DIGITAL HEALTH INTERVENTIONS AND ENVIRONMENTAL SUSTAINABILITY: A TARGETED LITERATURE REVIEW

Liz Hamilton, MPH[1*], Zipporah R. Abraham Paiss[1], Ellie Goldman, MPH[1], Sumudu Dehipawala, MPH[1], Abigail Silber, MPH[1], Matthew O'Hara, MBA[1]
1. Trinity Life Sciences, Waltham, MA, USA; *Presenting Author

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INTRODUCTION

- As the pressure of climate change reshapes healthcare, a growing dialogue has emerged around how digital health technologies can be leveraged not only to improve clinical outcomes but also to reduce environmental impact[4,17]. Digital health interventions (DHIs)—including telemedicine, remote patient monitoring, and virtual platforms—have increased in use following the COVID-19 pandemic[2,11]. At the same time, global healthcare systems face increasing patient scrutiny regarding their environmental impact, prompting calls for more sustainable care models[13,16]
- **As DHIs replace traditionally resource-intensive in-person services, they offer new opportunities to reduce greenhouse gas (GHG) emissions and resource consumption, particularly by avoiding patient travel and streamlining care delivery[12,18,19].** While the clinical utility of DHIs has been widely explored, their environmental implications remain underexamined in Health Economics and Outcomes Research (HEOR). Developing a framework to quantify and communicate these environmental benefits may be a step forward as sustainability becomes a strategic priority for healthcare systems, payers, and pharma/medical device manufacturers alike[4,10]

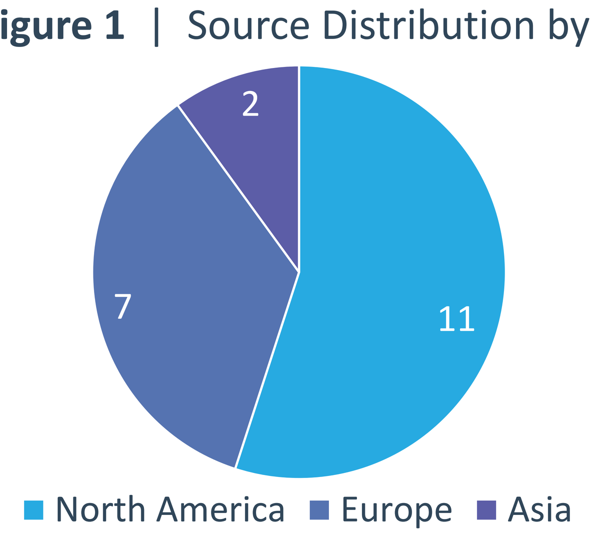
OBJECTIVES

- This targeted review aimed to evaluate the environmental impact of remote-care DHIs, such as telemedicine and remote patient monitoring, by analyzing evidence of emissions reductions, resource savings, and other sustainability outcomes. In doing so, we sought to explore methodological approaches that quantify environmental outcomes within HEOR frameworks, such as life cycle assessment (LCA) and carbon accounting. The review also synthesized global findings to highlight regional perspectives and challenges, and to assess the implications of DHIs for healthcare decision-makers seeking to align clinical innovation with sustainability goals.

METHODS

- A targeted literature review was conducted to identify published and gray literature evaluating the environmental impact of digital health interventions (DHIs) between January 2019 and December 2024. The search strategy focused on identifying studies that assessed the sustainability implications of telemedicine, remote patient monitoring (RPM), virtual care platforms, and other DHIs in clinical or system-level settings.
- Searches were conducted using PubMed and supplemented by manual searches of gray literature, including industry white papers and non-governmental publications. The PubMed search combined terms related to digital health and environmental sustainability, such as: **("digital health" OR "telemedicine" OR "remote patient monitoring" OR "telehealth") AND ("environmental impact" OR "carbon footprint" OR "CO_2 emissions" OR "life cycle assessment" OR "sustainability").**
- Gray literature was identified through structured Google searches, citation tracking, and targeted review of reports from recognized health sustainability groups and life sciences think tanks. Only studies published in English were included.
- Inclusion criteria focused on articles that:
  1. Evaluated a digital health intervention in a clinical or system-level context,
  2. Quantified at least one environmental outcome (e.g., avoided emissions, resource use reductions, LCA outputs)
  3. Provided empirical data or proposed methodological frameworks applicable to Health Economics and Outcomes Research (HEOR).

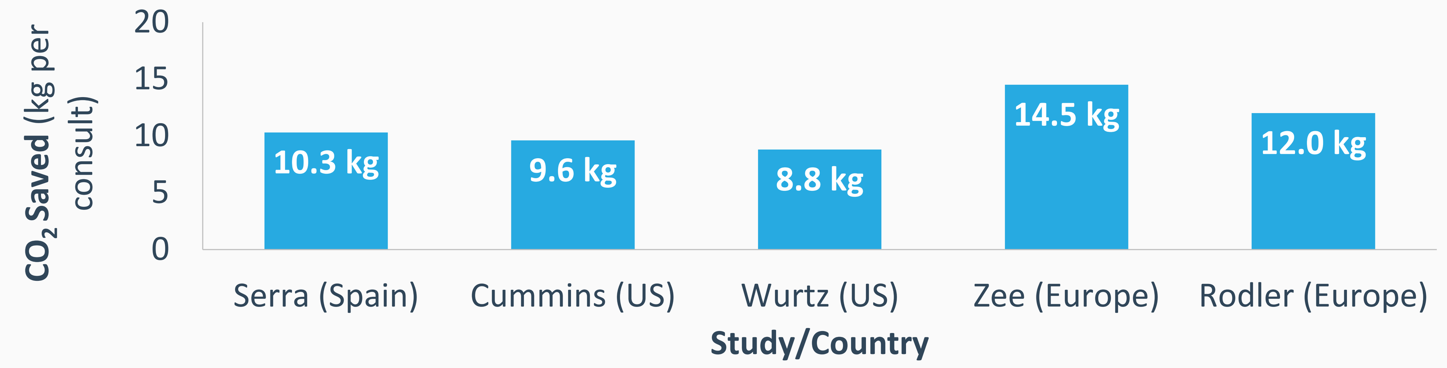
Figure 1 | Source Distribution by Continent



Studies were selected to ensure diversity in intervention type, clinical area, and geographical context. Final inclusion consisted of 20 sources spanning North America (n=11), Europe (n=7), and Asia (n=2), representing a globally distributed perspective on the environmental implications of DHIs. No formal governmental reports were included in the final set as shown in **Figure 1**.

RESULTS

Figure 2 | Average CO_2 Saved Per Digital Health Consult



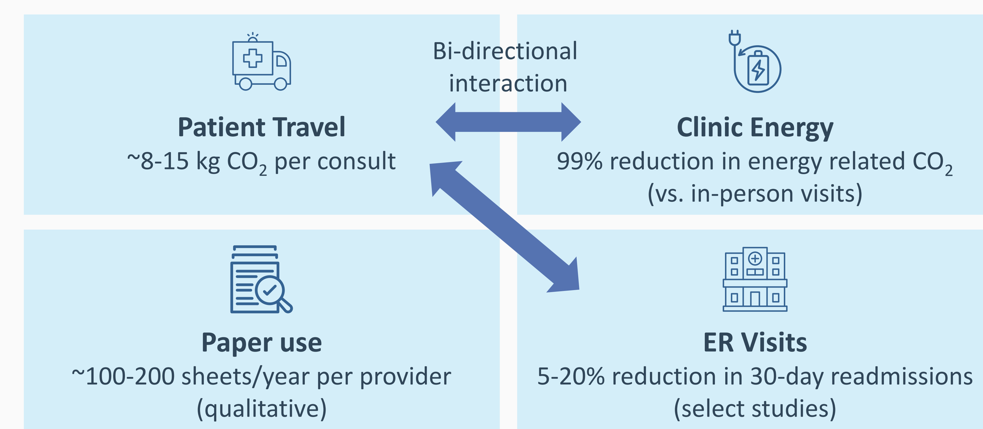
Among the 20 sources included in analysis, the most consistently reported environmental benefit of DHIs was the reduction of greenhouse gas emissions through avoided patient travel. Across studies, **estimated CO_2 savings per consultation ranged from approximately 8 to 15 kilograms**, with large-scale implementations reaching thousands of metric tons of avoided emissions annually. Notably, telehealth in Spain prevented over 6,600 tons of CO_2 through remote consultations alone[12], while U.S.-based analyses reported comparable reductions across surgical care, chronic disease management, and primary care settings[2,18,19]. A comparative summary of these findings is shown in **Figure 2.**

Figure 2. Average carbon dioxide savings per digital health consultation across selected studies ranged from 8 to 15 kg. At scale, these avoided emissions translate to thousands of metric tons annually, with travel avoidance as the primary driver[2,11,12,18,19]

Figure 3 | Quantified Environmental Touchpoints Affected by DHIs

Emissions avoided by reducing patient commutes to healthcare facilities were estimated to save 8-15 kg CO_2 per virtual consult by replacing car or public transit travel[2,12,19]

Replacing printed records, intake forms, and prescriptions with digital workflow reduced administrative paper burden by an estimated 100-200 sheets per provider annually[15,16]



Facility-level energy (e.g., lighting, HVAC, equipment standby power) is significantly reduced during virtual care, with up to 99% fewer emissions compared to in person visits[13,17]

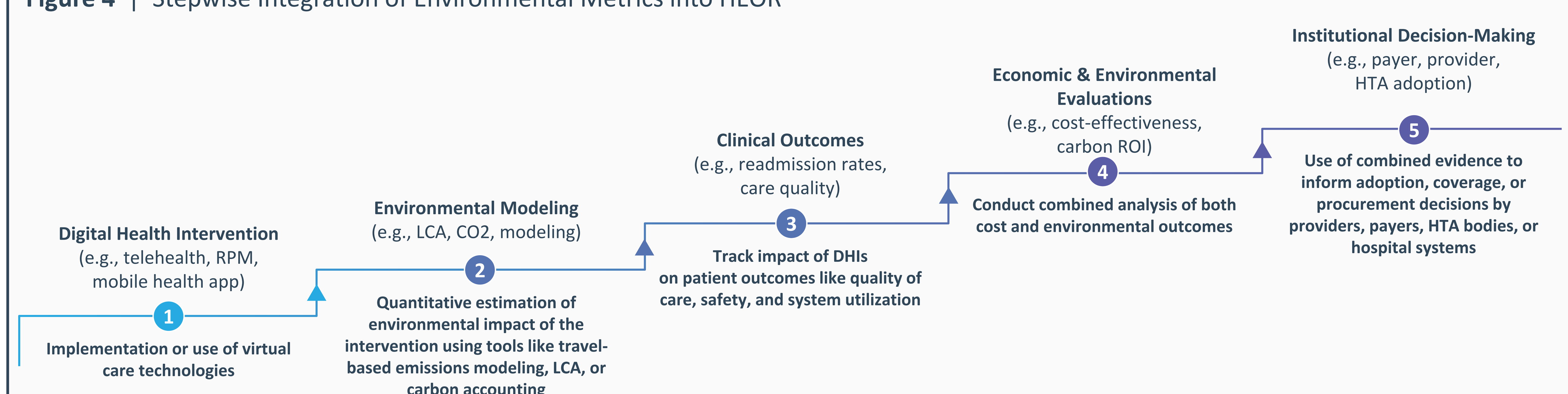
Remote monitoring and early intervention can prevent avoidable ER use and readmissions, reducing the environ-mental impact of high-resource acute care[4,7,14]

Beyond emissions reductions from travel, DHIs produced environmental efficiencies across additional healthcare touchpoints. **Figure 3** highlights four key areas of impact: patient travel, paper use, clinic energy consumption, and emergency care utilization. For example, virtual care models reduced demand for printed forms and physical documentation, with several sources describing reductions in administrative paper use and storage burdens when health records and communication systems were digitized[15,16]. Remote monitoring interventions were associated with a 5–20% reduction in hospital readmissions, helping prevent energy- and resource-intensive emergency department visits[5,7,14]. DHIs also reduced the need for in-person clinic energy use—including lighting, HVAC, and facility operations—by replacing onsite appointments with virtual ones[13,17].

Figure 3. DHIs impact multiple key points* in the healthcare delivery process —travel, clinic energy, paper use, and emergency care – many of which are interdependent. Remote care reduces travel and emissions, while also decreasing demand for energy-intensive services and printed documentation[15,16,17].

*Primary sustainability touchpoints include travel, clinic energy, paper use, and ER visits. Secondary drivers such as medical waste, reduced facility overhead, and digital triage may also contribute to environmental savings and merit future evaluation[8,13,15]

Figure 4 | Stepwise Integration of Environmental Metrics into HEOR



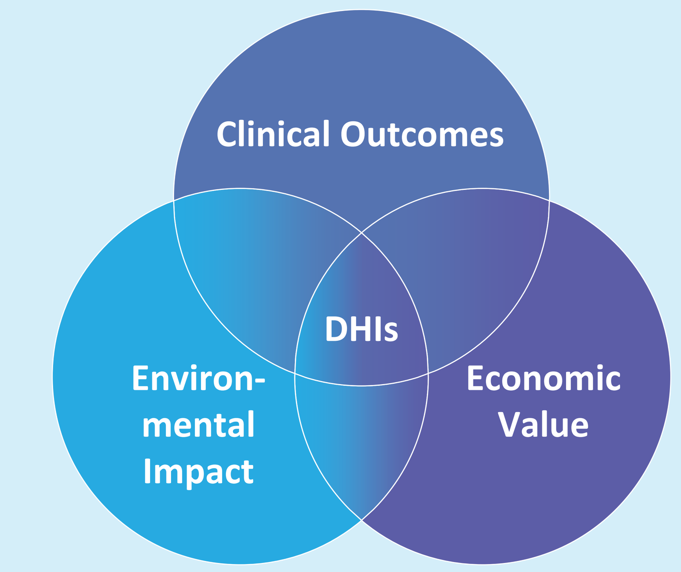
While a few studies noted that digital interventions themselves consume energy (e.g., electricity for devices, data centers, and internet infrastructure), these impacts were described as minimal compared to the avoided emissions from travel and facility use[16,17,19].
Finally, several studies applied or proposed structured environmental assessment frameworks—most commonly life cycle assessments (LCAs), carbon accounting models, or hybrid HEOR approaches—to evaluate the environmental value of DHIs. While still in early stages of adoption, these methods offer a pathway for integrating sustainability into value-based assessments. A conceptual roadmap for how environmental metrics can be incorporated into HEOR evaluations is shown in **Figure 4**, outlining the progression from digital intervention to policy, payer, and provider decision-making[4,7,16,17].

Figure 4. Environmental outcomes can be incorporated into HEOR by evaluating digital health interventions through a staged approach: intervention design, environmental modeling (e.g., LCA), clinical outcomes, combined valuation, and payer decision-making[4,7,17].

DISCUSSION & CONCLUSION

- **This targeted review highlights the emerging role of DHIs in promoting environmental sustainability across global healthcare systems.** The strongest evidence supports DHIs' ability to reduce greenhouse gas emissions, primarily through avoided patient travel. Additional efficiencies—such as reductions in clinic energy use, paper documentation, and emergency care utilization—suggest that when thoughtfully implemented, DHIs can generate meaningful environmental benefit.
- **However, these gains are not without trade-offs.** Access to technology and reliable internet remains limited for some rural and underserved populations, raising equity concerns. In certain clinical contexts, in-person evaluation remains essential. To mitigate disparities, hybrid models that balance environmental and clinical considerations are needed.
- **From a HEOR perspective, there is an opportunity to better incorporate environmental outcomes into value assessments.** While methods such as life cycle assessment (LCA) and carbon accounting were referenced across several sources, they remain underutilized in current HEOR and health technology assessment (HTA) practices.

Figure 5 | Value Intersection of DHIs



DHIs represent a unique opportunity to deliver clinical benefit, economic efficiency, and environmental sustainability – positioning them at the intersection of value-based care.

- **Sustained policy and reimbursement support will be critical.** Though some COVID-era policies established reimbursement parity for virtual care, many are now being rolled back, potentially undermining the momentum and sustainability gains achieved to date[20]. Digitizing health records and workflows may also offer further environmental efficiencies, though challenges like interoperability persist.
- **For healthcare decision-makers, several actionable insights emerge:**
  - Incorporate environmental impact into DHI evaluations and pilot programs
  - Leverage real-world data to assess avoided emissions and resource savings
  - Use LCA-informed models to communicate environmental value to stakeholders
  - Invest in digital equity infrastructure to avoid exacerbating disparities
  - Support reimbursement parity and hybrid care models to sustain DHI use
  - Expand digital health record use to minimize paper and printing
- **Further research should focus on standardizing environmental metrics, validating modeling tools, and comparing DHIs to in-person care across clinical, economic, and environmental outcomes.** Embedding environmental sustainability into HEOR offers a strategic pathway to shape a more resilient and responsible healthcare system.

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ABBREVIATIONS

DHI – Digital Health Interventions| **GHG –** Greenhouse Gas | **HEOR –** Health Economics and Outcomes Research| **LCA –** Life Cycle Assessment | **RPM –** Remote Patient Monitoring | **HVAC –** Heating, Ventilation, and Air Conditioning | **HTA –** Health Technology Assessment| **ER –** Emergency Room

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