Clim. Dynam. **49**, 4237–4261 (2017).
4. Wu, X., Okumura, Y. M. & DiNezio, P. N. *J. Clim.* **32**, 5941–5965 (2019).
5. Iwakiri, T. & Watanabe, M. *Sci. Rep.* **11**, 17465 (2021).
6. Fang, S.-W. & Yu, J.-Y. *Geophys. Res. Lett.* **47**, e2020GL087933 (2020).
7. Park, J.-H. *et al. Int. J. Climatol.* **41**, E1353–E1370 (2021).
8. Kim, J.-W. & Yu, J. Y. *npj Clim. Atmos. Sci.* **5**, 88 (2022).
9. Hasan, N. A., Chikamoto, Y. & McPhaden, M. J. *Front. Clim.* **4**, 1001174 (2022).
10. Lee, S. *et al. npj Clim. Atmos. Sci.* **5**, 82 (2022).
11. Wills, R. C. J., Dong, Y., Proistosecu, C., Armour, K. C. & Battisti, D. S. *Geophys. Res. Lett.* **49**, e2022GL100011 (2022).
12. Guilyardi, E., Capotondi, A., Lengaigne, M., Thual, S. & Wittenberg, A. T. in *El Niño Southern Oscillation in a Changing Climate* (eds McPhaden, M. J., Santoso, A. & Cai, W.) Ch. 9 (Am. Geophys. Un., 2020).

The author declares no competing interests.

Public health

A sustainable solution for infectious-disease control

Nathan C. Lo & Benjamin F. Arnold

A trial in Senegal has tested an innovative method for tackling a common human parasitic disease. The approach reduced infection numbers and also offered agricultural and economic benefits. **See p.782**

Schistosomiasis, one of the most common human parasitic diseases, is a global menace because of its high rates of infection and contribution to poverty. Over the past two decades, global campaigns using antiparasitic medication have been carried out to combat the scourge of the disease. In 2022, the World Health Organization released guidelines[1] to further expand the scale of these mass-treatment campaigns, with the goal of eliminating schistosomiasis as a public-health problem by 2030. Although this strategy has yielded clear public-health benefits[2], the following key question remains: what solutions can be devised to further combat schistosomiasis and forge a sustainable future? On page 782 , Rohr *et al.*[3] identify an innovative and transdisciplinary solution to reduce cases of schistosomiasis.

The authors took the approach of removing invasive freshwater vegetation to dismantle the habitats of the snails responsible for transmitting the parasite. The intervention not only reduced parasite prevalence in humans, but also improved agricultural and livestock yield by making use of the vegetation. This is therefore potentially a win–win approach for human health and economic development.

The parasitic worm's life cycle includes an intermediate stage in a freshwater snail host of the genus *Biomphalaria* (Fig. 1) or *Bulinus*. Human infection, caused by worms of the genus *Schistosoma*, occurs with freshwater exposure (such as in a lake), when skin-burrowing juvenile parasites enter and migrate through the human body. The worms produce eggs that are excreted from the body in urine or stools. If these eggs reach areas of fresh water, hatch and find a snail, and then infect a human host, their complex life cycle is completed.

Because of the parasite's requirement for snails as part of its life cycle, there is a long history of public-health interventions aimed at reducing the snail population. Such approaches have focused on chemically treating freshwater bodies[4]. These interventions have shown public-health benefits, but their adoption rates have been low, partly because of ecological concerns about the use of chemicals. This underscores the need for transdisciplinary research to develop holistic solutions for snail control that also consider key social and economic factors.

Rohr and colleagues carried out a trial (a three-year cluster randomized controlled trial) in 16 communities in Senegal. The authors tested an intervention that removed invasive underwater vegetation (*Ceratophyllum demersum*) from key water points. The vegetation supports a high density of snails, and the authors hypothesized that removing this habitat would reduce the snail population and, in turn, parasite infection among children.

During the trial, the study team removed a remarkable 433 tonnes of aquatic vegetation over multiple trips. In the communities that received the intervention, the authors found an eightfold reduction in the snail population and, more importantly, a 32% reduction in *Schistosoma mansoni* infection in schoolchildren (although there was no clear effect on *Schistosoma haematobium* infections) compared with those in control communities.

A key novelty of this study is what the authors did next: they hypothesized that farmers could use this removed aquatic

ANDREW LISTER/GETTY

Figure 1 | *Biomphalaria pfeifferi*. This species of snail can host the parasite that causes the human disease schistosomiasis.

vegetation to increase crop and livestock yields, boosting economic well-being, and thereby incentivizing uptake of the intervention. The composted vegetation was used as a fertilizer, which increased both onion and pepper production. The vegetation could also replace conventional livestock feed — it was similar in quality to typically purchased feed, but was up to 179 times cheaper.

Environmental interventions such as this run the risk of having unintended consequences by disrupting a complex ecological web. The authors diligently looked for changes in water quality and chemistry and in human usage. The intervention did not seem to cause any deleterious environmental effects. The dense vegetation might have been a result of the construction of the Diama Dam, which altered water availability in a way that might aid vegetation growth, and the authors argue that the intervention restores the habitat to closer to its previous levels of vegetation.

This project demonstrates the creative potential at the intersection of scientific disciplines, and provides an admirable example of team science: in this case, a partnership of scientists from Senegal and the United States with diverse academic backgrounds — ecologists, economists and epidemiologists — working to develop and test innovative solutions in global health (*Nature* **525**, 308–311; 2015). The proposed intervention, after further research, could be considered as an option to complement the current mass drug-treatment campaigns for schistosomiasis. Achieving elimination will surely require more than drugs alone, and these multi-disciplinary environmental strategies will probably be key to any successful elimination efforts.

Key questions remain to be answered. First, will the positive health and economic effects seen in this study generalize to other locations in which schistosomiasis is prevalent? Although these findings are exciting, *Schistosoma* transmission is a complex and varied process. Factors such as variation in freshwater bodies and vegetation between locations and over time, human behaviour and environmental and ecological factors all affect transmission and might change the intervention's effect. Furthermore, assessing *Schistosoma* infection is challenging because diagnostics are at present imperfect, and because seasonal variation and other complexities affect measurement. Therefore, the conditions that produced the results here might not be present elsewhere, underscoring the need to carry out further research in other settings before the approach can be scaled up.

Second, will this intervention achieve high and sustained large-scale uptake in the real world? The field of public health is filled with examples of well-proven interventions that end up gaining limited uptake and generating 'response fatigue' over time. Any future implementation should be paired with close measurement and evaluation — preferably with further randomized trials, given the complexities of infectious-disease transmission — to ensure that the public-health benefit of this intervention is long term, robust and demonstrated at scale.

A compelling feature beyond the immediate health benefits of this approach is its tangible economic benefits for the community, which might position it well for adoption and uptake. However, navigating the translation of the findings into practice will be challenging.

The results of this study should invigorate the pursuit of environmental approaches to reduce the spread of infectious diseases. Such research is an example of a global health solution that breaks down the boundaries of academic siloes, and might pave the way for more innovative solutions.

Nathan C. Lo is in the Division of Infectious Diseases and Geographic Medicine, Stanford University, Stanford, California 94305, USA.
Benjamin Arnold is in the Francis I. Proctor Foundation and in the Department of Ophthalmology, University of California, San Francisco, San Francisco, California 94158, USA.
e-mails: nathan.lo@stanford.edu; ben.arnold@ucsf.edu

1. World Health Organization. *WHO Guidelines on Control and Elimination of Human Schistosomiasis* (WHO, 2022).
2. Deol, A. K. *et al. N. Engl. J. Med.* **381**, 2519–2528 (2019).
3. Rohr, J. R. *et al. Nature* **619**, 782–787 (2023).
4. King, C. H., Sutherland, L. J. & Bertsch, D. *PLoS Negl. Trop. Dis.* **9**, e0004290 (2015).

N.C.L. declares competing interests. See go.nature.com/3jnjmek for details.
This article was published online on 12 July 2023.

In retrospect

Sixty years since the report of global lead pollution

Jerome Nriagu

The 1963 discovery that even the vast oceans were highly contaminated with lead from car exhausts sparked debate and policy changes that benefited the health of millions — and revolutionized the practices of marine biogeochemistry.

In the early 1960s, the observation of a high concentration of lead in the surface waters of the Pacific Ocean off southern California sparked debate. Was it from a previously unknown geological source, or was it symptomatic of environmental contamination in the entire Northern Hemisphere, caused by emissions of lead compounds from industrial sources and car exhausts[1,2]? And if it was a symptom of worldwide contamination, then what were the risks to human health, especially in urban areas? The geochemical puzzle was solved in 1963 by Tatsumoto and Patterson[3], who reported in *Nature* that the oceans were being highly polluted with lead produced from the use of leaded petrol. The paper did not receive the acclaim that it deserved at the time, but it became a milestone in the public-health controversy surrounding the use of leaded petrol[4].

Tatsumoto and Patterson set out to show that the ocean was lead-free in pre-industrial times, because this would indicate that most of the lead in the contemporary ocean came from anthropogenic sources. They were not the first to study lead concentrations in the ocean, but two features made their study unique. First, they used highly sophisticated measurement procedures that could determine low levels of lead in seawater with a precision that was unattainable in most laboratories at the time. And second, the seawater samples were collected from five locations strategically chosen to capture the influence of lead emissions transported through the air from North America and Europe. The authors also measured lead in recently fallen snow taken from a mountain top in California, to estimate the baseline of atmospheric deposition of lead compounds at remote continental sites.

From the differences in isotopic composition of lead in the snow and of lead found in prehistoric sediments of the Atlantic Ocean[5,6], Tatsumoto and Patterson were able to 'fingerprint' the source of the lead in the ocean water. The concentration of silica in the snow was also determined as a measure of the amount of dust present; because the dust derives from natural mineral sources, this measurement allowed the authors to calculate how much lead from