV acquisition, likely due to inflammation causing mucosal barrier breakdown in the genital tract. Finally, there is mounting evidence, albeit cross-sectional, that FGS may be associated with cervical dysplasia and cancer, although further studies are required to confirm this. In men, male genital schistosomiasis (MGS) symptoms are also related to inflammation in the genital organs, with haemospermia, pain during coitus or ejaculation, change in appearance of semen, epididymo-orchitis and prostatitis all reported. Complications include infertility due to obstruction or infiltration in the testes" (pp1-2).

Rafferty and Bustinduy (2026) listed seven studies of PZQ for FGS, with symptom reduction by 34% to 73%, but they could find no trials with MGS.

In terms of hybrid infections of genital schistosomiasis, Rafferty and Bustinduy (2026) listed the potential effects as:

i) A shift in the organ of pathology from the urogenital tract - "Hybrid ova may be more or less effective at being excreted into the bladder or bowel lumen compared with non-hybrids. If more eggs are entrapped in the mucosa, more pathology may follow" (Rafferty and Bustinduy 2026 p4).

ii) Changes in the degree and type of inflammation in response to the parasite eggs (and the risk of cancer development).

iii) Changes in symptoms.

iv) Reduced sensitivity of traditional diagnostic methods - eg: "hybrid ova may appear morphologically different to ova from pure *S.haematobium* or *S.mansoni* and may be more likely to be misidentified, especially by lab technicians with less hybrid detection experience" (Rafferty and Bustinduy 2026 p5).

v) Potential for drug resistance.

6.6. A NUANCED POSITION

Webster and Huyse (2026) took the view that "not all 'hybrids' matter", that is, a distinction between transient hybrids, evolutionary "dead-ends", and zoonotic threats. "Advanced genomic analyses suggest the apparent rise in hybrid reports likely reflects expanded molecular

surveillance rather than biological emergence, as many forms may have existed historically but went undetected. The absence of baseline or longitudinal data impedes testing of temporal trends, justifying enhanced surveillance while also cautioning against over-reaction. Policy and funding responses should therefore remain proportionate and evidence-based” (Webster and Huyse 2026 p1).

These authors continued: “We argue that many hybridisation scenarios do not warrant reactive control measures, especially where existing interventions remain effective. Overstating their significance risks misdirecting the already limited resources towards interventions, such as livestock treatment, that lack feasibility or justification” (Webster and Huyse 2026 p1).

Webster and Huyse (2026) outlined four views on hybridisation:

i) Public health - Focused on the growing threat of hybridisation to avoid control and elimination efforts. Vigilance, based on evidence, not over-reaction is the advice of Webster and Huyse (2026).

ii) Clinical - Hybrids may challenge the three main diagnostic methods of schistosomiasis - microscopy (eg: for eggs in urine), antigen detection (eg: anti-bodies against infection), and standard molecular assays (ie: genetic analysis) - and so infections will be missed ⁹. Webster and Huyse (2026) saw no need for new diagnostic methods at this time.

iii) Academic scientists - “The challenge is not to pathologise hybridisation per se, but to understand its variable outcomes and evolutionary significance. Monitoring hybridisation through high-resolution genomic tools offers a window into real-time evolution and species-specific adaptations, but also demands a nuanced interpretation grounded in evolutionary theory” (Webster and Huyse 2026 p10).

iv) “Nuanced” - This is the preferred position of Webster and Huyse (2026): “Recognizing the importance of *Schistosoma* spp hybridisation does not justify its prioritisation over other aspects of schistosomiasis control and elimination; rather, it demands further

⁹ Genetic studies of the *S.haematobium*, for example, tend to focus on two markers for classification, but new markers will be needed with hybrids. Platt et al (2026) reported genotyping research to do this.

research to develop advanced research methodologies and tools, generate deeper data and enable a balanced, context-aware interpretation of its consequences. This balanced approach will support the development of nuanced, pragmatic and evidence-based control strategies that are responsive to both local realities and broader ecological patterns" (p11).

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7. CANCER

- 7.1. Air pollution
- 7.2. Environmental radiation and urinary tract cancers
- 7.3. Climate change

7.1. AIR POLLUTION

Laryngeal cancer has been linked to risk factors like tobacco use, alcohol consumption, and viral infections like human papilloma virus (HPV) (Soopramanien et al 2026). What about ambient air pollution as a risk factor?

"Ambient air pollution occurs as a result of the combustion of fossil fuel sources for industrial, personal or commercial purposes. Ambient air pollution is a key risk factor for many diseases worldwide including respiratory and cardiovascular disease [...] The carcinogenic effects of ambient air pollution and particulate matter are also well documented. The effects are propagated by a cascade of abnormal cell proliferation, oxidative stress, inflammation and resulting DNA damage, which result in a tumour-promoting environment" (Soopramanien et al 2026 pp1; 1-2).

Soopramanien et al (2026) performed a literature review on the topic, and nine relevant studies published before mid-2024 were found. The overall conclusion was this: "Current evidence on the relationship between ambient air pollution and laryngeal cancer remains limited, inconsistent, and methodologically constrained. NO₂ [nitrogen dioxide] shows the most consistent association across well-designed cohort studies, while evidence for PM_{2.5} [particulate matter ≤2.5 μm] is suggestive but inconsistent, and other pollutants provide little clarity" (Soopramanien et al 2026 p8).

The main problem was the methodological variety between the studies, including (Soopramanien et al 2026):

i) Exposure to air pollution - the data source used (eg: local government records), and how the exposure was estimated (eg: regional averages; distance from incinerators). "Even in well-designed cohort studies, the exposure measurements for individuals are based on some modelling inferences based on residential address, making it difficult to consider confounding from other activities, such as occupational exposure" (Soopramanien et al 2026 p8).

ii) The outcome measure - laryngeal cancer incidence, but no data on mortality. Measures included standardised incidence rate (SIR), incidence rate ratio (IRR), and relative risk (RR).

iii) Which pollutant measured - seven in total.

iv) Study design - five cohort (of which four were retrospective) and four ecological studies.

v) Adjustment for confounders - This was inconsistent. "While some cohorts adjusted for smoking and alcohol, several studies did not, and very few considered socio-economic status. No study considered the confounding effect of HPV status on laryngeal cancer incidence, a small but important contributor to laryngeal neoplasms. None of the included studies reported outcomes by laryngeal sub-site (glottic, supraglottic, sub-glottic), which could mask sub-site-specific risks given differing pollutant deposition patterns. Finally, consideration of time difference between carcinogenic exposure and cancer incidence was inconsistent, and often not reported" (Soopramanien et al 2026 p8).

Overall, seven studies were rated as "fair" and two as "good" in terms of methodological quality (based on the National Institute for Health (NIH) 2013 study quality assessment tool with fourteen criteria¹⁰). Though seven of 21 associations between air pollution and laryngeal cancer were statistically significant, but any conclusions "must remain cautious", ended the researchers (Soopramanien et al 2026 p8).

The relationship between air pollution and all-cause mortality in colorectal cancer patients is unclear because of contrary evidence (Wang et al 2025). For example, Jiang et al's (2024) analysis of UK Biobank data found a positive relationship, while Coleman et al (2020) in the USA reported no significant association. Yet more confusing, a study in the USA and Puerto Rico (Turner et al 2017) found increased NO₂ exposure and increased mortality, but no relationship for PM_{2.5} exposure (Wang et al 2025).

Wang et al (2025) explained that these studies were probably "limited by their reliance on database diagnostic codes, which excluded key clinical information such as cancer stage and histological grade. Since these

¹⁰ Information at <https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools>.

factors are major determinants of survival, their omission may introduce confounding and weaken or mask true associations" (p2).

These researchers analysed data from Taiwan; specifically, 5126 colorectal cancer patients since 2010. Importantly, clinical cancer stage, histology grade, and demographic characteristics were included. Annual average concentrations of air pollution was modelled by machine learning for each patient's home address. Other variables controlled for included distance to nearest airport, and co-pollutants.

Higher exposure to air pollution was associated with greater all-cause mortality, overall. The clinical stage of the cancer heightened the all-cause mortality, with the effect being "generally stronger" in stages 0-I, and II-III of the cancer.

In other words, the more advanced the individual in the cancer, the more vulnerable to the impact of air pollution in terms of mortality from any cause. It is known from other research that colorectal cancer patients' survival is affected by the presence of co-morbidities like cardiovascular disease, and this disease is impacted by air pollution. Also, "cancer patients undergoing chemotherapy or radiation therapy exhibit increased PM_{2.5}-related risks for cardiopulmonary mortality" (Wang et al 2025 p2).

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7.2. ENVIRONMENTAL RADIATION AND URINARY TRACT CANCERS

Urinary tract cancers (UTC), which includes kidney cancer and urinary bladder cancer, is linked to older age, being male, obesity, smoking, hypertension, genetics, and environmental exposures (Li et al 2025).

An example of the latter is natural radioactivity (eg: radon concentration). Li et al (2025) analysed whole population data for Finland from 1987 to 2021. Average exposure was calculated based on municipality-level radiation concentrations for uranium and radon in the water, and radon in the indoor air. UTC cases in 2017-2021 was the outcome measure.

Long-term environmental exposure to radiation was associated with UTC risk with a dose-response pattern, especially for men. For example, one standard deviation increase in radiation exposure was associated with a 5% higher UTC risk in the total population. The relationship was independent of birth cohort factors, socio-demographic factors, municipal-level lung cancer incidence, and family history of cancer and health conditions.

Li et al (2025) was a total population study, and the researchers believed it to be the first of its kind on the topic. Though it was an observational study, cancer incidence on 2017-2021 after many years of radiation exposure suggested causation.

This study had no individual information on occupational exposure to radiation, or lifestyle behaviours like alcohol consumption. Only official information on health conditions were available. Annual exposures to radiation were used, and uranium and radon levels were proxy/indirect measures of natural radioactivity.

Previous studies had found mixed results. For example: "Positive associations between radiation exposure and kidney or bladder cancer mortalities were observed in uranium miners and uranium processing workers in France, Germany, and Canada; in radiation workers in France, the UK, and the US; and in a population living near uranium milling and mining operations in New Mexico. Associations between radiation exposure and kidney and bladder cancer were reported in residents of Ukraine after the Chernobyl nuclear power plant accident, and in the general populations of the UK and Germany" (Li et al 2025 p5).

But many of these studies "included only highly

selected exposed populations, had small sample sizes, and lacked general population controls” (Li et al 2025 p5).

On the other hand, non-significant associations were found for uranium miners in studies in France, Germany, Canada, and the Czech Republic (Li et al 2025). “No significant association between radiation exposure and kidney cancer or bladder cancer was found in atomic bomb survivors in Japan, or in the general population of the US or Finland. In observational studies of the general population, common concerns included inaccurate exposure assessments on the individual level and difficulties in tracking population movements and relocations over time” (LI et al 2025 p5).

REFERENCE

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7.3. CLIMATE CHANGE

“Climate change has been linked to an increased risk of various cancers through various pathways. Air pollution, exacerbated by industrial emissions, wildfires, and increased particulate matter due to changing weather patterns, is a known risk factor for lung cancer and potentially other cancers. Factors such as these and exposure to environmental toxins are linked to increased cancer risk; so are climate change-related human behaviour change and food insecurity. Ultra-violet (UV) radiation exposure, a known risk factor for skin cancer, is expected to intensify due to global warming and ozone depletion. Exposure to polycyclic aromatic hydrocarbons (PAHs) and heavy metals, often linked to rising temperatures and industrial activity, further compounds the risk of cancers such as bladder and liver cancer. Environmental pollutants and global warming can alter the composition and diversity of Gut Microbiota (GM), resulting in dysbiosis, chronic inflammation, and oxidative stress, which are recognised risk factors for Early-Onset Colorectal Cancer (EOCRC). Temperature fluctuations have been associated with liver cancer through food storage issues. Rising temperatures and extreme weather events can accelerate the release of Persistent Organic Pollutants (POPs), such as dioxins, into the environment and food chains, increasing carcinogenic potential” (Gupta et al 2025 p2).

Climate change can impact cancers directly/primary, and indirectly/secondary (eg: via changes in the environment), as well as the tertiary effects of changes in society and behaviour (eg: increased smoking due to increased anxiety and stress). "Moreover, healthcare infrastructure in vulnerable regions may struggle to cope with the dual burden of climate-related impacts and rising cancer prevalence, highlighting the need for systemic resilience" (Gupta et al 2025 p2).

Concentrating on publications between 2000 and 2024, Gupta et al (2025) mapped the growth in research on climate change and cancers since the 2010s, with the most studies coming from and involving the USA, China, and the UK. Little research on or from the Global South, however.

Dominant themes of the research included cancer and pollution, and sun exposure and temperature. Longitudinal research, however, was needed to establish causality (Gupta et al 2025).

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