Unitaid
SAVE LIVES FASTER

Beyond the daily dose:

The climate-smart potential of long-acting technologies

Discussion paper



1. Introduction

Health systems are entering a new era of challenges, as climate change disrupts healthcare services and the supply of lifesaving medicines, while increasing the risk of disease outbreaks and other emerging health threats. This is happening in health systems that are already strained by shrinking funding and geopolitical disruptions to energy and health infrastructure. These pressures operate on two timescales. Acute shocks such as floods[1] and cyclones interrupt care abruptly (Figure 1), while chronic stresses, including rising temperatures and degrading infrastructure, steadily erode the capacity of systems to deliver care. The consequences of both fall hardest on people in regions affected by high transmission of infectious diseases like HIV, tuberculosis, and malaria. Both also make it harder for people to access medicines, follow their treatment schedules and remain in care, particularly when treatment must be taken daily or several times a week, over months or even a lifetime.

Figure 1: Examples of ways climate shocks can disrupt healthcare delivery

Disease/thematic area	Focal point
Supply chain disruption Floods and storms block routes, damage ports, and break cold chains globally and regionally.	**India floods in Kerala (2018):** Supply shortages across the state left many without access to essential medicines.[2]
Facility damage/closure Clinics and hospitals may be flooded, damaged, or lose power and water.	**Cyclone Freddy in Mozambique, Malawi, Madagascar (2023):** More than 300 health facilities were destroyed or flooded across the three countries.[3]
Transport breakdown Health facilities may be unreachable due to damaged roads and unsafe conditions.	**Cyclone Idai in Mozambique (2019):** The percentage of children under 5 within 2 hours of travel time to a healthcare facility decreased from 78.8% to 52.5%, as more than 3,000km2 of land were submerged.[4]
Workforce disruption Staff may be displaced or unable to travel.	**Cyclone Ditwah in Sri Lanka (2026):** Health workers were among the more than 26k families that were displaced by floods and landslides.[5]
Demand surges Acute events increase injuries and illness, placing extra pressure on health systems.	**Pakistan floods (2022):** Flooding caused a malaria outbreak of more than 540k cases.[6]

1 https://www.afro.who.int/news/around-13-million-people-affected-severe-flooding-southern-africa
2 https://www.adb.org/sites/default/files/publication/1103166/sdwp-113-health-care-supply-chains.pdf
3 https://news.un.org/en/story/2023/03/1134962
4 https://www.frontiersin.org/journals/tropical-diseases/articles/10.3389/fitd.2024.1328926/full
5 https://www.who.int/srilanka/news/detail/09-01-2026-standing-strong-together--health-system-resilience-and-emergency-response-in-kegalle-district-following-cyclone-ditwah
6 https://news.un.org/en/story/2022/11/1130082

Long-acting technologies (LATs), medicines that maintain therapeutic drug levels in the body for weeks to months, offer a promising solution to these challenges. LATs span several delivery forms, such as injectables, implants (which are already widely used for contraception), oral formulations, and microarray patches. By reducing the frequency of doses and the quantity of product needed for effective therapy or prevention, LATs can lessen the burden on people seeking care, on fragile supply chains, and on health systems. In doing so, they have the potential to bridge acute interruptions in care and lower the stress on overstretched systems, leading to greater resilience to climate shocks and chronic pressures. Fewer doses and fewer clinic visits can also reduce the carbon footprint across the product lifecycle, positioning LATs as both a climate adaptation tool and a mitigation strategy.

This potential has been recognized at the highest levels of global health governance. The Belém Health Action Plan,[7] for example, explicitly identifies innovation in LATs as a priority for ensuring equitable access to essential health products. However, this area remains largely underexplored.

To build the evidence needed to act on this opportunity, Unitaid partnered with two organizations to assess the potential climate benefits of long-acting technologies (LATs). The Centre of Excellence for Long-acting Therapeutics – Global Health (CELT Global Health) at the University of Liverpool conducted a literature review (Long-Acting Therapeutics for Climate-Vulnerable Populations)[8] examining their climate adaptation benefits, while Ecovamed carried out a life cycle assessment comparing the carbon footprints of several LATs with those of their daily oral equivalents, included in Appendix 1. Initial analysis focused on injectables due to their dominance in the drug development pipelines and market[9]. Some conclusions are specific to that delivery form. Considerations such as sharps disposal and cold chain requirements may differ for other forms of LATs, and these should be assessed on a product-by-product basis. This paper situates learnings from this analysis within Unitaid's climate-smart product framework, grounds them within the realities of health programs, and outlines how LATs are being prioritized within Unitaid's broader climate and health strategy.

This discussion paper argues that as health systems enter a new operating environment, products must be designed, selected, and introduced not only for their clinical safety, efficacy, and access under normal conditions, but also for how they perform as conditions change. This means withstanding acute shocks when systems are disrupted and adapting to the longer-term pressures reshaping where and how care is delivered. LATs offer one example of how products can support both resilience and adaptation, while also reducing the environmental footprint of treatment.

7 The Belem Health Action Plan for the Adaptation of the Health Sector to Climate Change. https://cdn.who.int/media/docs/default-source/climate-change/en---belem-action-plan.pdf

8 **https://www.liverpool.ac.uk/celt-global-health/about-us/research/projects/climate-and-sustainability/long-acting-therapeutics-for-climate-vulnerable-populations/**

9 https://www.emergenresearch.com/industry-report/long-acting-drug-delivery-technologies-services-market

2. Long-acting technologies through the lens of Unitaid's climate-smart product framework

Unitaid's Climate and Health Strategy for 2023-2027[10] introduced a climate-smart product framework with four characteristics that define the term "climate-smart." As discussed below, learnings from the literature review and comparative life cycle assessments demonstrate the climate-smart potential of LATs as a possible contributor to more resilient health systems and greener healthcare.

The climate-smart product framework is not to be viewed as a gateway that products must pass through to be advanced. Rather, it adds a lens that strengthens a product's value proposition as a complement to its clinical benefits. In this new operating environment shaped by climate shocks, displacement, and supply chain disruption, products that are resilient, responsive, locally adapted, and not harmful (Figure 2) can reach harder-to-reach populations, maintain access when systems are under stress, and attract additional financiers and partners with shared objectives. Where the framework surfaces environmental trade-offs, such as waste management or cold-chain needs, these are areas to assess, manage, and improve rather than unilateral reasons not to advance a product. Viewing LATs through the lens of this framework identifies where these products can create the greatest opportunity, so that people can access the products they need, where and when they need them, even as the climate shifts.

Figure 2: Climate-smart products - key principles

Not harmful

By requiring less API, LATs reduce the carbon footprint of medicine production.

Resilient

By requiring fewer doses and enabling strategic pre-administration, LATs reduce dependence on unstable health systems and supply chains to keep communities protected when services are disrupted.

Responsive

Informed by data and strategic planning, LATs can be deployed to targeted climate-vulnerable populations, including displaced communities, to meet their specific health needs.

Locally adapted

LATs can be a cornerstone of locally-adapted, decentralized care models, potentially delivered by community health workers, tailored to sub-national climate risks and seasonality, and manufactured regionally.

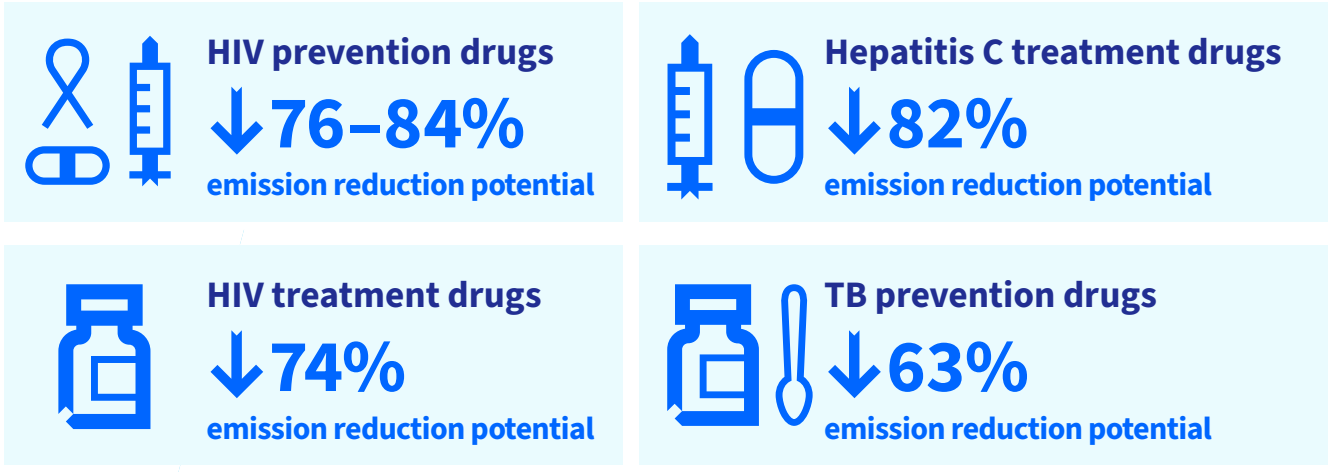
10 Unitaid Climate and Health Strategy. https://unitaid.org/uploads/Unitaid-Climate-and-Health-Strategy-2023-2027.pdf

Not harmful: Products that are not harmful to climate and nature, globally and locally, all along their life cycle

The life cycle assessments of multiple products (Appendix 1) revealed that active pharmaceutical ingredient (API) production is the primary driver of carbon emissions and the dominant hot spot across product value chains. This is primarily due to energy-intensive, multi-step processes, that require large quantities of solvents and complex starting materials, and generate substantial waste requiring incineration. LATs address this challenge by achieving clinical efficacy with lower drug doses,[11] reducing API requirements by 86-99% in analyzed products. For many products, this reduction in API is made possible by more potent drugs and long-acting formulations, and it is critical to lowering the carbon footprint across the entire product lifecycle. As seen in the analysis completed by Ecovamed in Appendix 1, shifting from current drug regimens to LATs could lead to significant emission reductions: 76-84% for HIV prevention drugs; 74% for HIV treatment drugs; 82% for Hepatitis C treatment drugs; 63% for TB prevention drugs.

Prevention is the preferred public health strategy for addressing the burden of infectious diseases, and the primary value of LATs lies in their clinical and public health benefits. Reduced emissions can be an important secondary benefit. The Ecovamed analysis found that LATs for HIV prevention have a lower carbon footprint than daily oral prevention, and that one year of oral TLD for treatment generates nearly eight times the emissions of one year of lenacapavir for HIV prevention. Each infection prevented therefore averts the health burden of HIV and has the potential to avoid the higher emissions associated with lifelong treatment. Complementing existing prevention strategies with LATs, where appropriate, can protect communities from infection while also keeping individuals from entering treatment pathways with a greater climate impact.

Figure 3: Emission reduction potential of LATs



Note: HIV prevention estimates are based on lenacapavir and cabotegravir, both currently on the market. All other estimates are based on products still in development.

11 https://pmc.ncbi.nlm.nih.gov/articles/PMC7618339/

Resilient: Products that can be manufactured, delivered, stored and used in a way that is resilient to climate and nature risks

Evidence suggests that transitioning from daily oral regimens to LATs can be a useful strategy for building health system resilience in the face of escalating climate and nature risks.

Conventional healthcare models, which rely on daily dosing, assume a level of system reliability and continuity of access to medication that may not exist for climate-vulnerable populations at risk of climate shocks. When extreme weather events like floods or cyclones occur, individuals are often displaced and may forget or lose their medication or might not have road access to return home. Furthermore, climate shocks can cut off entire communities from health services, making it impossible for individuals to refill prescriptions. For agriculture-dependent communities experiencing droughts, the loss of income can further restrict health seeking behavior, while the need to tend to urgent survival matters can significantly decrease daily adherence.

LATs are expected to offer an alternative approach to treatment and adherence by reducing reliance on the immediate stability of the health system, which may be unexpectedly disrupted. Some of these products can provide extended protection through less frequent administration (e.g. monthly, bimonthly, bi-annually), meaning they can be strategically administered in advance of known or expected seasonal shocks. For example, communities in high-risk zones could be targeted with certain long-acting products before the onset of cyclone seasons or predictable monsoon flooding. This could help ensure that even if health services are subsequently disrupted, communities remain protected.

Beyond adherence and improved care, LATs can strengthen the resilience of the global supply chain. Fragile health systems in low- and middle-income countries often struggle with stock-outs and infrastructure breakdowns, which are exacerbated by climate-driven damage to transport routes. By reducing the number of doses, LATs can simplify logistics and storage while reducing the burden on health facilities. This makes the entire delivery and storage lifecycle less susceptible to the disruptions that frequently accompany climate shocks.

Responsive: Products that address the evolving needs of communities that are impacted by climate change

Climate change is a risk multiplier for fragile health systems, changing the health and social needs of communities. LATs can offer an opportunity to enable care that is as dynamic as the risks that communities face.

The infectious diseases at the core of Unitaid's mission, HIV, tuberculosis, and malaria, are climate-sensitive and are being exacerbated by climactic shifts.[12,13,14,15] Changing climates and shifting weather patterns directly influence disease epidemiology, including changing the transmission dynamics for malaria in areas where humidity and temperature are conducive to both the parasite and the vector. This complicates the timing of when malaria incidence will increase or decrease, directly impacting where and when interventions are needed. TB determinants, such as undernutrition, poverty, and population mobility are also influenced, increasing disease risk and making traditional care models harder to maintain. Furthermore, evidence shows that HIV transmission patterns can change due to climate shocks. Droughts can lead to transmission spikes, often due to the social and economic disruptions they cause.[16]

12 https://www.who.int/publications/i/item/9789240109940
13 https://frontlineaids.org/resources/hiv-climate-change-safeguarding-health-in-a-changing-world/
14 https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report-2023
15 https://www.nature.com/articles/s41558-022-01426-1
16 https://pubmed.ncbi.nlm.nih.gov/37523018/

Additionally, climate change is accelerating displacement and analysis shows that displaced and migrant communities are at a significantly higher risk of infectious diseases compared to the general population. This could lead to 216 million internal climate migrants by 2050, with 86 million of those in Sub-Saharan Africa.[17] Current health delivery models may not be responsive to the needs of these communities, as evidenced by findings that refugees are less likely to initiate and remain in care.

LATs can be a responsive solution informed by surveillance and early warning systems that identify communities where epidemiological shifts and climate-driven outbreaks or extreme events are likely to increase disease risks and disrupt care. This can enable targeted implementation to protect communities and empower individuals to maintain their health even when risks rise and disruptions sever their connection to static facilities. This should include adapted models to ensure displaced and migrant populations who may not have access to traditional health services can access LATs as their needs evolve.

More than a billion people (1 in 8) are on the move, globally, and an estimated 117.3M of those people are forcibly displaced from their homes. This is up from 83M in 2020, with climate change expected to continue driving that upward trend. Nearly 42% of displaced persons are children.[18]

Locally adapted: Products that are delivered as part of locally-adapted interventions

LATs can serve as a cornerstone of locally adapted strategies that incorporate climate-smart products into health services for communities where climate risks and extreme weather frequently destabilize traditional care pathways. They fit well within intervention packages tailored to specific community needs and within decentralized delivery models, such as nurse-led outreach, mobile clinics and community health posts. Newer models that shift tasks further, such as delivery through pharmacies and trained community health workers, could further improve access, particularly in underserved communities. Unitaid is currently exploring these approaches. By reducing reliance on centralized facilities, these models can help maintain continuity of care when mobility is restricted or facilities are hard to reach. This also requires consistent investment in building a pipeline of easy-to-use (e.g. does not require cold chain, can be administered subcutaneously, etc) LATs that meet community-led target product profiles.

Furthermore, a key component of local adaptation is utilizing local data and context to inform where and when LATs can be most valuable. Intervention packages can be tailored sub-nationally to reflect the needs of specific communities based on climate-driven risks and seasonality. For example, for seasonal diseases like malaria, if LATs were to be available, they could be prioritized for rural, displaced communities where services have been fully disrupted.

Finally, with the LAT pipeline evolving[19,20,21] appropriate and technically feasible (see limitations below).[22,23,24] This ensures market proximity can be prioritized as manufacturing lines are established and that African-based manufacturers are established as market leaders of these greener products.

17 https://openknowledge.worldbank.org/entities/publication/2c9150df-52c3-58ed-9075-d78ea56c3267
18 **https://www.who.int/news-room/fact-sheets/detail/refugee-and-migrant-health**
19 https://www.aidsmap.com/news/mar-2026/new-antiretrovirals-pipeline-could-be-part-twice-yearly-hiv-treatment
20 https://link.springer.com/article/10.1186/s12936-024-05128-1
21 https://unitaid.org/project/long-acting-medicines-for-malaria-tuberculosis-and-hepatitis-c/
22 https://www.aidsmap.com/news/mar-2026/new-antiretrovirals-pipeline-could-be-part-twice-yearly-hiv-treatment
23 https://link.springer.com/article/10.1186/s12936-024-05128-1
24 https://unitaid.org/project/long-acting-medicines-for-malaria-tuberculosis-and-hepatitis-c/

3. Operational risks and tensions: the balance of scale

While the climate-smart potential of LATs is a novel lens with promising opportunities that warrant further exploration, there are real risks and tradeoffs to these products that must be considered and addressed as part of any implementation strategy. This points to the need for LATs to be a complementary product that enhances existing product portfolios and options, where appropriate, versus fully replacing them in all settings.

3.1. Infrastructure and energy limitations

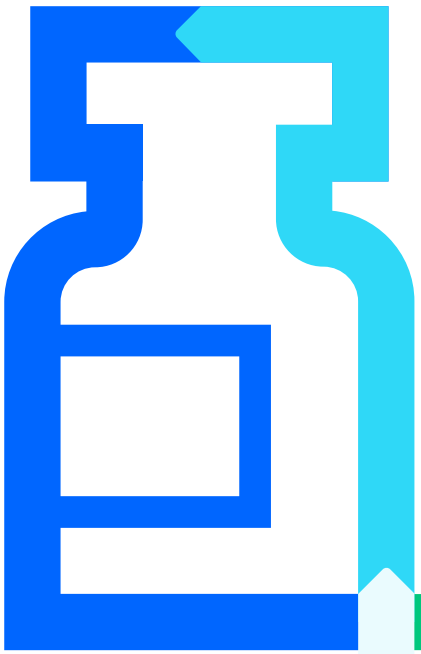
Unreliable power supply is a known vulnerability of health systems in low and middle-income countries (LMICs), which is exacerbated by climate shocks and extreme environmental conditions. Many health facilities do not have access to stable electricity,[25] so LATs that require consistent cold chains to maintain their quality from the point of manufacture to the point of use may not be appropriate for widespread use. Cold chains often require additional resources and are vulnerable to rising temperatures and infrastructure damage from extreme weather. Scale-up strategies must consider these limitations and not push LATs into systems that are incapable of maintaining their quality. LATs should first be introduced into already-resilient supply chains and programs that can assure their quality while additional investments are made in innovations to safeguard quality in more volatile settings, including solutions to improve product heat stability.

Additionally, while LATs present the potential to reduce carbon emissions by using less API in each dose, they can also have more complex and resource-intensive manufacturing processes. For example, formulations that enable an extended release of APIs over time may require more stringent production conditions and advanced manufacturing processes to ensure product quality standards are met. This has implications on the ability of products to be manufactured regionally and/or in environmental settings where heat and humidity may present a challenge to maintaining these conditions. The challenge lies in the infrastructure and energy costs required to consistently maintain Good Manufacturing Practice-compliant environments. While this is not true of all LATs, in settings where reliable power supply cannot be guaranteed, sustaining these conditions presents real constraints for locally adapted products.

25 https://www.who.int/news-room/fact-sheets/detail/electricity-in-health-care-facilities

3.2. The waste paradox

While LATs can significantly reduce secondary packaging in comparison to daily oral regimens, they also introduce the potential operational challenge of generating other types of waste. LATs that are administered via injection will have sharps and biological waste that require more complex management and disposal systems than oral tablets. This presents a challenge for some health systems where waste management systems are weak, especially due to infrastructure gaps for safe disposal via incineration, recycling, or other methods. This could prove to be a limitation to decentralized and community-based delivery approaches that do not currently have the capabilities to safely manage sharps disposal, meaning increased local pollution could be a real risk. Therefore, appropriate waste management, disposal, and environmental impact should be a consideration of any new operational model implementing LATs. While this analysis did not explore vaccination programs, they could be a source of learnings and approaches to apply here.



3.3. Clinical and social risks

One of the most critical tensions that must be addressed is the potential risk for increased drug resistance, which is already a global challenge. Research has shown that the resistance risk profile for LATs differs from daily oral regimens and can be higher if there is a long pharmacokinetic tail,[26] indicating the importance of intentional follow up. One of the primary benefits of LATs is improved drug adherence. While single-dose regimens may be achievable for some use cases, such as tuberculosis prevention, many LATs still require repeat administration, particularly for chronic conditions like HIV or long-lasting preventives, and each dose remains a point at which care can be interrupted. This introduces the risk of missing follow-up injections, which has shown to be a real vulnerability that could be higher in climate-vulnerable settings where systems are less stable. Operational planning must consider how systems can ensure on-time injections in these settings to prevent these communities from becoming more susceptible to drug resistance.

Research cited in the literature review has shown that previous experiences with LATs, such as those used for family planning, can create lasting mistrust that influences uptake. Additionally, individuals and communities may have a fear of injections and side effects that also influence product uptake. This demonstrates that acceptance of injectables versus oral medicines is context-dependent, shaped by perceptions of trust and efficacy, highlighting the importance of community engagement product design and introduction, while also utilizing a choice-based approach to product introduction.

26 "The pharmacokinetic tail refers to the prolonged period during which measurable drug concentrations persist after the last injection because of slow release from the intramuscular depot." Source: https://pmc.ncbi.nlm.nih.gov/articles/PMC13457505/

4. Solutions-oriented: emerging opportunities and Unitaid's actions

4.1. Emerging opportunities

To transition LATs from clinical innovations into scaled, accessible, climate-smart products, Unitaid has identified four immediate climate and health priorities that must be incorporated into existing and future efforts that incorporate LATs into health programs. These priorities focus on aligning product access with the realities of communities that are facing increasing risks caused by climate change.

Developing new products and formulations

The LAT pipeline offers an opportunity to design products around the needs of climate-affected communities from the outset. Embedding climate considerations, such as heat stability, cold-chain independence, waste management, and carbon footprint, into target product profiles can help ensure new LATs are climate-smart by design. The characteristics that help a product to be climate-smart lead to benefits in other areas, such as decreased cost, increased adherence and simplicity of use that should also be reflected in target product profiles (see Unitaid examples in Section 4.2). External examples include early-stage long-acting injectables for malaria chemoprevention being developed by Medicines for Malaria Venture (MMV), which could provide season-long protection from a single dose,[27] and Merck's investigational once-monthly oral PrEP pill,[28] which could offer reduced dosing without the need for injection.

Understanding demand drivers and acceptability

While the clinical advantages of LATs are clear and increasing, the demand drivers and user acceptability within climate-affected communities is under-explored. The motivations for product uptake can differ based on environmental context and the risks that are present within specific communities. For example, drivers for people in drought-affected locations may differ from those in more flood-prone areas, where the ability to access facilities and the potential impact on livelihoods can impact care-seeking behaviors. Understanding these nuances as part of broader implementation approaches for LATs can ensure that local preferences and dynamics inform more responsive delivery models.

27 https://www.mmv.org/research-development/rethinking-chemoprevention
28 https://www.merck.com/news/merck-to-initiate-phase-3-trials-for-investigational-once-monthly-hiv-prevention-pill/

Evaluating the effectiveness at reaching vulnerable communities

Existing health delivery models can fail to meet the needs of displaced, mobile, and refugee communities, who are already less likely to seek care and adhere to medicines. Implementation approaches must be evaluated to ensure they are truly reaching these populations before, during and after climate shocks. This should include exploring the feasibility of shifting services to community-based models that can build resilience to maintain services when facility access is at risk.

Building climate-resilient delivery models

Finally, it is a priority to ensure that delivery models themselves are climate-resilient. This requires identifying and optimizing the operational levers that are likely to fail in climate-affected communities and/or during extreme weather events. These levers can include supply chain logistics, cold-chain integrity, waste management models, administration methods, and community mobilization efforts. By strategically defining and pressure-testing these models against both current risks and future climate scenarios, confidence can be established in their ability to maintain access to services and products in the most extreme conditions.

4.2. Unitaid's actions

Climate-smart through Unitaid's long-acting product portfolio: Since 2020, Unitaid has invested in long-acting products for HIV, TB, malaria, and hepatitis C through the University of Liverpool,[29] Medincell,[30] and the University of Washington.[31] Where appropriate, the investment portfolio sets specification targets for administration, dosing frequency, heat stability, and price, many of which already reflect the realities of climate-affected communities. Moving forward, Unitaid will continue to embed the climate-smart lens into product development, ensuring specifications reflect climate considerations, such as performance during supply disruption, cold-chain independence, waste management, and lifecycle emissions. This will ensure design decisions effectively align products with implementation challenges on the ground, responding to specific community needs and strengthening resilience.

29 https://unitaid.org/project/long-acting-medicines-for-malaria-tuberculosis-and-hepatitis-c/
30 https://unitaid.org/project/long-acting-medicines-for-innovative-vector-control/
31 https://unitaid.org/project/long-acting-injections-to-treat-hiv/

Resilient through heat-proofing health products: Unitaid has developed a knowledge paper[32] exploring the potential of heat-proofing health products to ensure they stay safe, effective, and accessible in the hottest locations, both now and in the future. This paper is complemented by an investment[33] to investigate the heat stability of essential health products. The project will systematically map real-world environmental conditions that products are exposed to across their lifecycle, assess the impact on priority products in climate-vulnerable settings, and identify and advance innovations that protect product quality in locations with infrastructure limitations. This investment will strengthen system resilience to help ensure that existing and pipeline products, including LATs, are accessible in increasingly warming communities.

Responsive through accelerating access to lenacapavir: Building on the landmark agreement to make lenacapavir available at US$40 per year[34] and a longstanding portfolio of investments in HIV pre-exposure prophylaxis (PrEP), Unitaid is investing in decentralized, community-based delivery models as a core part of its access strategy for the product.[35] These projects are identifying ways to generate demand and deliver lenacapavir closer to where different groups at risk of HIV live, such as through pharmacies, mobile clinics, health posts, and community health workers. They are also integrating lenacapavir with services such as maternal and newborn health and family planning. Communities are central to this work, shaping where services are offered and leading peer-based outreach and demand generation. Because climate change is a risk multiplier that can cut off access to facility-based care, the evidence these projects generate on the cost-effectiveness and impact of decentralized, integrated delivery will inform models to keep communities protected when disruptions occur, building resilience to climate-related threats.

Locally-adapted through regional manufacturing: Ensuring that lenacapavir reaches the people who need it most will require not only LATs and community-based delivery models, but also a deliberate push toward regional manufacturing. Africa currently imports the vast majority of its antiretroviral treatments and preexposure prophylaxis (PrEP) such as lenacapavir. Unitaid's work on decentralized and community-based delivery models for long-acting PrEP recognizes that last-mile access is as critical as product development; however, these models can only succeed if the supply chain that anchors them is resilient and regionally grounded. In this context, Unitaid's Regional Manufacturing for Equitable Access initiative through the Medicines Supply Resilience (MedSuRe) Africa program aims to support quality-assured African manufacturing of LAT PrEP, including coordinated market entry to reduce supply chain vulnerability, lower long-term costs by reaching adequate scale, and signal a broader commitment to health sovereignty.



32 https://unitaid.org/uploads/12858-Knowledge-Paper-Heat-Proofing-Health-Products-RGB14.pdf
33 https://unitaid.org/call-for-proposal/investigating-the-heat-stability-of-health-products-in-the-context-of-climate-change/
34 https://unitaid.org/news-blog/lenacapavir-for-hiv-prevention/
35 https://unitaid.org/news-blog/unitaid-approves-new-investments-to-accelerate-equitable-access-to-lenacapavir-for-hiv-prevention/

5. Conclusion

Health systems are entering a new operating environment. For many countries, climate shocks, displacement, conflict, infrastructure gaps, workforce constraints, and supply chain disruptions are converging to make continuity of care harder to guarantee, particularly for people at risk of climate-sensitive diseases such as HIV, TB, and malaria. In this environment, products can no longer be judged only on their efficacy and accessibility under normal conditions. Products must now be designed, selected, and introduced not only on their clinical benefits, but on how they perform when systems are disrupted. LATs can help health systems both withstand and adapt to these pressures. By providing extended protection through infrequent dosing, they reduce reliance on the day-to-day stability of health systems, and by requiring substantially less API, they can lower the carbon footprint of treatment. However, climate-smart does not mean impact-free. Cold-chain requirements, waste management, energy-intensive manufacturing, and resistance risks associated with missed doses must be managed, and these trade-offs may differ across oral, injectable, and implantable products.

However, climate security and environmental considerations are not sufficiently integrated into LAT development and scale-up. Closing this gap will require action across the global health community:



National governments and health programs can use climate risk data to target LAT introduction to the highest risk populations and support task-sharing policies that enable delivery closer to communities.



Procurers and regulators can recognize the resilience and emissions benefits of LATs, in addition to unit price, and support standards for product testing and delivery models that reflect climate realities.



Health and climate financiers can fund adaptation and mitigation together by recognizing LATs and their delivery models as eligible climate investments.



Manufacturers and product developers can make resilience a core design criterion, alongside efficacy, by prioritizing heat stability, low waste, and low-carbon manufacturing from the outset.



Implementers and humanitarian actors can build delivery models that hold up under climate stress, including for displaced and mobile populations.



Communities and civil society can help design and lead choice-based introduction of LATs, building the trust needed to expand demand and access in the hardest-to-reach settings.

This gap is also an opportunity. LATs represent an emerging frontier of climate innovation, with the unique potential to function as both an adaptation tool and a mitigation strategy. Unitaid is committed to ensuring they are integrated into health services as a climate-smart option, optimized for both the health of communities and the environment.

Acknowledgements of internal contributors

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Cover photo: © The Global Fund/John Rae

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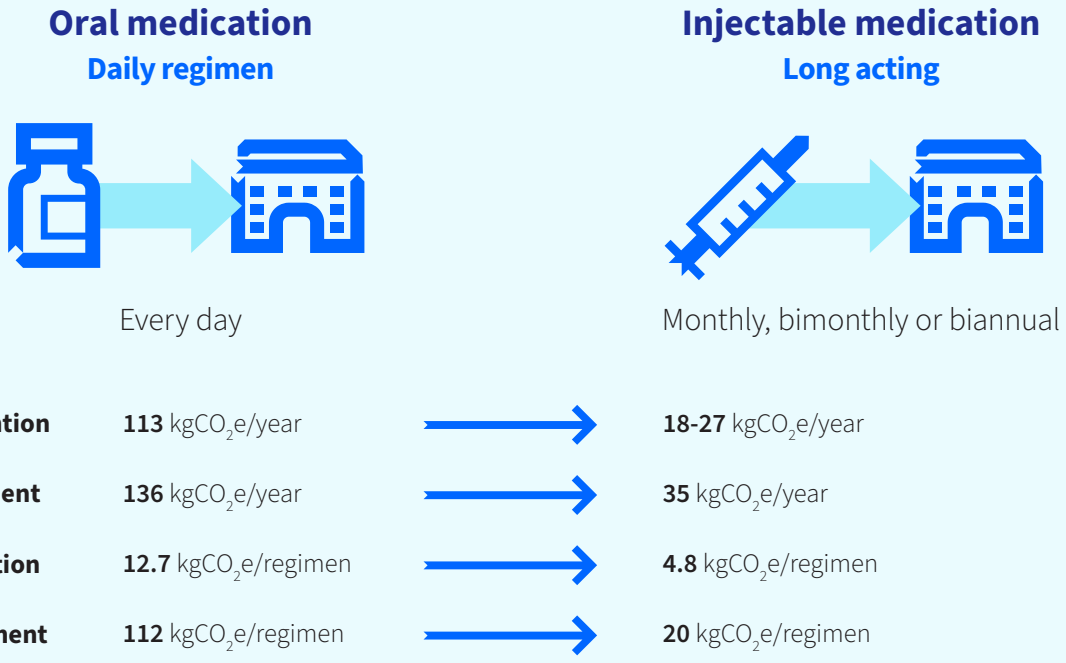
Sustainable healthcare
December 2025

Appendix 1:

Long acting anti-infectives: a sustainable medical strategy to cut healthcare greenhouse gas emissions by 77% while enhancing patient care

Climate change is widely recognized as a major threat to global health[1], yet the healthcare sector itself contributes 5-10% of greenhouse gas emissions from all countries[2], making it a significant contributor to global warming. Reducing the carbon footprint of healthcare pathways is becoming a necessity to mitigate the global climate impact. Long-acting injectable medicines are showing a promising alternative to daily oral medication to cut greenhouse gas emissions and potentially enhancing patient care thanks to an improved adherence and treatment completion[3,4]. It has been demonstrated in this study a **63% to 84% CO_2e emission reduction** for several anti-infective prophylaxis and treatment against the Human Immunodeficiency Virus (HIV), Tuberculosis (TB) and Hepatitis C Virus (HCV), as shown in Figure 1, so an average 77% reduction.

Figure 1: Environmental benefit of 4 long-acting prophylaxis and treatments against HIV, TB and HCV



1 https://www.who.int/news-room/commentaries/detail/we-must-fight-one-of-the-world-s-biggest-health-threats-climate-change
2 P.-P. Pichler *et al*, 2019, Environ. Res. Lett., 14, 064004
3 Garris C *et al*, 2023, Open Forum Infect Dis., 10, ofad500.055
4 John M *et al*., 2024, HIV Med., 25(8), 935-945

Eco-designing healthcare

Environmentally sustainable prescribing[5] is receiving increasing attention within the healthcare professional community, with the aim of delivering the best possible patient care while preserving the planet. One of the main challenges faced by physicians and pharmacists involved in eco-prescribing or eco-designing healthcare pathways is the limited availability of data on the environmental footprint of health products such as pharmaceuticals and medical devices as well as that of care pathways, including hospital infrastructure, medical biology and imaging, home care, community pharmacies, and patient transportation.

Several initiatives have recently emerged to provide access to the environmental footprint of health products[6,7,8] or to develop methodologies for assessing the impact of pharmaceuticals, either through a multi-impact approach[9] or with a specific focus on climate impact[10]. These initiatives are expected to facilitate the integration of environmental considerations into the selection of care pathways or treatments when several options offering equivalent quality of care are available.

Multiple studies have already identified care pathways with lower environmental footprints. Among these, comparisons between injectable medicines and their oral (*per os*) counterparts generally show that oral administration has a significantly lower impact, largely due to reduced manufacturing requirements for tablets compared with injectables, and the absence of medical devices needed for administration[11]. However, most existing studies compare therapeutic regimens using equivalent doses of active pharmaceutical ingredient (API). This raises the question of **how conclusions might differ if the total dose required for a complete treatment course varies between options, or if patient adherence differs between the two routes of administration.**

Objectives and methodology

Long-acting technologies are medicine formulations that slowly release the active pharmaceutical ingredient (API) over months, or even longer, thereby eliminating the need for daily medication. While many existing long-acting medicines are administered via injection, other delivery methods such as transdermal patches and implants also exist. For the studied medicines, long-acting technologies require a lower total API dose over the full duration of a treatment or prevention regimen. The aim of this study, commissioned and supported by Unitaid, was to compare the carbon footprint of daily oral versus long-acting injectable regimens for HIV prevention and treatment, tuberculosis (TB) prevention, and hepatitis C virus (HCV) treatment. A key expectation of the study is to clarify whether the reduced API dosage offsets the higher environmental impact associated with producing and administering injectables.

The functional unit for the assessment is defined as one year of prevention or treatment for HIV, and one full treatment regimen for TB prevention and HCV treatment, all for a patient or a user, in the case of prophylaxis living in Africa (see Table 1 for regimen description).

5 Frederic Bounoure *et al*., 2025, Ann Pharm Fr. doi: 10.1016/j.pharma.2025.10.003
6 Drew, Jonathan *et al*., 2022, The Lancet Planetary Health, 6(12), e1000 - e1012
7 Max Piffoux *et al*., 2024, Journal of Cleaner Production, 475, 143576
8 Nick Watts *et al*., 2025, Lancet. doi: 10.1016/S0140-6736(25)02280-9
9 PAS 2090:2025, Pharmaceutical products – Product category rules for environmental life-cycle assessments – Specification
10 https://www.entreprises.gouv.fr/la-dge/publications/methodologie-devaluation-de-lempreinte-carbone-des-medicaments
11 Jessica Davies *et al*., 2024, British Journal of Anaesthesia, 133(6), 1410 - 1412

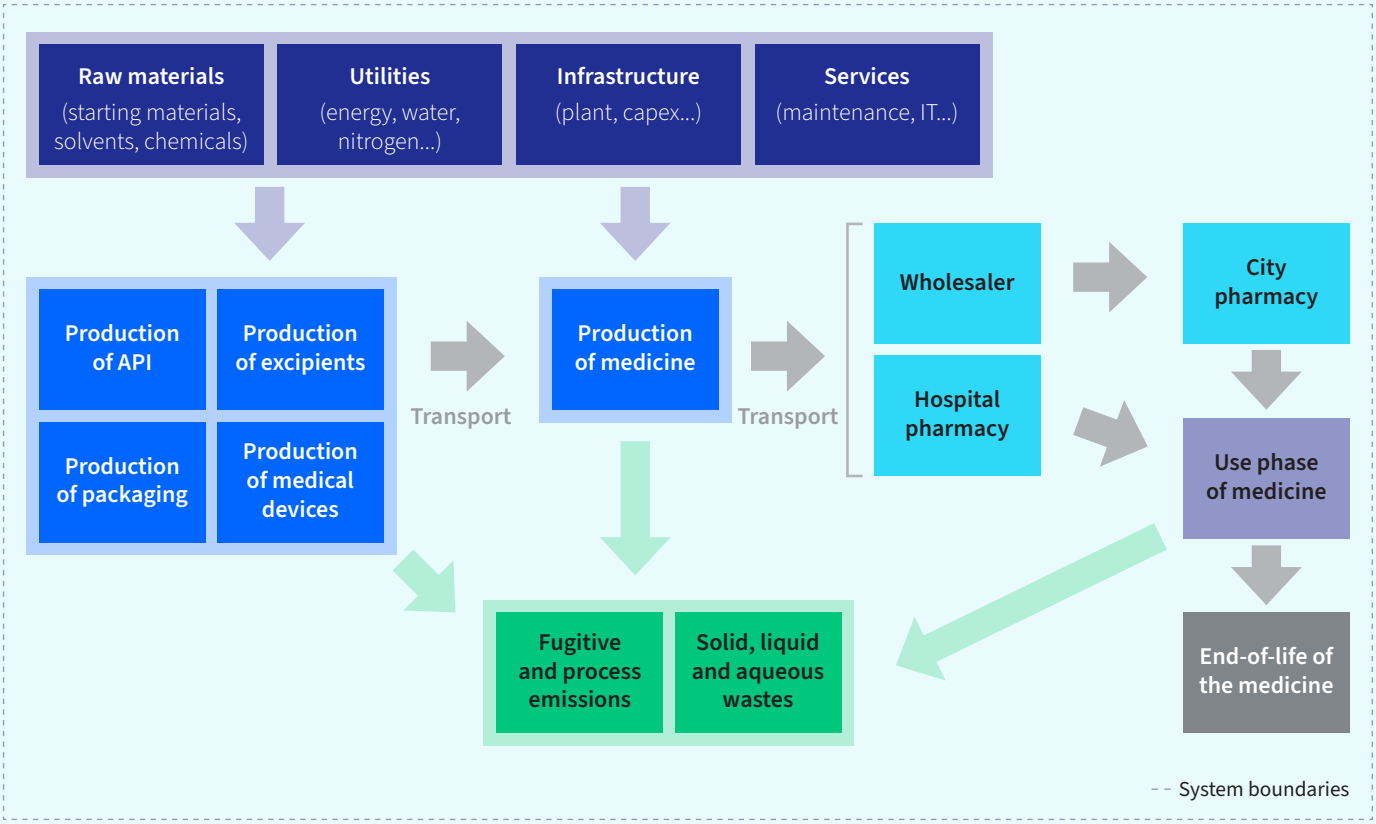
Table 1: Regimen description for each treatment and prevention scheme

		Number of unit per regimen	API quantity per treatment
HIV prevention (1 year)	Oral Tenofovir/Lamivudine (300/300 mg)	365 tablets	219 g
	Long-acting Cabotegravir (CAB) 600 mg	7 injections	4.2 g
	Long-acting Lenacapavir (LEN) 927 mg	2 injections	3.1 g
HIV treatment (1 year)	Oral TLD (300/300/50 mg)	365 tablets	237.3 g
	Long-acting TLD (20/15/15 mg)	12 injections	0.6 g
TB prevention (1 prophylaxis)	Oral Rifapentine 600 mg + Isoniazid 300mg	4x28 + 2x28 tablets	25.2 g
	Long-acting Rifapentine (3500 mg)	Single injection	3.5 g
HCV treatment (1 treatment)	Oral Glecaprevir and Pibrentasvir (300/120mg)	56 tablets	23.5 g
	LAI Glecaprevir and Pibrentasvir (2167/1081mg)	Single injection	3.2 g

TLD = Tenofovir disoproxil fumarate, Lamivudine and Dolutegravir. LAI = Long Acting Injectable.

A cradle-to-grave inventory was conducted to evaluate all greenhouse gas emissions across the entire life cycle of these treatment and prevention schemes. The system boundaries, shown in Figure 2, include all life-cycle stages required under PAS 2090.

Figure 2: System boundaries of the climate-focused life cycle assessment



Carbon footprint results

The results of the study show that all long-acting treatments and prevention schemes have a significantly lower climate impact compared with their equivalent daily oral regimens. As illustrated in Figure 3, the primary driver of this reduction is the dramatically lower API requirement for long-acting technologies: between 86% and 99.7% less active ingredient is needed to achieve similar biological efficacy[12,13]. For HIV, annual API intake decreases from 220–240 grams roughly equivalent to a large glass of water to just 0.6-4.2 grams, so less than a small spoon full of water. For TB and HCV, API intake falls from 23–25 grams to 3–4 grams.

Across all treatments, API production is the dominant contributor to environmental impact. This is due to the high complexity of multi-step synthetic routes, which require large quantities of solvents and energy, rely on complex starting materials, and generate substantial amounts of waste that typically must be incinerated. Although optimized synthesis routes with solvent recycling were considered, APIs remain the environmental hot spot of most treatments. For long-acting technologies, the manufacturing footprint of the medicine itself is proportionally higher than for oral medications, owing to more stringent production conditions such as clean-room environments and fill-and-finish operations, as well as heavier packaging per dose and more complex formulations. For example, long-acting HIV treatment requires lipid nanoparticle encapsulation to achieve prolonged release[12].

The distribution phase includes storage and transportation from the manufacturing site to the medical facility in Africa, as well as patient travel to either collect the medicine or receive the injection. Patient transport is the dominant contributor of the distribution phase, accounting for approximately 90% of its total impact, even though 75% of patient journeys were assumed to be non-motorized and thus climate-neutral and the remaining 25% were assumed to use shared taxis, which reduces per-capita emissions.

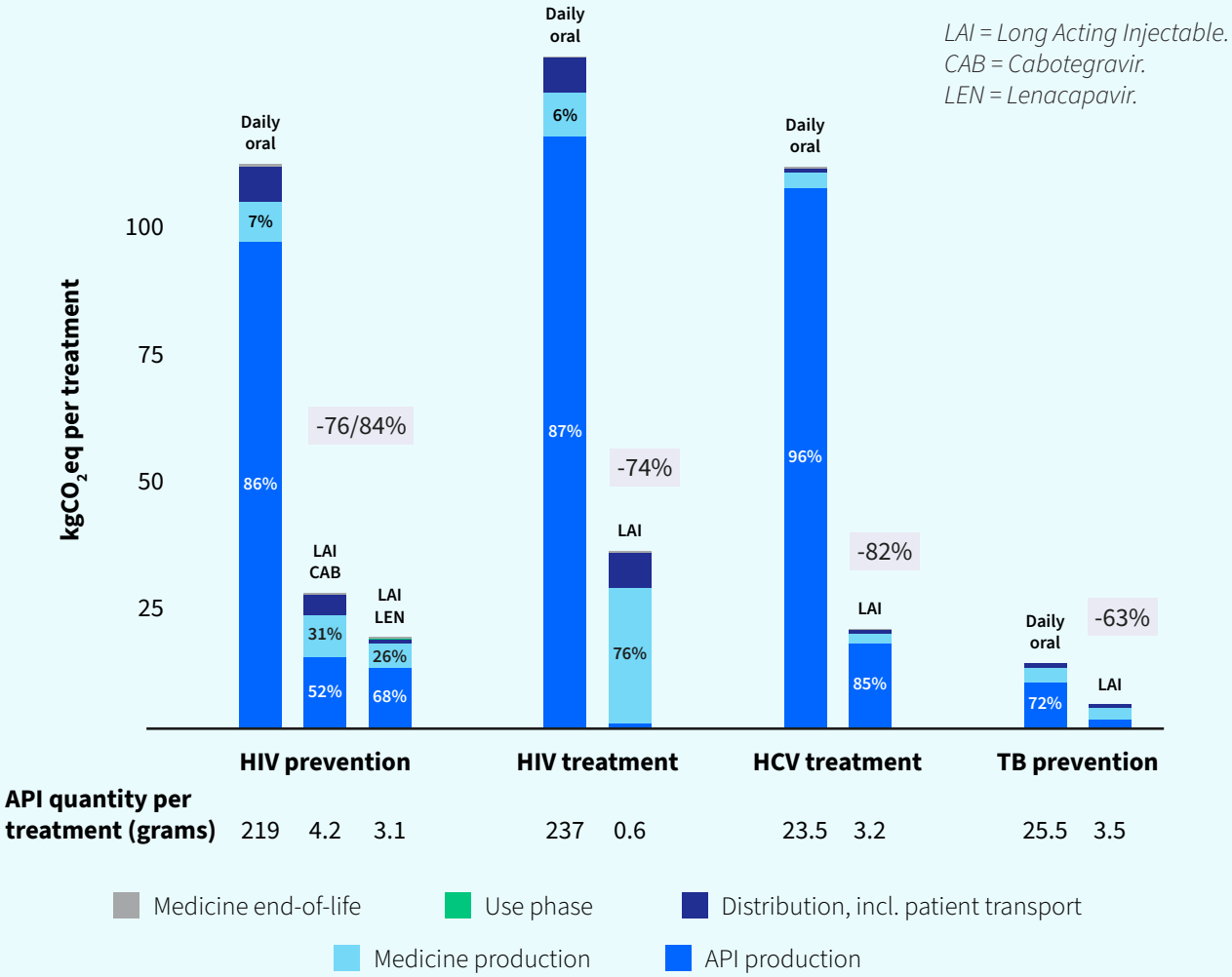
The use phase contributes minimally to the overall results: 0% for oral medication (since drinking a glass of water has no climate impact if not washed with hot water), and only 0.6% for injectables. This low value reflects the fact that most medical devices required for injection are already included in the medicine packaging, leaving only a swab, a small amount of disinfectant, and a sharps-disposal container to be added.

End-of-life considerations for the medicine include disposal of all packaging, administration devices, and the environmental fate of ingredients excreted by patients into wastewater. Packaging and administration-device waste were assumed to be disposed of in landfills.



12 Henry Pertinez NC, et al. (2023), 30th CROI; Denver, CO, USA
13 S. Perazzolo et al., 2023, AIDS, 37(14), 2131–2136

Figure 3: Detailed carbon footprint results for all treatment/prevention schemes



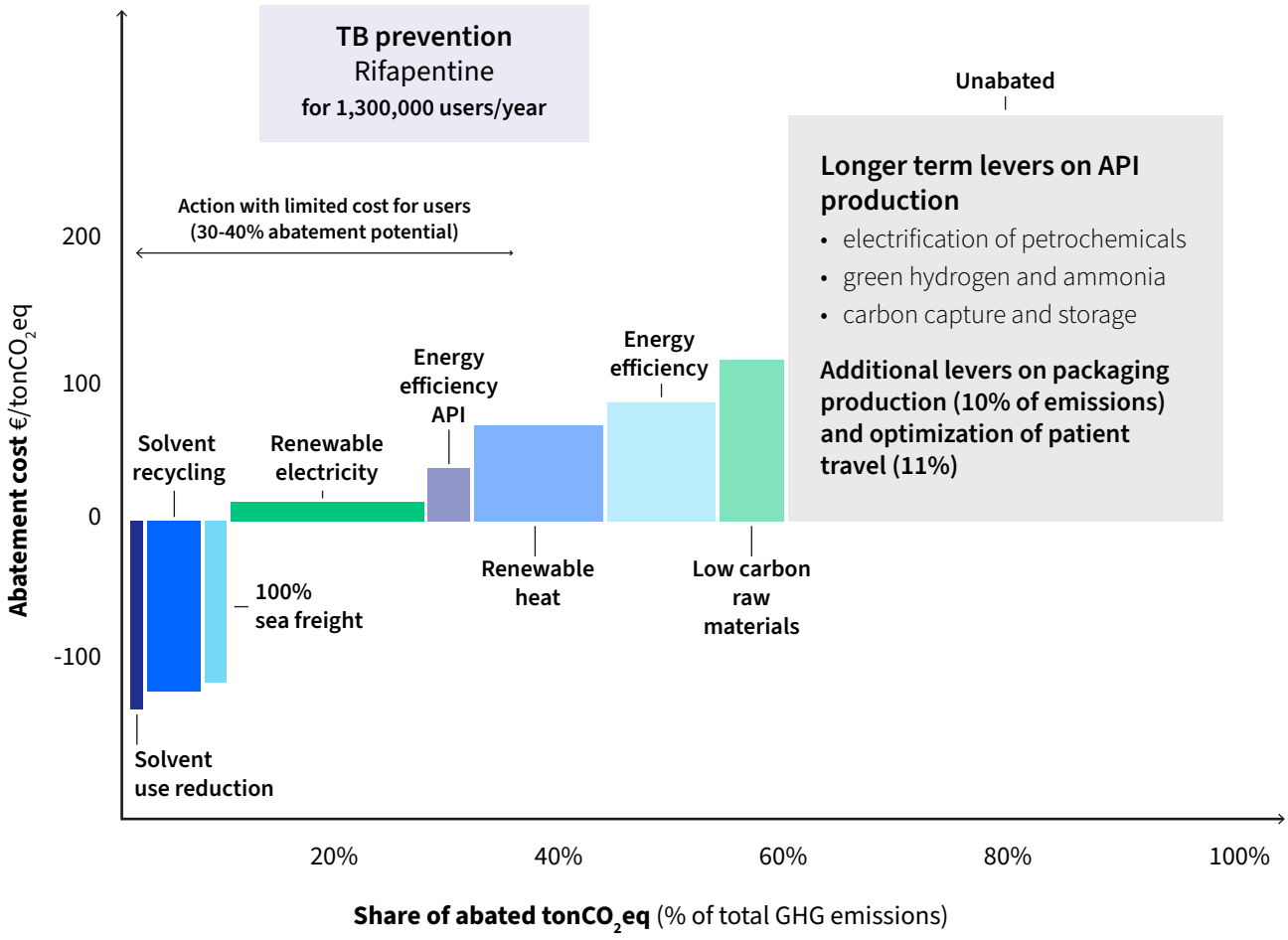
As limitations of this study, the manufacturing processes for APIs and drug products were derived from patents and scientific literature rather than from primary industrial data. As a result, uncertainties must be taken into account when interpreting the findings although these uncertainties remain smaller than the differences observed between long-acting and daily oral regimens. Since this study focuses exclusively on greenhouse gas emissions, other environmental impact categories (such as ecotoxicity, water scarcity…) were not assessed. While it is unlikely that long-acting technologies would exhibit higher impacts in these categories, this assumption would need to be formally demonstrated.

Another limitation is that, with the exception of Cabotegravir and Lenacapavir for HIV prevention, all other long-acting medicines considered in this study are still at the preclinical stage. Their therapeutic efficacy and formulations therefore remain to be validated, and clinical trials will be required to confirm the potential for lower dosing.

Decarbonization roadmap

Even though long-acting technologies already demonstrate a substantially lower carbon footprint, several additional mitigation levers have been identified and quantified to further reduce their climate impact. Marginal Abatement Cost Curves (MACC) over a 10-year horizon were developed to illustrate this decarbonization pathway (see, for example, Figure 4 for tuberculosis prevention). A potential reduction of more than 60% in the carbon footprint of the treatment course was identified, with approximately 30–40% achievable at limited cost to users when reduction measures are amortized over a 10-year period.

Figure 4: Marginal abatement cost curves for long acting rifapentine in TB prevention



These Marginal Abatement Cost Curves serve as a visual tool to support the prioritization and planning of healthcare pathway decarbonization.

Conclusion

Long-acting technologies offer promising environmental benefits in addition to potential health advantages, such as improved treatment adherence, reduced risk of drug resistance, and better access to care. Supporting the development and adoption of these technologies can contribute to climate mitigation in the healthcare sector. Moreover, assessing the environmental impact of their production, distribution, and use phases from the clinical trial stage onward can help further minimize their ecological footprint.

This study highlights the importance of evaluating the environmental impact of healthcare pathways, particularly given the multiple treatment options often available to patients. Life Cycle Assessment (LCA) can play a key role in optimizing both patient health and the health of the planet.

About Ecovamed

We are an innovative company created in 2020, with the ambition to contribute to a sustainable health. By relying on improved methodologies and tools, **Ecovamed allows the healthcare industry and the chemical, polymer and biotechnology industries to assess the carbon footprint and LCA of their products**, which is the first step before setting environmental impact reduction plans. Ecovamed is also supporting health professionals to eco-design healthcare pathways.

For more information on Ecovamed, visit www.ecovamed.com or contact us at contact@ecovamed.com.

Conflict of interest

Ecovamed provides services to the healthcare industry, to health professionals and public institutions, including LCA and carbon footprint assessment of health products and healthcare pathways, as well as support for developing decarbonization roadmaps within the health sector. As of today, no studies on these products has been conducted for pharmaceutical companies by Ecovamed.

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