

# education

**FROM THE JOURNALS** Edited highlights of weekly research reviews

## Biopsy strategies for prostate cancer

Prostate cancer screening may be less controversial if we could reduce overdiagnosis of low risk disease. A new study suggests that magnetic resonance imaging (MRI)-targeted biopsy could help achieve this. Over 13 000 men aged 50-60 years were invited for a prostate-specific antigen (PSA) test, and if the result was  $\geq 3$  ng/mL they were randomised to have a prostate biopsy only if suspicious lesions were found on MRI (the targeted biopsy group) or a targeted biopsy in addition to a systematic biopsy (the systematic biopsy group).

After a median follow-up period of 3.9 years, 185 of the 6575 (2.8%) men in the targeted biopsy group and 298 of the 6578 (4.5%) men in the systemic biopsy group had been diagnosed with prostate cancer. Diagnosis of clinically insignificant cancer was lower in the targeted biopsy group, with a relative risk of 0.43 (95% confidence interval 0.32 to 0.57) compared with those randomised to systematic biopsy. Fifteen men in the targeted biopsy group and 23 in the systemic biopsy group had an advanced or high risk cancer diagnosed during the study period (relative risk 0.65, 95% CI 0.34 to 1.24).

• *N Engl J Med* doi:10.1056/NEJMoa24060

## Gender pay gap in the US

Although women make up more than half of medical students in the US, they are under-represented in higher paid specialties. An investigation of national trends has found that more women are entering high compensating surgical specialties, but in 2022 still only made up 40.8% (up from 32.7% in 2008). The study used survey data to categorise specialties as high or low compensating: neurosurgery tops the list of highest paying specialties, with an annual income of \$788 313, and at the bottom are paediatrics and family medicine—although these still come with an average salary of over \$200 000.

• *JAMA* doi:10.1001/jama.2024.17516

## A new digital divide

A digital therapeutic (or DTx as we're apparently supposed to call them) is "a novel type of health software that delivers medical interventions to treat or manage illness or injury." These may range from mobile phone apps—such as online-based cognitive behaviour therapy for depression—to

devices such as insulin pumps. Investigators in the US identified digital therapeutics and looked at how many of them had any published evidence to support them. They excluded wellness products but found DTx across a range of conditions, including mental health problems, arthritis, diabetes, and sleep disorders. Of the 79 DTx examined, 34% had no published clinical efficacy or effectiveness study to support their use.

• *JAMA Intern Med* doi:10.1001/jamainternmed.2024.4972

## H pylori screening fails to take off

If we're inviting the public to send their stools to the NHS in the name of colorectal cancer screening, why not throw a *Helicobacter pylori* stool antigen (HPSA) test in there at the same time? *H pylori* is a known carcinogen, after all.

Investigators in Taiwan did just that, as part of a pragmatic trial in which 240 000 people aged 50-69 years were invited to have either faecal immunochemical testing (FIT) plus HPSA test or FIT alone. No significant difference in gastric cancer rates or gastric cancer mortality was found between the groups after over five years of follow-up.

• *JAMA* doi:10.1001/jama.2024.14887

## Closing eating windows for metabolic syndrome

Since I'm officially middle aged, I recently decided to try to lose weight and become more healthy. Being both a habitual evening snacker and someone who struggles with complicated ideas, I've opted for time-restricted eating (as well as more regular exercise). With time-restricted eating, you can eat whatever you want, but only within a certain time window, usually 8-10 hours.

A new randomised controlled trial aimed to find out if time-restricted eating can help people with metabolic syndrome to improve their HbA1c. The 108 participants were randomised to either personalised time-restricted eating (8-10 hour window each day, with a least a 4 hour reduction in their eating window) or nutritional counselling alone. As I've found, it does seem to help, but only a bit: compared with nutritional counselling, time-restricted eating improved HbA1c by  $-0.1\%$  (95% CI  $-0.19\%$  to  $-0.003\%$ ) after three months.

• *Ann Intern Med* doi:10.7326/M24-0859

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Cite this as: *BMJ* 2024;387:q2192

## WHAT YOUR PATIENT IS THINKING

# Navigating surgery with ADHD and autism

CPD  
READING  
0.5 HOURS

**Kirsty Brown** shares her experience of undergoing surgery as a person with attention deficit/hyperactivity disorder (ADHD), and explains some of the ways that health professionals could help others like her

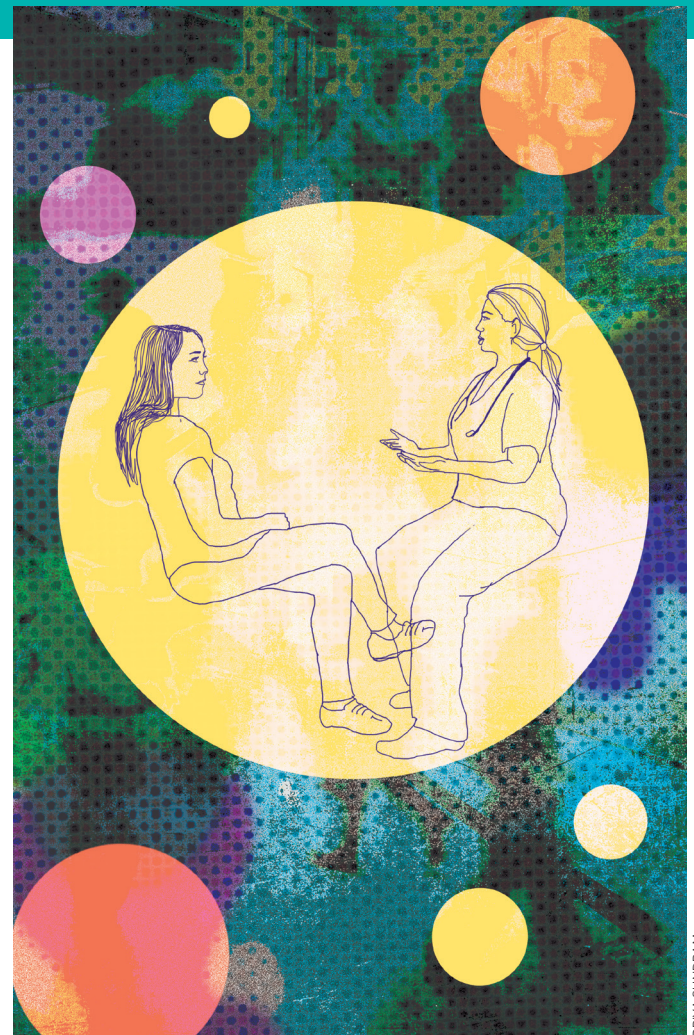
I have always felt different from others, but these differences became more apparent while I was at university and during the pandemic. As my anxiety and obsessive-compulsive disorder became worse, I received a diagnosis of ADHD at the age of 22. For me, ADHD feels like constant restlessness, racing thoughts and overthinking, and a rollercoaster of energy and emotions. I constantly feel that I am racing to keep up with life, yet I'm always behind.

About 18 months after the ADHD diagnosis, I also received a diagnosis of autism. My experiences have been affected by both ADHD and autism all my life.

### How can we help you?

I often find it difficult to ask for help and support. A year after my diagnosis of ADHD, I had to have laparoscopic surgery, and during a pre-op call I was asked how ADHD affected me. I was totally stumped, as it affects me in so many ways. I ended up calling the ward to ask for my own room for before and after the operation. I knew that being away from lots of people would help my anxiety. Fortunately, I was given a private room, which helped immensely because it removed some of the environmental stimulation and reduced sensory sensitivities that contribute to my anxiety.

While in hospital, some of the staff tried as best they could to



PRIYA SUNDARAM

help me through the procedure and the experience of being in hospital. I explained some of my concerns and how my conditions affected me. They didn't rush and made me feel understood. It meant that when I woke up after surgery and completely panicked, my health team weren't surprised and knew how to help.

### Clear communication

After surgery I developed a high temperature and was told I would need to stay in overnight for monitoring. The next day the healthcare team came round, and I could tell they were in a rush. They told me I needed to stay in another night because of my temperature. Having ADHD and autism makes me sensitive to change. I had not anticipated staying in one night, let alone two. Explaining, in a calm way, that I needed to stay in because of

the temperature would have helped a lot.

I also like to ask questions to fully understand what is going on and why, as it helps me to feel more in control. This is easiest one to one, and it is harder when I have to see many health professionals at once. With the conditions I have, I also think very literally. All or nothing. Black or white. And I am target driven. At an appointment with the surgeon a year before the surgery, I asked how long it would take to recover. They said I would be back on the hockey pitch after two weeks. I latched on to this and repeated it to friends and family. I wish I hadn't been told these very clear-cut points in the recovery journey, as I fixated on them. Instead, I wish they had told me to rest and focus on my recovery, rather than timelines or dates.

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## WHAT YOU NEED TO KNOW

- Having an open conversation about how ADHD and/or autism might affect someone during a hospital stay can help relieve concerns
- Giving people with ADHD/autism an opportunity to ask questions one to one may help them manage the unpredictability of hospital stays
- People with ADHD/autism can take things literally, especially when it comes to meeting goals or targets

## EDUCATION INTO PRACTICE

- How could you help ensure that someone with ADHD and/or autism feels supported and comfortable when preparing for surgery?
- What language could you avoid when discussing recovery with people with ADHD/autism to avoid any misunderstanding?

## ADDITIONAL RESOURCES

- Additude. Resources for people with ADHD. <https://www.additudemag.com/>
- ADHD UK. Resources and support for people with ADHD. <https://adhduk.co.uk/>

# The impact of increasing temperatures due to climate change on infectious diseases

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State of the Art Reviews are commissioned on the basis of their relevance to academics and specialists in the US and internationally. For this reason they are written predominantly by US authors.

**Heatwaves and high temperature periods have been increasing in intensity, frequency, and duration, and these trends are expected to worsen due to climate change.<sup>1</sup> Climate change, with associated high temperatures and irregular rainfall, has multifaceted impacts on the transmission of infectious diseases, leading to changes in pathogen development, vector distribution, and human behaviour, with increases in some infectious diseases (figure).<sup>2,3</sup>**

This review summarises the infectious disease challenges posed by increasing temperatures and climate change and considers the responses needed from global health systems and health professionals to minimise the negative impacts.<sup>15</sup>

## Sources and selection criteria

We conducted literature searches between February and April 2024 using PubMed and Embase. We used the following search terms, with appropriate database-specific modifications (addition of MeSH terms when searching PubMed), to identify relevant peer reviewed articles: high temperature, heatwave, hot weather, climate change, global warming, infectious disease, and communicable disease, as well as disease-specific keywords for the conditions discussed in this review.

### WHAT YOU NEED TO KNOW

- Global temperatures will continue to rise due to climate change, and infectious diseases are influenced by temperature and other climatic variables
- Targeted efforts and investments are needed to support low and middle income countries to prepare for and respond to the increasing infectious disease threats posed by rising temperatures
- This can be facilitated by the development of robust disease and entomological surveillance and early warning systems with integration of climatic information to enhance understanding of the geographic distribution of disease risk
- Medical education programmes must include evidence based components on the impacts of climate change on infectious diseases



0.5 HOURS

## Impacts of increasing temperatures on vector-borne and zoonotic diseases

### Dengue fever

Dengue, a mosquito-borne viral infection transmitted by *Aedes* mosquitoes, poses a global health threat, affecting 3.8 billion people (53% of the global population), with an estimated 100-400 million infections and over 20 000 deaths annually.<sup>116 117</sup> Dengue is predominantly prevalent in tropical and subtropical climates, especially in urban and semi-urban areas, with a high concentration of cases (about 70%) in the Asia-Pacific region.<sup>117 118</sup>

Various factors influence dengue transmission, with temperature, rainfall, and humidity accelerating mosquito breeding, extending mosquito lifespan, and enhancing the replication rate of the dengue virus within mosquitoes.<sup>5-7 119</sup>

A 2023 systematic review and meta-analysis<sup>16</sup> of 54 research studies showed a 13% increase in risk of dengue infection for each 1°C increase in high temperatures, with recent studies<sup>17-19</sup> reinforcing this association.

### Malaria

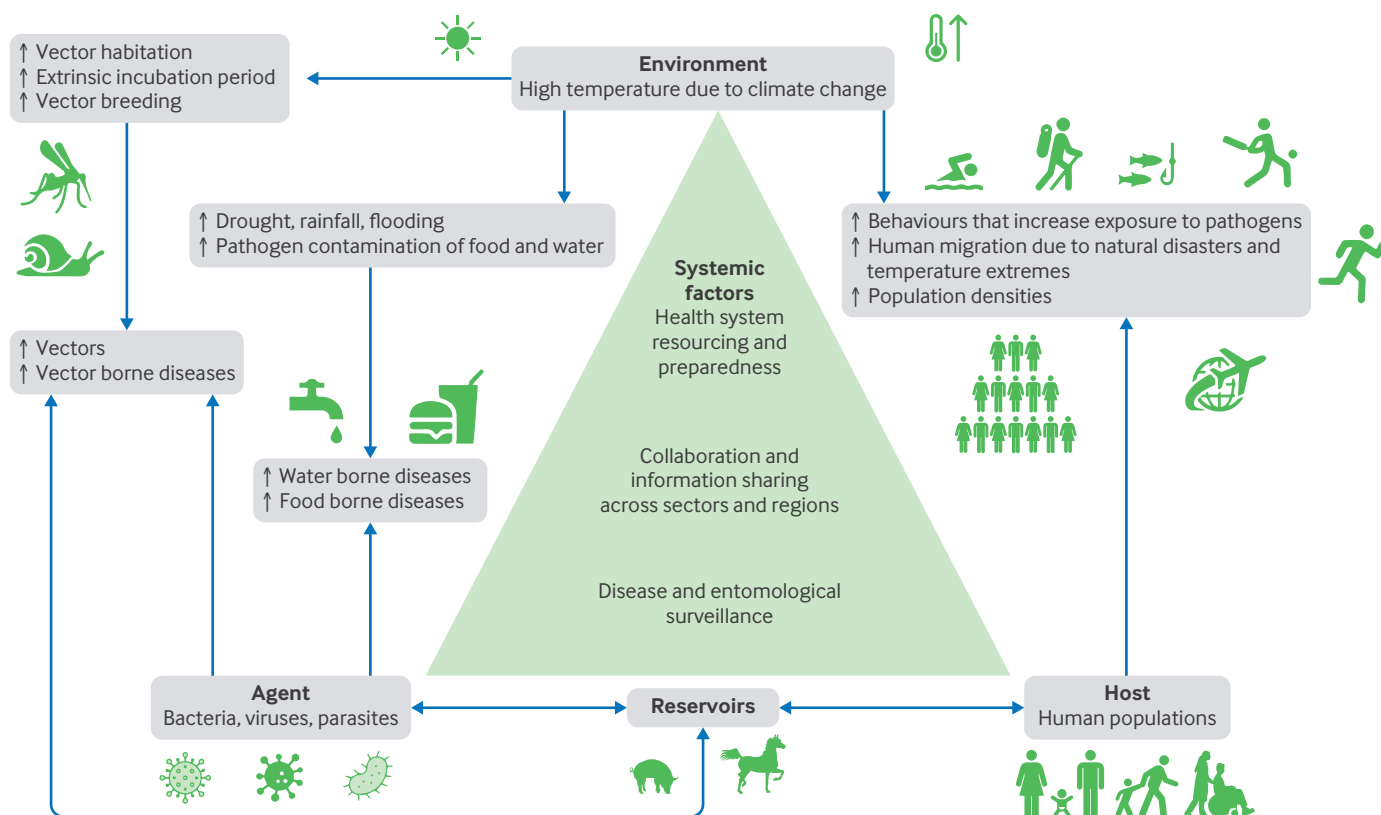
Malaria is an *Anopheles* mosquito-borne infectious disease caused by parasites of the *Plasmodium* genus. Warmer temperatures enable mosquitoes to proliferate in areas previously unsuitable for their survival, including higher altitudes and cooler regions.

A northward shift of the malaria epidemic belt in North America, Europe, and Asia and the occurrence of new cases in some African highlands have been reported.<sup>21</sup> Conversely, increasing temperatures may reduce the environmental suitability for malaria transmission by *Anopheles* mosquitos in sub-Saharan Africa.<sup>123</sup>

Indirect effects of climate change on malaria transmission (and other vector-borne diseases such as dengue fever) can be mediated through socioeconomic factors such as poor living conditions, reduced access to healthcare services, population displacements due to climate change, and rising food insecurity leading to malnutrition.<sup>121</sup> Fluctuations in temperature and humidity may compromise the efficacy of antimalarial drugs.<sup>124 125</sup>

### Japanese encephalitis

Japanese encephalitis is a mosquito-borne zoonotic disease transmitted by *Culex* mosquitoes, which acquire the Japanese encephalitis virus by feeding on infected pigs or poultry.<sup>126</sup> An estimated three billion people reside in regions where Japanese encephalitis is endemic,



Effects of climate change on transmission of infectious diseases

predominantly across 24 countries in South East Asia and the Western Pacific.<sup>126</sup> Annually, approximately 68 000 clinical cases are recorded, with a case fatality rate of 25-30% and chronic neurological effects in 30-50% of survivors.<sup>126</sup>

Observational studies have consistently reported positive associations between number of cases and climatic variables such as temperature, relative humidity, and rainfall.<sup>22-34</sup>

### West Nile fever

West Nile fever is caused by West Nile virus (WNV), a mosquito-borne flavivirus, characterised by a global distribution maintained through an enzootic cycle involving *Culex* species mosquitoes and avian hosts.<sup>129</sup> A warming climate can accelerate mosquito and pathogen development, heighten vector competence for WNV, and alter mosquito traits such as longevity, blood feeding behaviour, and fecundity.<sup>36 130 131</sup> Alterations in the timing of bird migration and breeding patterns may further contribute to shifts in long range virus movement.<sup>131 132</sup>

Predictions suggest a broadened WNV distribution and elevated risk worldwide in the context of climate change, albeit with considerable regional variability.<sup>35 36</sup>

### Zika virus disease

Zika virus (ZIKV) disease is a viral disease transmitted by infected *Aedes aegypti* and *A albopictus* mosquitoes.<sup>135</sup> An estimated 3.6 billion people (42% of the global population) live in tropical and subtropical regions where ZIKV disease risk is elevated, and, without

preventive measures such as vector controls, the virus could potentially affect over 6.2 billion people globally (79% of the global population).<sup>135-138</sup> ZIKV disease has emerged as an important global health threat, with 89 countries across five of the six WHO regions reporting evidence of autochthonous ZIKV disease with over 1.4 million suspected and confirmed cases.<sup>135</sup> ZIKV disease is particularly concerning due to its potential to cause severe birth defects such as microcephaly and other congenital anomalies, and many infections go undetected as roughly 75% of cases are asymptomatic.<sup>135 139 140</sup>

Similar to dengue virus, which is transmitted by the same mosquito species, evidence suggests climatic factors can influence ZIKV disease outbreaks, with mechanistic models from laboratory studies showing maximal transmission occurring at temperatures between 26° and 30°C.<sup>40 41</sup>

### Schistosomiasis

With 207 million cases globally (more than 90% of those in Africa), schistosomiasis is caused by six different species of *Schistosoma*, which use freshwater snails as necessary intermediate hosts. The snails release the larval forms of the parasites (cercariae), which can penetrate skin during the contact with infested water, thus leading to human infection. In endemic areas farmers can become infected during routine agricultural, domestic, and occupational activities, and people undertaking recreational activities such as swimming or fishing can also be at risk.

The impact of climate change on schistosomiasis is complex, as the disease's response to climatic factors not only depends on snail types and schistosome species but also ecological and socioeconomic determinants such as dam building and agricultural expansion.<sup>43 142</sup> Within the optimal temperature range of 15-31°C, elevated temperatures are associated with increased snail infection, egg laying, egg hatching, snail maturation, and human infection.<sup>42</sup> Moderate precipitation facilitates snail breeding, while heavy rainfall may disrupt snail habitats and reduce cercariae survivability.<sup>145</sup>

### Leishmaniasis

Leishmaniasis is caused by the *Leishmania* genus of parasitic protozoa. Symptoms range from mild (such as, skin sores, fatigue, loss of appetite) to severe (such as, persistent fever, anaemia, and liver and spleen enlargement) and are influenced by the host's immune response as well as the species of *Leishmania*.<sup>146</sup> It is transmitted to humans through the bites of infected female sandflies and has a variety of reservoirs, including humans, domestic animals, horses, rodents, birds, and reptiles.

Leishmaniasis is endemic in 90 countries, predominantly in South America, East and West Africa, the Mediterranean region, Central Asia, and the Indian subcontinent.<sup>146</sup> However, higher temperatures due to climate change, as well as the rapid movement of people and animals facilitated by mass transit networks, have led to sandflies increasingly appearing in countries and regions with traditionally colder climates, with cases of leishmaniasis detected in previously unaffected countries in recent years.<sup>146</sup>

### Haemorrhagic fever with renal syndrome

Haemorrhagic fever with renal syndrome (HFRS), a rodent-borne disease caused by the *Hantavirus* genus, has an estimated global incidence of 60 000 to 150 000 cases annually, with mainland China accounting for nearly 90% of cases.<sup>147 148</sup> The fatality rate of HFRS varies by virus strain, ranging between 1% and 15%.<sup>149</sup> Humans typically contract the viruses through inhalation of or contact with contaminated rodent droppings, urine, faeces, and saliva.<sup>48 150</sup>

Environmental factors, especially climate, significantly influence HFRS transmission by affecting rodent populations and their interaction with humans.<sup>61</sup> Several epidemiological studies have shown a positive association between temperature, rainfall, humidity, and HFRS cases.<sup>48-62</sup>

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## Impacts of increasing temperatures on foodborne and waterborne diseases

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### Bacterial infections

#### Cholera

Cholera is an acute diarrhoeal disease caused by *Vibrio cholerae*. This waterborne disease occurs in over 40 countries and can be fatal.<sup>151</sup> There has been a recent global emergence of cholera, and climate change and associated extreme weather events could be one of the drivers.<sup>152 153</sup> Cholera transmission can be enhanced with inadequate access to safe water and basic sanitation,

and increasing flooding due to climate change may play an important role. Warmer temperatures can also favour growth of bacteria and produce a higher concentration of pathogens in water;<sup>8</sup> studies consistently found increased risks of cholera with higher temperatures.<sup>63 64</sup>

#### Salmonellosis

Salmonellosis is one of the most prevalent bacterial forms of gastroenteritis, causing over 90 million cases and 155 000 deaths worldwide each year.<sup>155</sup> The optimal temperature for *Salmonella* species is 35-37°C. High temperatures can boost the transmission and replication of the bacteria to contaminate food such as eggs and meat, causing human infections when consumed.<sup>9</sup>

Studies have shown that a 1°C increase in temperature increases the estimated risk of salmonellosis by between 3% and 13%.<sup>71</sup>

#### Campylobacteriosis

The WHO recognises *Campylobacter* infection as “the most common bacterial cause of human gastroenteritis worldwide.”<sup>155</sup> The relationship between temperature and *Campylobacter* infection is less clear than for salmonellosis.

#### Shigellosis (bacillary dysentery)

Shigellosis is caused by *Shigella* bacteria and often results in mild diarrhoea, but severe cases with bloody diarrhoea can be fatal. Quantitative studies are too limited to show that shigellosis is a climate sensitive disease, as the effects of temperature vary across different areas.<sup>79</sup> A 2023 global risk mapping and prediction model study in lower and middle income countries found that shigellosis is sensitive to climatic factors, with infections peaking at 33°C and decreasing above this point.<sup>159</sup>

#### Escherichia coli infection

*E coli* O157 is of particular public health concern as it can cause severe stomach ache, bloody diarrhoea, and kidney failure.<sup>161</sup> Although cases are usually mild, young children and the elderly can be at high risk and complications can be life threatening.<sup>162</sup> In a meta-analysis of 18 studies of *E coli* using temperature modelling, a positive association was found in 15 studies, with a pooled risk estimate of an 8% increase in the incidence of diarrhoeagenic *E coli* for a 1°C increase in mean monthly temperature.<sup>84</sup>

#### Legionellosis

Legionellosis is a form of pneumonia caused by *Legionella* bacteria, which is found in freshwater and in water systems in the built environment. The number of cases in developed countries has been increasing.<sup>163</sup> Rising temperatures have been reported to increase legionellosis in some regions, but the effects are small and inconsistent.<sup>71 85-87</sup>

#### Viral gastroenteritis

The interconnections among viruses that cause enteric infections and climate factors have not been sufficiently examined and understood.

### *Rotavirus infection*

Rotavirus infection is the leading cause of severe, acute diarrhoea in children less than 5 years old. Annually, it is estimated there are over 25 million outpatient visits and more than 2 million hospitalisations worldwide, predominantly in developing countries.<sup>166</sup> Some observational studies have indicated a reduced risk for rotavirus cases associated with warmer temperatures.<sup>92-99</sup> However, time series and cross-sectional studies in China and Africa have reported more cases associated with higher temperatures.<sup>100 101</sup>

### *Norovirus infection*

Norovirus is a leading cause of gastroenteritis causing 200 000 deaths each year.<sup>168</sup> As with rotavirus, the impact of warmer temperatures on norovirus infections is unclear, even though temperature has been identified as a key variable affecting virus persistence in surface waters.<sup>102</sup>

Increases in norovirus outbreaks (>70%) have been reported in cold and dry seasons,<sup>103 104</sup> indicating that lower temperatures may favour the survival of the pathogen in the environment.

### *Hand, foot, and mouth disease (HFMD)*

HFMD is highly contagious and often infects young children. There have been recent outbreaks in the Asia-Pacific region. Both high and low temperatures (non-optimal ambient temperature) may promote the transmission of HFMD, demonstrating an M-shaped relationship with two peaks on both ends of the temperature spectrum.<sup>107-109</sup>

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## International agency and healthcare system response

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### **Disease surveillance, notification, and information sharing**

Climate change poses considerable challenges to overloaded global healthcare and disease surveillance systems, particularly for traditional surveillance systems that rely on historical case notification data.<sup>179</sup>

Integrated surveillance and early warning systems enhance the capacity of health systems to prepare for and respond to infectious diseases sensitive to climate.<sup>180</sup> <sup>181</sup> These systems integrate multiple data sources such as traditional disease surveillance, vector surveillance, and weather data to enable more accurate detection, investigation, and response to infectious disease outbreaks. They rely on timely and transparent information sharing and cooperation between agencies, including health and agricultural departments, meteorological agencies, and vector and animal disease surveillance efforts, both nationally and internationally.<sup>182 183</sup>

The use of satellite remote sensing and geographic information systems technologies enables the identification of spatial and temporal climatic patterns that may influence infectious disease risk, which can be applied to predict epidemics based on these risk conditions.<sup>186</sup> Understanding the geographic distribution of cases is central to enabling resources and preventive efforts to be proactively targeted to at-risk locations and populations.<sup>187</sup>

### **Healthcare workforce knowledge and capacity**

As higher temperatures contribute to the geographic spread of infectious diseases, health service providers, particularly in regions not previously routinely affected by these conditions, may lack knowledge and experience in identifying and treating them.<sup>191</sup>

Increases in consultations and hospital admissions for infectious diseases may contribute to increased unsustainable workloads among healthcare providers, thus reducing their capacity to respond to the health challenges posed by rising temperatures.

As the impacts of high temperatures on infectious disease become more pronounced globally, there is likely to be greater demand for healthcare providers with knowledge and experience in this field, which presents an important opportunity to develop specialised education and training programmes.

### **Healthcare system response: resourcing and collaboration**

The impacts of climate change on infectious disease outcomes pose challenges to the allocation of finite health resources and necessitate greater collaboration between countries and across sectors to adequately prepare for and respond to infectious disease outbreaks.<sup>179 197</sup>

Such efforts could include the development and implementation of targeted training courses and educational workshops for frontline healthcare workers and researchers to improve infectious disease prevention, diagnosis, treatment, and management. Additionally, infectious disease surveillance efforts could be strengthened by facilitating the sharing of information and expertise between countries through the involvement of the WHO and its regional offices.

It is equally important to engage with local communities to participate in and deliver infectious disease control and mitigation interventions. These include education about temperature related health risks and preventive strategies such as distributing mosquito nets and identifying and removing vector breeding sites, particularly in socioeconomically disadvantaged communities.<sup>198</sup> Increasing population adaptive capacity and knowledge of the broader health impacts of increasing temperatures rather than focusing specifically on infectious diseases may promote greater community resilience to the far reaching consequences of climate change.<sup>203</sup>

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## Guidelines

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No specific guidelines for the prevention, treatment, and management of infectious diseases due to high temperatures and climate change have been developed to date. However, general guidelines pertaining to reducing the negative health impacts of heat exposure have been developed, including the WHO European Region Heat-Health Action Plan Guidance.

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# Switching from inhaled to intravenous general anaesthesia

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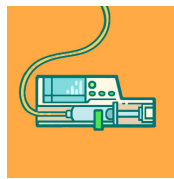
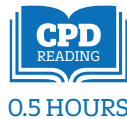
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This article is part of a series that offers practical actions clinicians can take to support reaching net zero. Browse all the articles at <https://sandpit.bmj.com/graphics/2023/tangibleActions-v8/>. To pitch your idea for an article go to <https://bit.ly/46EtI9i>



**Inhalational and intravenous medications can be used to induce and maintain general anaesthesia. In recent years, the use of total intravenous anaesthesia (TIVA) has increased.<sup>1</sup> Although both techniques are safe, TIVA has some clinical and environmental benefits when compared with inhalational anaesthesia.**

## Why change is needed

The “triad of anaesthesia,” comprising unconsciousness, analgesia, and immobility, is typically achieved with hypnotics and analgesics, with or without muscle relaxants. Inhalational anaesthetic agents are greenhouse gases; volatiles (eg, sevoflurane, desflurane) persist in the atmosphere for up to 21 years; nitrous oxide (an analgesic and sedative) persists for more than 100 years. Inhaled anaesthetic agents are estimated to account for up to 3% of total national healthcare greenhouse gas emissions in high income countries, and between 0.01% and 0.1% of greenhouse gas emissions overall.<sup>2</sup>

Inhalational anaesthesia has an impressive safety profile and some valuable clinical uses (eg, induction of anaesthesia in patients without intravenous access), but is also associated with postoperative nausea and vomiting, can trigger malignant hyperthermia in susceptible

patients, and staff working in operating theatres risk occupational exposure. TIVA, typically based on propofol (a hypnotic agent) and an opioid such as remifentanyl, offers a smooth and rapid return of consciousness, which may have implications for patient satisfaction and recovery, and is preferable in situations when ventilation may have to be interrupted (eg, during “tubeless field” airway surgery). Although each technique has indications and contraindications, the decision to use TIVA or inhalational anaesthesia is predominantly determined by anaesthetist preference and institutional norms.

Multiple studies have investigated major complications with inhalational and intravenous anaesthesia, with inconsistent results. A national audit of accidental awareness under general anaesthesia (where a patient is aware of events despite the intention to administer general anaesthesia) identified TIVA as a risk factor, particularly when unusual techniques were used or equipment checks were incomplete.<sup>3</sup> A Cochrane review on cognitive outcomes in older people found that postoperative cognitive dysfunction (a persistent impairment of cognition following surgery) was less likely with propofol-based TIVA,<sup>4</sup> and a meta-analysis of randomised controlled trials found that propofol based TIVA was associated with a lower incidence of emergence agitation in children.<sup>5</sup> At present, we deem it reasonable to consider TIVA and inhalational anaesthesia equivalent from a safety perspective; three major ongoing randomised controlled trials (Vital, expected to conclude in 2026; Vapor-C, expected to conclude in 2026; and Thrive, expected to conclude in 2029) will add further information about the relative risks and benefits of both techniques.<sup>6</sup>

## Evidence for the solution

Multiple studies show that TIVA has a lower carbon footprint than inhalational anaesthesia.<sup>7-9</sup> The studies are based on “life cycle analyses,” using 100 year global warming potential to quantify greenhouse gas emissions. This metric has been criticised in the context of short lived greenhouse gases (such as volatiles), but no alternative has been agreed.<sup>10</sup> TIVA typically leads to more plastic and pharmaceutical waste than inhaled anaesthesia; a recent study indicated that TIVA generates 31 g more plastic per anaesthetic, and 16% of the propofol that is drawn up for TIVA is wasted without being administered to a patient.<sup>9</sup> Propofol is toxic to aquatic life so surplus drug must be destroyed by incineration rather than disposed of through general clinical waste stream.<sup>11,12</sup>

### WHAT YOU NEED TO KNOW

- Inhalational anaesthetic agents are greenhouse gases; total intravenous anaesthesia (TIVA) usually has a lower carbon footprint, and avoids greenhouse gas emission at the point of use
- TIVA has clinical benefits over inhalational anaesthesia in the early postoperative phase, but there is equipoise regarding major complications
- Switching to TIVA relies on staff expertise, equipment availability, and medication supply
- Safety checklists such as *Peruse Before You Infuse* can help to standardise equipment setup and avoid error



Target controlled infusion pumps (Alaris Plus PK, Becton, Dickinson, Franklin Lakes, USA). The upper pump holds a syringe of propofol and the lower pump holds a syringe of remifentanyl. A sevoflurane vaporiser (Vapor 2000, Dräger, Lübeck, Germany) is seen in the background. Ce=effect site concentration; Cet=effect site concentration target

A life cycle analysis of anaesthetic drugs found that propofol TIVA has a carbon footprint nearly four orders of magnitude lower than desflurane or nitrous oxide.<sup>7</sup> A simulation study of paediatric anaesthesia showed that TIVA based on propofol and remifentanyl has a lower carbon footprint in all but the shortest of cases.<sup>8</sup> An observational study of two large hospitals calculated that the average carbon footprint attributable to anaesthetic agents was 20 times lower in the hospital that favoured TIVA.<sup>9</sup>

## What you can do

Anaesthesia providers who wish to use TIVA must ensure that they are appropriately trained, and should be prepared to discuss the risks and benefits of different anaesthetic options with their patients. Since 2021, the UK's Royal College of Anaesthetists has specified that anaesthetists should be trained to use TIVA for non-complex cases in the first stage of training;<sup>13</sup> further training can be sought for more complex situations. Clinicians who work outside of anaesthesia may find it beneficial to have an awareness of TIVA, so they can discuss anaesthesia options with colleagues and patients.<sup>14</sup>

Anaesthetic departments should ensure that appropriate equipment and a robust supply of the required medications is available. Target controlled infusion pumps deliver drugs based on mathematical pharmacokinetic models (fig 1). The user programmes the pump by selecting the drug and the model, and inputting patient data. The initial bolus dose and subsequent infusion rates are based on the target concentration specified. Pumps include models for hypnotics and analgesics, with a choice of plasma and effect site (brain) targets. They should be user friendly and have inbuilt safety alarms. Drug administration sets should incorporate a secure Luer lock connector at each end, and anti-siphon and anti-reflux valves to ensure the

## KEY MESSAGES FOR PATIENTS

- General anaesthesia during an operation can be provided by total intravenous anaesthesia (TIVA, given by an intravenous drip), or inhalational anaesthesia (given by breathing a gas).
- Anaesthetists' first responsibility is patient safety. TIVA and inhalational anaesthesia are both safe for most patients.
- In some circumstances TIVA is not suitable; for example, when no reliable intravenous drip is available. Likewise, inhalational anaesthesia is not suitable for some patients, such as those who are having certain types of airway surgery.
- Anaesthetic gases are greenhouse gases which are thought to contribute up to 3% of the total healthcare related carbon footprint in high income countries. TIVA has been found to have a lower carbon footprint.
- TIVA may have benefits for patient experience (eg, a lower risk of vomiting after surgery)
- Specialised equipment and staff training are required before TIVA can be used. Safety checklists can be used to help the anaesthetic team set up the equipment in a standardised and reliable way.

infusion is administered as intended. The Association of Anaesthetists and Society for Intravenous Anaesthesia recommend depth-of-anaesthesia monitoring based on processed electroencephalography when TIVA is combined with a muscle relaxant, and locating the cannula where it can be visualised intra-operatively to allow the prompt identification of disconnection or "tissinging."<sup>15</sup>

Anaesthetic teams should ensure that TIVA drugs and equipment are thoroughly checked before use, to minimise the risk of errors. The *Peruse Before You Infuse* checklist<sup>17</sup> is a practical guide to help standardise equipment setup and ensure that anaesthetists deliver TIVA correctly. While not formally validated, this checklist has been adopted by some anaesthetic departments across the UK.

TIVA is less well established in obstetric and paediatric anaesthesia, compared with general adult anaesthesia. This is probably because of the complexity of introducing this technique in sometimes stressful situations, pharmacological concerns, and (in paediatrics) potentially challenging intravenous access. Pharmacokinetic models are less well validated in pregnant women and children, yet these patients arguably have much to gain from TIVA (eg, because of the uterine relaxant qualities of volatile anaesthetics, and the increased risk of postoperative nausea and vomiting and agitation on emergence in paediatric practice).<sup>16,18</sup> Uncertainties include the pharmacokinetic implications of various pathologies and stages of pregnancy, and wide pharmacokinetic and pharmacodynamic variability across the paediatric population. Depth-of-anaesthesia monitoring is particularly useful to optimise the dose of TIVA in situations in which pharmacokinetics are less predictable.

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# How education can transform children's anxiety into agency

Policy makers need to do more to mitigate the mental health impact of the climate crisis on young minds

**G**rowing evidence shows how climate change is negatively affecting children's health and wellbeing. Children who were aged 10 or younger in 2020 will live in a much hotter world than their grandparents born in the 1960s: under a 1.5°C warming scenario, they will experience climate events four times as extreme.

Climate exacerbated disasters have disrupted the education of nearly 40 million children each year by destroying schools or causing illnesses that keep children out of classrooms. Over the past six years, climate exacerbated disasters have led to the internal displacement of 20 000 children a day.

More children are realising how profoundly climate change affects their right to health, education, and a safe environment—leading to many negative emotions often described as climate anxiety, solastalgia, or climate distress. A study of 10 000 children and young people around the world found that 59% were worried about climate change, and 45% said their concerns negatively affected their daily lives.

Although 196 countries ratified the Paris Agreement in 2015 and committed to promoting and considering children's rights when taking climate action, fewer than half of their plans are child sensitive, and only 2.4% of major global climate funds support programmes targeting children. This is why Unicef called on country leaders at the 28th UN Climate Conference to mandate the facilitation of an "expert dialogue addressing the disproportionate climate effects on children" in the following year. This dialogue took place in June, urging leaders to consider children's unique vulnerabilities in the negotiation process and to adopt child sensitive policies on which to build funding and programming.

As the youth envoy to the 27th UN Climate Conference in Egypt (COP27), I facilitated the participation of children and young people in negotiations, ensuring their perspectives were integrated. Together with the Children

and Youth Constituency, we organised a youth policy forum bringing ministers and negotiators together with young people.

The forum led to the inclusion of text in the conference's outcome decision on children and young people, including the appointment of the first youth envoy—a role that has become permanent for all future UN climate conferences. Throughout my term I witnessed the psychological burden and burnout faced by young climate activists. But I also saw how they collectively transformed their climate anxiety into agency in these intergovernmental forums.

The question is, how can educators, parents, and policy makers help children to understand and reflect on their psychological responses to climate change? An important first step is to listen to children without downplaying their emotional reactions. Instead, validate their concerns using simple science, and explain that climate anxiety is likely to be an adaptive response rather than a pathological one.

Creating safe spaces such as climate cafes can strengthen children's ability to process and express challenging emotions, allowing them to overcome the fear of judgment and stigma while fostering their resilience. Discussing inspiring stories of action, along with measures to take as a family or in the community, can help reinforce the idea something can be done.

While schools play a critical role, 70% of educators in the UK report they haven't been adequately trained to teach about climate change or solutions. The Climate Cares Centre and the youth led Force of Nature are making efforts worldwide to equip teachers with resources and training on climate and mental health education. Educators have an opportunity to develop competencies that school

leaders can incorporate into the curriculum. These competencies can be taught through art, drama, music, creative writing, and storytelling to empower children to understand their responses to climate change and envision their future roles in tackling it.

## Interventions

Despite an expanding body of evidence on how climate change affects children's mental health, there's still a lack of knowledge about how it is experienced by different age groups, which interventions are effective, and why. More research is needed to guide the development of support interventions for children, parents, and carers. This support should be integrated into social services, healthcare, and education, as well as during disaster preparedness and response efforts.

Scaling up child responsive mental health services in climate planning is necessary to help protect children from immediate distress while mitigating the long term mental health consequences resulting from their exposure to extreme climate events.

Children, a positive disruptive demographic, are determined to change the world. As members of the health community we have a responsibility to foster wider conversations, awareness, and research into the psychological impact of climate

change on children. This should be complemented by collaborating with schools to develop programmes and interventions that equip children, and those caring for them, with the psychological tools for coping and acting in the climate emergency.

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SOPHIALAMY

**I have seen the psychological burden and burnout faced by young activists**

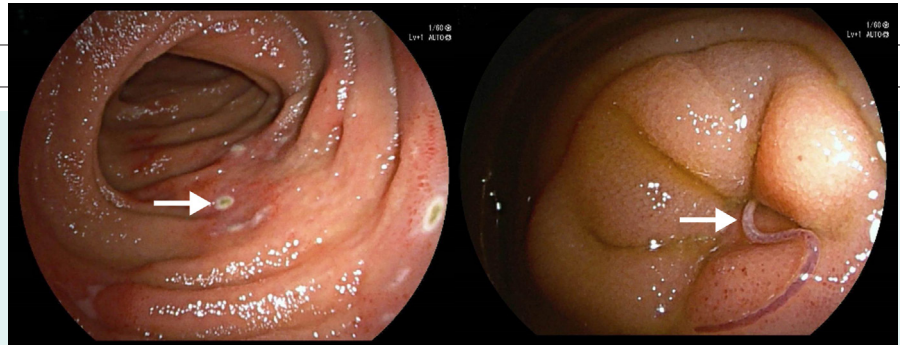


## MINERVA

### A parasitic cause of abdominal pain

This is a double balloon enteroscopic image of the small intestine of a man in his 40s who presented with recurrent periumbilical pain. Blood test results for liver function, urea and electrolytes, and full blood count were normal except for a raised eosinophil count of  $2.39 \times 10^9/L$ . Initial findings from oesophagogastroduodenoscopy and colonoscopy were unremarkable, but computed tomography showed segmental swelling in the upper ileum. On subsequent enteroscopy, alongside superficial ulceration (left hand image, arrow) a hookworm was seen attached to the intestinal wall (right hand image, arrow).

Hookworm infection can cause abdominal pain, gastrointestinal bleeding, iron deficiency



anaemia, protein deficiency, and eosinophilia. Hookworms might reside in the small intestine of human hosts for many years before causing symptoms. Hookworms are soil transmitted parasites, with infection occurring through the ingestion of contaminated food or water, or percutaneously, such as walking barefoot on contaminated soil. Despite urbanisation and improved sanitation leading to reduced prevalence of hookworm infection in high and middle income countries, global prevalence

remains high, particularly in tropical areas. The effects of climate change on soil temperature might lead to changes in the geographical distribution of hookworm infection. This patient was treated with albendazole for three days and the abdominal pain resolved after a week.

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If you would like to write a Minerva picture case, please see our author guidelines at [bit.ly/29HCBAL](https://bit.ly/29HCBAL) and submit online at [bit.ly/29yyGSx](https://bit.ly/29yyGSx)

### West Nile virus

More than 700 cases of West Nile virus infection have been recorded across Europe so far this year, all locally acquired (*Nature* doi.org/10.1038/d41586-024-03031-y). As it's a mosquito borne disease, climate change seems the obvious culprit. *Culex pipiens*, the mosquito that transmits West Nile virus from infected birds to humans and other animals, has been native to Europe for centuries, however. The story behind the spread of West Nile virus is complicated and, although climate change is an important part, changes in population density, agriculture, and patterns of travel are also involved (*Nature Communications* www.nature.com/articles/s41467-024-45290-3).

### Tectonic plates and past climate changes

Among the planets in the solar system, Earth is unique in having plate tectonics. Its rocky surface is split into large fragments that grind and jostle into each other to create mountains, volcanos, and earthquakes. Movement of tectonic plates locks up vast amounts of atmospheric carbon dioxide by recycling marine sediments rich in calcium carbonate into the Earth's interior, although this process happens only over extremely long time scales. Watch a fascinating animation which compresses 1.8 billion years of tectonic plate

movement into just over a minute (<https://theconversation.com/witness-1-8-billion-years-of-tectonic-plates-dance-across-earths-surface-in-a-new-animation-238209>).

### Ancient Rapanui genomes

Famous for its megalithic statues, Rapa Nui (Easter Island) is often presented as a story of a people that overexploited their resources, destroyed their ecosystem, and experienced a major population collapse. A recent reconstruction of the genomic history of the Rapanui challenges this idea (*Nature* doi.org/10.1038/s41586-024-07881-4). Using radiocarbon dated material from human remains of 15 ancient Rapanui individuals preserved in a French museum, whole genome sequencing showed no evidence of a population bottleneck during the 1600s that would have been expected if the theory of a self-inflicted population collapse was correct.

### Super-centenarians

Blue zones—areas of the world where people live beyond 100 in unexpectedly large numbers—have attracted attention as a way of learning about successful ageing. Minerva was never convinced that studying a few individuals at the extreme tail of a continuous distribution was a useful thing to do, but it turns out that the project fails for an entirely different reason (*bioRxiv* doi.

org/10.1101/704080). When these super-centenarians were tracked down, hardly any had a birth certificate. Far from being areas of outstanding longevity, blue zones correspond to regions with low incomes, low literacy, high crime rates, and short life expectancy relative to their national average. In short, most of these remarkable human age records can be explained by pension fraud or clerical error. The investigator behind this piece of research has just been awarded an Ig Nobel prize (<https://phys.org/news/2024-09-extreme-human-aging-rotten-ig.html>).

### Protective effect of coffee and tea drinking

Cardiometabolic multimorbidity, which means having at least two out of type 2 diabetes, coronary heart disease, and stroke, is substantially less frequent in people who drink tea and coffee. Among nearly 200 000 participants in the UK Biobank study who were free from these diseases at the time of recruitment, regular consumers of moderate amounts of coffee—three cups of coffee a day or the equivalent in other caffeine containing beverages—were 40 to 50% less likely to develop cardiometabolic multimorbidity than people who drank less than 100 mg caffeine a day (*J Clin Endocrinol Metab* doi.org/10.1210/clinem/dgae552).

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