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GREEN RECOVERY

Decarbonising healthcare in low and middle income countries: potential pathways to net zero emissions

*Healthcare in low and middle income countries has a high carbon footprint. Reducing emissions should be integral to plans for universal health coverage, say **Fawzia Rasheed and colleagues***

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Considerable attention has been paid to the role that healthcare systems have in combating climate change.¹ Recent analysis has calculated the global carbon footprint of healthcare as equivalent to 2-2.4 Gt of CO₂, about 4-5% of total global emissions.^{2,3}

The focus is often on reducing emissions in high income countries (HICs) and adaptation in low and middle income countries (LMICs).⁴ Few LMICs are included in studies on carbon emissions from healthcare.

This imbalance is understandable, given the greater relative contribution to greenhouse gas emissions from health systems in HICs and the disproportionate

burden of climate change impacts on LMICs.^{5,6} Nevertheless, healthcare in LMICs is a carbon intensive activity and likely to grow with the delivery of commitments to universal health coverage (UN Sustainable Development Goal 3.8).

Table 1 shows emissions intensity data grouped by country economic classification.⁴ All direct and indirect emissions from healthcare and the healthcare supply chains are included (Greenhouse Gas Protocol scopes 1 (healthcare operations), 2 (electricity), and 3 (supply chains)). This suggests, at least in economic terms, that healthcare in LMICs is more carbon intensive than that in HICs.

Table 1 | Healthcare sector emissions by country economic classification⁴

Income group	No of countries with data	Average (range) CO ₂ intensity (kgCO ₂ e/\$)
Low income	0	0
Lower middle income	7	1.44 (0.5-3.9)
Upper middle income	17	0.87 (0.23-2.08)
Low and middle income	24	1.03 (0.23-3.9)
High income	37	0.38 (0.07-2.09)

The UN 2025 target is for one billion more people to benefit from access to affordable healthcare.⁷ Most LMICs haven't yet fully met basic needs for healthcare services. In 2017, the World Health Organization financing team estimated that by 2030 an additional \$371bn (£262 bn; €303 bn) would need to be invested every year in 67 LMICs to meet the Sustainable Development Goal targets for universal health coverage.⁸ Over two thirds of the additional resources were estimated to be for primary healthcare services, which currently receive 54% of healthcare spending in LMICs.⁹

If the carbon impact of this investment follows the average emissions intensity for the 24 LMICs in **table 1**, achieving universal health coverage could result in an additional 382 million tonnes of CO₂ equivalent (tCO₂e) a year. This would increase the global carbon footprint of healthcare by about 16% from 2.4 billion tonnes. This figure could be substantially higher if investment is weighted towards lower middle income countries.

Climate change may increasingly threaten the achievement of universal health coverage.¹⁰ As such,

to ensure gains in healthcare are sustainable in the long term, it is imperative that emissions reduction forms an integral part of the delivery of universal health coverage.

Conversely, measures to mitigate carbon emissions can also deliver cost savings (eg, energy efficiency), short term public health benefits (eg, reduced air pollution), and timely access to care (eg, telehealth). Integrating carbon mitigation investment into delivery of universal health coverage could leverage greater gains in health and healthcare coverage in LMICs. The 2017 WHO costings paper also broadly identified the critical importance of efficiency gains in reaching Sustainable Development Goal targets.

Sources of carbon emissions

The quality of the care environment in many major hospitals in LMICs may be on a par with that in HICs; however, care in rural areas is often delivered in less well resourced facilities.¹¹ A study of 21 indicators compiled from 78 LMICs, representative of 129 557 healthcare facilities, showed that 50% of facilities lack piped water and 59% lacked reliable energy services. The study highlighted that poor

environmental quality increases risks to the health of patients and healthcare workers.

Another recent study showed that less than two thirds of hospitals providing surgical care in 21 LMICs had a continuous electricity source or a generator.¹² Health outcomes are linked to sustainable power supply.^{13 14}

Fossil fuelled emergency generators are found in hospitals worldwide. In LMICs, unreliable electricity grids leave facilities dependent on expensive and polluting generators daily or as their primary power supply. In January 2021, for example, a country-wide power cut in Pakistan, where power cuts are common, left hospitals and health facilities running on fossil fuelled generators. Essential facilities such as hospitals often use diesel generators as a back-up power supply; many areas have no electricity for several hours a day.¹⁵

Where grid power is available, it may be more carbon intensive than in HICs. In India, in 2017 each unit of grid supplied electricity resulted in 743 g CO₂, compared with an average of 303 g per unit across 27 EU states.^{16 17}

Typically, emergency, non-emergency, and public health outreach vehicles in LMICs have to navigate poor and dangerous roads. Vehicles may be old and public transport options limited, exacerbating accessibility for remote communities.¹⁸

Many suppliers of pharmaceuticals and medical devices in LMICs are the same ones that supply higher income countries. Many, but by no means all, multinational companies already report their emissions publicly.¹⁹ Where available, corporate carbon reports for these global brands show that emissions from their supply chain are considerably higher than those from their own operations.²⁰ For many products, particularly personal protective equipment and generic drugs, LMICs are significant manufacturers and exporters.^{21 22} Manufacturers in these countries are likely to share some of the emissions challenges and opportunities faced by LMIC healthcare providers.

Although some multinationals have set net zero targets, the emissions intensity of the pharmaceutical sector is about 55% higher than that of the automotive sector.¹⁹ It is time that this sector is scrutinised more closely, by HICs and LMICs alike.

Healthcare models

Healthcare provision in LMICs can be highly fragmented.²³ The need to work across public, private, and third sector providers increases coordination challenges to effect system-wide changes. These are issues being explored widely in the delivery of universal health coverage.

Current trends of building hospitals with an over medicalised, fragmented approach to healthcare, which forfeits efficiency, must change. Care that doesn't improve health, admission of patients to carbon intensive hospitals when they could have equally been managed at home, and occurrence of avoidable illnesses should be seen as systemic and moral failures.²⁴

The most rational and cost effective way to achieve universal access and reduce emissions is to invest in keeping people healthy^{24 25}—that is, promoting health literacy, facilitating healthier lifestyles, detecting cases earlier, and bringing services closer to patients' homes. This principle, central to universal health coverage, would yield all-round gains for patients, the planet, and healthcare costs.^{26 27} It also underlines the importance of prioritising primary care.

Covid-19 has increased incentives to invest in universal health coverage to deliver less fragmented and more digitally enabled health systems.²⁸ Digital care and telehealth have proved indispensable during the pandemic, increasing access in LMICs while reducing costs and carbon emissions.^{29–31}

WHO projects that delivery of universal health coverage will require the construction of at least 415 000 new health facilities, 378 000 of which would be primary health centres.⁸ This presents a unique opportunity to build zero carbon facilities, which in our experience is particularly feasible for these smaller facilities.

Achieving net zero across all sectors is one of the most important global health interventions.^{23 32} We argue that healthcare leadership in decarbonisation in LMICs would be a public good in itself, under the maxim “first do no harm.”

Measuring the carbon footprint of healthcare

Reducing a healthcare provider's carbon footprint begins with robust baseline calculations. In many HICs, regulatory requirements on carbon reporting are supported with government endorsed tools and methods, developed in line with international protocols. As with other areas of systematic data collection and measurement,⁹ healthcare providers in LMICs have had limited access to carbon footprinting tools.

Deficits in data to drive investment in improvement, sector specific expertise, national carbon footprinting guidance, and uneven regulations may all have delayed progress.

Recently, several agencies have started filling this gap. An expert meeting hosted by WHO in February 2021 discussed tools and approaches to calculate the footprint of health operations.³³ These included those used by the Aga Khan Development Network, the NHS in England, and the international non-governmental organisation Health Care Without Harm. This is an area in which WHO seems poised to provide guidance.

Together with networks such as the World Organization of Family Doctors (WONCA), efforts to embed related training into accredited continuing medical education could also be transformative.³⁴ Indeed, enabling health workers to understand their own footprints is already helping drive changes in practice, as well as resulting in partnerships with professional networks and governments to widen impact (box 1).

Box 1: Carbon footprinting for healthcare professionals

Aga Khan Health Services developed its own carbon footprinting tool in 2020.³⁵ The tool was deployed for use by healthcare professionals across operations in nine LMICs.

Within months of initial orientation, after identification of anaesthetics and propellant inhalers as product carbon hotspots, clinicians took action to reduce impacts.

Aga Khan Health Services' anaesthesiologists established plans to make recommended substitutions to lower carbon gases and reduce volumes overall, and pharmacists did the same with respect to inhalers.

In Kenya, anaesthesiologists started working with professional networks including the Kenyan Society of Anaesthesiologists to influence change. Through the opportunity of a government collaboration and multinational pharmaceutical companies in Kenya, pharmacists negotiated to make propellant-free inhalers cheaper. This helped encourage their use throughout the country. They also worked with the government to raise awareness to help change policies and practices.³⁶

Health professionals are seen as particularly credible advocates, and leveraging their potential can provide substantial impetus to efforts to reduce carbon emissions. This is particularly the case in

LMICs, where they form a larger part of the economic and political elite. As has been shown in the covid response, health workers can work with researchers, media, and policymakers, as well as communities, to co-produce plans.³⁷ This same thinking must be applied in embedding carbon reduction into the wider approach to universal health coverage.

Achieving net zero

Achieving net zero in the provision of essential healthcare, while achieving universal health coverage, will require action on many fronts, although three hotspots constitute the bulk of the emissions challenge: energy, travel, and the supply chain (table 2).

Table 2 | Examples of opportunities to act to reduce emissions

Area of focus	Initiative	Financial value	Environmental value	Health value
Planning and strategy	Calculate carbon footprint using newly available tools	Investment cost in staff time	Essential first step to targeted action and initiation of cross-organisational and systemic engagement	
	Further strengthen WHO support for environmental sustainability ³⁸	Improve evidence informed policy	Efficiently and effectively coordinate global efforts to decarbonise healthcare	
	Shift from hospital centric to community and preventive care ⁷	Lower healthcare costs	Fewer emissions associated with healthcare facilities	Increased focus on prevention and timely access to care
	Comply with the healthcare professionals' call for a healthy recovery from covid 19 ³⁹	Cumulative global gross domestic product gains of \$98tn between now and 2050 ⁴⁰	Reduced carbon emissions, air pollution, water pollution, and nature degradation	Respiratory, cardiovascular, cancer, foetal development, infant birth outcomes, and more
Act on energy (design of new and retrofit of existing healthcare facilities)	LED (light emitting diode) lighting and lighting controls ⁴¹	Up to 85% less expensive to run	Up to 85% less CO ₂ . Avoids use of mercury in fluorescent lights	Emit less UV, attract fewer insects, less vector borne illness risk ⁴²
	Battery power (on-grid sites) ⁴³	Lower cost to run than petrol generators ^{44 45}	Less CO ₂ , air pollution, and noise Although mining impacts LMICs ⁴⁶	Less air pollution, noise, occupational health risk
	Efficient cooling ^{7, 49}	Inverter driven AC units can cost 50% less to run	Less CO ₂ from electricity use and refrigerants leaks	Essential cooling becomes more affordable
	Solar photovoltaic (off-grid sites) ⁵⁰	Lower running cost than off-grid petrol generators	Far fewer carbon emissions, air pollution, and noise	Less air pollution, noise, occupational health risk
Act on transport	Optimise video conferencing post-covid 19	Efficient use of staff time, healthcare facilities, lower fuel costs ²⁹	Lower CO ₂ from transport and healthcare facilities	Less burden to staff from travel. More time for healthcare
	Accelerate shift to telehealth post-covid 19 ²⁷⁻²⁹			Improved healthcare access and quality; less infection, accident risk, travel burden
	Move to plug-in hybrid electric vehicles and car pooling ⁵¹	Lower fuel and maintenance costs		Less noise and air pollution
Act on procurement and product choice	Reduce overprescribing, increase non-pharma options ^{52 54}	Drugs and devices costs	Fewer emissions associated with pharma and supply chain	Reduced health risk of adverse drug reactions and antimicrobial resistance
	Low carbon inhalers. Favour propellant-free devices and better condition management ⁵⁵	Dependent on product	Avoided emissions of high carbon propellants ^{56 57}	Improved management of respiratory conditions
	Low carbon anaesthetics and replacing surgical N ₂ O with medical air/O ₂ ⁵⁸	Dependent on product	Less CO ₂ and ozone depletion impact from anaesthetics ³⁶	Less risk to healthcare staff from occupational exposure to gases ⁵⁹
	Geographical sourcing to favour lower carbon country of origin ⁶⁰	Potential to stimulate industry and governments to invest in sustainability and green growth ^{61 62}	Some LMICs and specific companies are already decarbonising Accounting and valuing CO ₂ in procurement can reduce supply chain emissions and encourage wider change	Stimulating growth in cleaner, more environmentally responsible suppliers creates employment, reduced pollution, and supports the wider determinants of health
	Favour low CO ₂ suppliers			
Advocacy	Favour low CO ₂ products, packaging, and logistics			
	Visible standards, targets, and public reporting of progress in decarbonised healthcare	Wider scale of uptake and impact from measures such as those identified above	Wider understanding and appreciation among the public and policy makers of the need to factor carbon and environmental issues into public planning and investment, in healthcare and beyond	Safeguarding the environmental determinants of health
	Health professional's engagement with national and regional professional and media networks, encouraging clear commitments with practical actions ^{37 38}			
Health providers' engagement with governments encouraging policy and financial incentives for carbon reduction ^{3 33 36}				

Direct emissions from healthcare operations (scope 1), together with electricity (scope 2), typically comprise just over a quarter of the carbon footprint of healthcare. Energy and fuel use are also major

sources of air pollution.^{3 63} Progress in reducing emissions from energy and fuel will require healthcare providers to invest in energy efficiency as well as zero carbon energy sources, in new and existing

facilities. Net zero will require the addition of renewables and government policies for national grid and vehicle fleet decarbonisation (box 2).⁶⁵

Box 2: Examples of decarbonisation projects

- *Bamyan hospital*—In 2016 a 400 kW solar electric system was installed at a hospital in Bamyan, Afghanistan. It provides 50-60% of the power to the 141 bed hospital, with diagnostics and surgery.⁶⁴
- *India* has committed \$1.4bn towards electrifying the transportation sector: policies include public fleet procurement, charging points for electric vehicles, financial incentives (and disincentives for polluting vehicles), bulk procurement for cost reductions, and an overarching goal of 30% penetration by 2030.⁵¹
- *Santa Isabel Hospital*—The main challenges in delivering a carbon reduction programme for this hospital in Salvador, Brazil, were related to sourcing funds and negotiation of prices. Actions implemented in 2019, such as efficient lighting, solar water heating, and improvements to heating, ventilation, and air conditioning resulted in a 2% reduction in total greenhouse gas emissions compared with 2018. Overcoming funding barriers left a portfolio of potential investors. Emissions savings were calculated using a greenhouse gas inventory tool from the Healthy Hospitals Project.³
- *Valle del Lili Foundation University Hospital* in Colombia established a sustainable purchasing programme. Purchasing processes were created and strengthened, which, among other actions, prioritised reducing the use of toxic substances, replacing disposable materials with reusable ones, and promoting the use of energy efficient equipment. By 2019, the programme was achieving annual savings of around \$700 000.³

As with other consumption intensive sectors,⁶⁶ the remaining bulk of most health providers' emissions can be attributed to the supply chain (scope 3), most notably from the manufacture and supply of essential pharmaceuticals and medical devices.³³³ Progress in reducing emissions from procurement will require governments and health networks to wield their purchasing power. Suppliers

will need to be persuaded to reduce their own emissions and the emissions associated with their products.

Work in HICs, equally relevant to LMICs, has identified a few particularly environmentally damaging clinical products. Pressurised metered dose inhalers and anaesthetics merit specific focus, owing to the direct release of potent greenhouse gas emissions in their use.^{67 68} Progress in reducing emissions from these high carbon products will require clinicians to apply an understanding of their environmental impact in condition management, clinical practice, and product choice.

Conclusions

Much of the road to net zero healthcare is possible with transferable knowledge and technology already available in LMICs. The barriers are likely to be in the priorities set by healthcare providers, the general public, and lawmakers to implement effective targeted action, and most critically in access to the necessary financial resources to act.

Failure to integrate carbon reduction with the investment required to deliver universal health coverage and stimulus packages for covid recovery could undermine prospects for sustainability. Conversely, we have an opportunity to increase the efficiency, effectiveness, and equity of health systems through actively aligning all universal health coverage investment and programme management expectations with the global fight against climate change. Options for decarbonising health align perfectly with reinvigorating the evidence based primary healthcare movement.⁶⁹

The abilities of health workers in LMICs to innovate, build strategic south-south alliances, and secure the necessary political buy-in should not be underestimated. With effective leadership, coordination, and financing, charting a plan for health sector decarbonisation in LMICs is eminently feasible. This is a fast changing field where changes in technology, healthcare delivery, and products can transform what can and should be attempted. All engaged will have much to learn and share through WHO. The health sector in LMICs will be no exception.

**Key recommendations**

- Healthcare providers in LMICs should be expected by ministries of health to calculate the carbon footprints of their organisations and to embed action in the delivery of universal health coverage to reduce emissions.

- Donors and healthcare providers should ensure that virtuous circles in efficiency and health are maximised.
- Healthcare providers should seek opportunities to increase energy efficiency and move rapidly away from a reliance on fossil fuels and generators.

- Providers and ministries of health must identify and act on opportunities to reduce emissions in the supply chain.
- Clinicians should seek to understand which products have already been identified as particularly damaging and the possible mitigation measures.

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- Salas RN, Maibach E, Pencheon D, Watts N, Frumkin H. A pathway to net zero emissions for healthcare. *BMJ* 2020;371:m3785. doi: 10.1136/bmj.m3785 pmid: 33004403
- Lenzen M, Malik A, Li M, et al. The environmental footprint of health care: a global assessment. *Lancet Planet Health* 2020;4:e271-9. doi: 10.1016/S2542-5196(20)30121-2 pmid: 32681898
- Health Care Without Harm and Arup. Health care climate footprint report. Green paper number One. 2019. <https://noharm-global.org/ClimateFootprintReport>.
- World Health Organization. WHO guidance for climate-resilient and environmentally sustainable health care facilities. WHO, 2020. <https://www.who.int/publications/i/item/9789240012226>.
- Baker A, Mitchell I, Centre for Global Development. Projecting global emissions for lower-income countries. 2020. <https://www.cgdev.org/publication/projecting-global-emissions-lower-income-countries>.
- World Social Report UNDESA. Climate change: Exacerbating poverty and inequality. 2020. <https://www.un.org/development/desa/dspd/wp-content/uploads/sites/22/2020/02/World-Social-Report-2020-Chapter-3.pdf>
- World Health Organization. Universal health coverage (UHC). WHO, 2021. [https://www.who.int/news-room/fact-sheets/detail/universal-health-coverage-\(uhc\)](https://www.who.int/news-room/fact-sheets/detail/universal-health-coverage-(uhc)).
- Stenberg K, Hanssen O, Edejer TT, et al. Financing transformative health systems towards achievement of the health sustainable development goals: a model for projected resource needs in 67 low-income and middle-income countries. *Lancet Glob Health* 2017;5:e875-87. doi: 10.1016/S2214-109X(17)30263-2 pmid: 28728918
- OECD. Primary health care in low- and middle-income countries. In: Realising the potential of primary health care. OECD, 2020.
- Salas RN, Jha AK. Climate change threatens the achievement of effective universal healthcare. *BMJ* 2019;366:i5302. doi: 10.1136/bmj.i5302 pmid: 31548271
- Cronk R, Bartram J. Environmental conditions in health care facilities in low- and middle-income countries: Coverage and inequalities. *Int J Hyg Environ Health* 2018;221:409-22. doi: 10.1016/j.ijheh.2018.01.004 pmid: 29352706
- Chawla S, Kurani S, Wren SM, et al. Electricity and generator availability in LMIC hospitals: improving access to safe surgery. *J Surg Res* 2018;223:136-41. doi: 10.1016/j.jss.2017.10.016 pmid: 29433865
- Michtenberg A, McLaughlin B, DiGaetano M, et al. Health care during electricity failure: The hidden costs. *PLoS* 2020 Nov 4. <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0235760>.
- Ramji A, Patnaik S, Mani S, Dholakia HH. Powering primary healthcare through solar in India. Council on Energy, Environment and Water, 2017. <https://www.ceew.in/publications/powering-primary-healthcare-through-solar-india>.
- Kermani S. Pakistan power cut plunges country into darkness. *BBC News* 2021 Jan 10. <https://www.bbc.co.uk/news/world-asia-55606598>.
- European Environment Agency. Greenhouse gas emission intensity of electricity generation. 2020.
- Climate Transparency. Brown to green. The G20 transition to a low-carbon economy. India, country profile. 2018. <https://www.climate-transparency.org/media/india-country-profile-2018>.
- Kironji AG, Hodkinson P, de Ramirez SS, et al. Identifying barriers for out of hospital emergency care in low and low-middle income countries: a systematic review. *BMC Health Serv Res* 2018;18:291. doi: 10.1186/s12913-018-3091-0 pmid: 29673360
- Belkhir L, Elmeligi A. Carbon footprint of the global pharmaceutical industry and relative impact of its major players. *J Clean Prod* 2019;214:185-94doi: 10.1016/j.jclepro.2018.11.204
- Pharmaceutical Supply Chain Initiative. Scope 3 greenhouse gas emissions calculation: guidance for the pharmaceutical industry. 2020. <https://pscinitiative.org/downloadResourceFile?resource=779>.
- Guerin PJ, Singh-Phulgenda S, Strub-Wourgaft N. The consequence of COVID-19 on the global supply of medical products: Why Indian generics matter for the world? *F1000Res* 2020;9:225. doi: 10.12688/f1000research.23057.1 pmid: 32566139
- British Medical Association. In good hands. Tackling labour rights concerns in the manufacture of medical gloves. 2016. <https://www.bma.org.uk/media/1093/in-good-hands-medical-gloves-report-web-23-03-2.pdf>.
- Hasan MZ, Singh S, Arora D, Jain N, Gupta S. Evidence of integrated primary-secondary health care in low-and middle-income countries: protocol for a scoping review. *Syst Rev* 2020;9:260. doi: 10.1186/s13643-020-01514-3 pmid: 33168062
- Pencheon D, Wight J. Making healthcare and health systems net zero. *BMJ* 2020;368:m970. doi: 10.1136/bmj.m970. pmid: 32229478
- Healthier Societies for Healthy Populations Group. Healthier societies for healthy populations. *Lancet* 2020;395:1747-9. doi: 10.1016/S0140-6736(20)31039-4 pmid: 32505243
- Haines A, Floss M. The inverse care law in the Anthropocene epoch. *Lancet* 2021;397:773-4. doi: 10.1016/S0140-6736(21)00304-4 pmid: 33640046
- Xie E, de Barros EF, Abelsohn A, Stein AT, Haines A. Challenges and opportunities in planetary health for primary care providers. *Lancet Planet Health* 2018;2:e185-7. doi: 10.1016/S2542-5196(18)30055-X pmid: 29709275
- Lal A, Erondy NA, Heymann DL, Gitahi G, Yates R. Fragmented health systems in COVID-19: rectifying the misalignment between global health security and universal health coverage. *Lancet* 2021;397:61-7. doi: 10.1016/S0140-6736(20)32228-5 pmid: 33275906
- Hoffer-Hawlik MA, Moran AE, Burka D, et al. Leveraging telemedicine for chronic disease management in low- and middle-income countries during covid-19. *Glob Heart* 2020;15:63. doi: 10.5334/gh.852 pmid: 33150128
- Zulman DM, Verghese A. Virtual care, telemedicine visits, and real connection in the era of covid-19: unforeseen opportunity in the face of adversity. *JAMA* 2021;325:437-8. doi: 10.1001/jama.2020.27304 pmid: 33528520
- Tsagkaris C, Hoian AV, Ahmad S, et al. Using telemedicine for a lower carbon footprint in healthcare: A twofold tale of healing. *Journal of Climate Change and Health* 2021;1:100006doi: 10.1016/j.joclim.2021.100006
- Fu-Chun MCF. Accelerating towards net zero emissions: the most important global health intervention. *Lancet Planet Health* 2021;5:e64-5. doi: 10.1016/S2542-5196(20)30296-5 pmid: 33581063
- World Health Organization. Expert meeting on measuring greenhouse gas emissions and other environmental sustainability concerns in health care facilities. Meeting report. WHO, 2021
- WONCA Environment launches planetary health course. 2021. <https://www.ufgrs.br/telessauders/noticias/wonca-environment-launches-planetary-health-course/>.
- Aga Khan Development Network Publications. Calculating the footprint of AKHS operations. 2020. <https://www.akdn.org/our-agencies/aga-khan-health-services/climate-smart-health-care/special-environmentclimate>
- Aga Khan Development Network Publications. Inhalers and anaesthetics. special initiatives. 2020. <https://www.akdn.org/our-agencies/aga-khan-health-services/climate-smart-health-care/special-environmentclimate>
- Marten R, El-Jardali F, Hafeez A, Hanefeld J, Leung GM, Ghaffar A. Co-producing the covid-19 response in Germany, Hong Kong, Lebanon, and Pakistan. *BMJ* 2021;372:n243. doi: 10.1136/bmj.n243 pmid: 33593791
- World Organization of Family Doctors. WONCA action call for COP26. 2021. <https://www.global-familydoctor.com/News/WONCAActionCallforCOP26.aspx>.
- Iacobucci G. Covid-19: Public health must be "at the core" of global recovery plans, say doctors. *BMJ* 2020;369:m2077. doi: 10.1136/bmj.m2077 pmid: 32451324
- IRENA. Renewable energy can support resilient and equitable recovery. 2020 Apr 20. <https://www.irena.org/newsroom/pressreleases/2020/Apr/Renewable-energy-can-support-resilient-and-equitable-recovery>
- UN Environment—Global Environment Facility. Accelerating the global adoption of energy-efficient lighting. 2017. https://wedocs.unep.org/bitstream/handle/20.500.11822/20406/Energy_efficient_lighting.pdf.
- Wakefield A, Broyles M, Stone EL, Jones G, Harris S. Experimentally comparing the attractiveness of domestic lights to insects: Do LEDs attract fewer insects than conventional light types? *Ecol Evol* 2016;6:8028-36. doi: 10.1002/eece3.2527 pmid: 27878075
- Franco A, Shaker M, Kalubi D, Hostettler D. A review of sustainable energy access and technologies for healthcare facilities in the Global South. *Sustain Energy Technol Assess* 2017;22:92-105doi: 10.1016/j.seta.2017.02.022
- Warwick University. Researchers convert used car batteries into units that could power farms in the developing world. 2019. https://warwick.ac.uk/newsandevents/pressreleases/researchers_convert_used/.
- The Faraday Institute. Bringing cheap clean and reliable energy to developing countries. 2011. <https://faraday.ac.uk/wp-content/uploads/2019/10/Faraday-Insights-3.pdf>.
- UNCTAD. Developing countries pay environmental costs of electric cars batteries. 2020. <https://unctad.org/news/developing-countries-pay-environmental-cost-electric-car-batteries>.

- 47 Yaima R, Kita K, Domyo N. R32 as a solution for energy conservation and low emissions. International Refrigeration and Air Conditioning Conference 2000. Paper 509. <https://docs.lib.purdue.edu/iracc/509/>.
- 48 Lim J, Yoon MS, Al-Qahtani T, Nam Y. Feasibility study on variable-speed air conditioner under hot climate based on real-scale experiment and energy simulation. *Energies* 2019;12:1489doi: 10.3390/en12081489.
- 49 Howland Consulting. Health Care Without Harm. Global climate impact from hospital cooling. 2018. https://www.k-cep.org/wp-content/uploads/2018/10/Kigali_CEP_GlobalHospitalCooling_102418.pdf
- 50 Xu L, Wang Y, Solangi YA, et al. Off-grid solar PV power generation system in Sindh, Pakistan: a techno-economic feasibility analysis. *Processes (Basel)* 2019;7. doi: 10.3390/pr7050308 .
- 51 USAID. LMIC urban air pollution solutions. Technical document. July 2019. https://breathe-life2030.org/wp-content/uploads/2019/08/USAID_APSolutionsDoc_070219.pdf.
- 52 Rashidian A, Zaidi S, Jabbour S, Soleymani S, Jahanmehrn N. Identification of priority policy research questions in the area of access to and use of medicines in EMRO countries: Focusing on Iran, Pakistan and Lebanon. 2011. https://www.who.int/alliance-hpsr/projects/alliancehpsr_iranlebanon-pakistan_atmps.pdf.
- 53 Hamid H, Masood RA, Tariq H, Khalid W, Rashid MA, Munir MU. Current pharmacy practices in low- and middle-income countries; recommendations in response to the COVID-19 pandemic. *Drugs Ther Perspect* 2020;36:1-3. pmid: 32837187
- 54 van Niekerk L, Chater R, Naydenova E, et al. *Social innovation in health: case studies and lessons learned from low- and middle-income countries*. World Health Organization, 2017. <https://apps.who.int/iris/rest/bitstreams/1090126/retrieve>.
- 55 British Thoracic Society. Position statement. The environment and lung health 2020. <https://www.brit-thoracic.org.uk/document-library/governance-and-policy-documents/position-statements/environment-and-lung-health-position-statement-2020>
- 56 Janson C, Henderson R, Löfdahl M, Hedberg M, Sharma R, Wilkinson AJK. Carbon footprint impact of the choice of inhalers for asthma and COPD. *Thorax* 2020;75:82-4. doi: 10.1136/thoraxjnl-2019-213744 pmid: 31699805
- 57 Wilkinson AJ, Braggins R, Steinbach I, et al. Costs of switching to low global warming potential inhalers. an economic and carbon footprint analysis of NHS prescription data in England. *BMJ Open* 2019;9:e028763. doi: 10.1136/bmjopen-2018-028763 pmid: 31662306
- 58 Baum JA. The carrier gas in anaesthesia: nitrous oxide/oxygen, medical air/oxygen and pure oxygen. *Curr Opin Anaesthesiol* 2004;17:513-6. doi: 10.1097/00001503-200412000-00012 pmid: 17031087
- 59 Eftimova B, Sholjakova M, Mirakovski D, Hadzi-Nikolova M. Health effects associated with exposure to anesthetic gas nitrous oxide-N2O in clinical hospital—Shtip Personnel. *Open Access Maced J Med Sci* 2017;5:800-4. doi: 10.3889/oamjms.2017.185 pmid: 29104694
- 60 World Economic Forum. Net-zero challenge: The supply chain opportunity. Insight report. Jan 2021 http://www3.weforum.org/docs/WEF_Net_Zero_Challenge_The_Supply_Chain_Opportunity_2021.pdf.
- 61 Avis WR. Inclusive and green growth in developing countries. K4D Helpdesk report. March 2018. https://assets.publishing.service.gov.uk/media/5af9702340f0b622dd7aa2c8/Inclusive_green_growth_in_developing_countries.pdf.
- 62 Bowen A, Fankhauser S. Low-carbon development for least developed countries. World Economics 2011;12:145-62. https://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2011/01/low-carbon-development_Bower-Fankhauser.pdf
- 63 Health Effects Institute. State of global air 2019. Special report. Health Effects Institute, 2019. https://www.stateofglobalair.org/sites/default/files/soga_2019_report.pdf.
- 64 Aga Khan Development Network Publications. A new hospital for Bamyan. 2017. <https://www.akdn.org/publication/new-hospital-bamyan>.
- 65 Haines A, Ebi K. The imperative for climate action to protect health. *N Engl J Med* 2019;380:263-73. doi: 10.1056/NEJMra1807873 pmid: 30650330
- 66 Mckinsey Sustainability. Starting at the source: sustainability in supply chains. 2016. <https://www.mckinsey.com/business-functions/sustainability/our-insights/starting-at-the-source-sustainability-in-supply-chains>.
- 67 National Health Service. Delivering a 'net zero' National Health Service.2020. <https://www.england.nhs.uk/greenernhs>.
- 68 Baddley J. Is green the new blue. Presentation by NHS England to Health Education England regional conference. August 2019. <https://www.nwpgmd.nhs.uk/sites/default/files/Keynote%202020-%20Jerome%20Baddley.pdf>
- 69 Ghebreyesus TA. Strengthening our resolve for primary health care. *Bull World Health Organ* 2020;98:726-726A. doi: 10.2471/BLT.20.279489 pmid: 3317764

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