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Data-Driven Sustainability: Modeling the Emissions Impact of Virtual Health Services in Australia

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Abstract. The healthcare sector contributes approximately 5% of global greenhouse gas emissions, which are the leading driver of climate change and have substantial negative effects on human health. If considered as a country, it would rank as the fifth-largest emitter globally. Virtual health services, including telehealth and remote care, have emerged as a means to address this environmental burden while maintaining accessibility and equity. This study applies a recently developed multi-modal emissions measurement framework to Healthdirect Australia's FY 2023-24 service data to quantify the impact of emissions on their service. Analysis of the 964,278 calls received during the financial year shows that 56% of callers originally intended to visit a clinical service before calling Healthdirect. These calls generated an emissions saving of 1.845 kt of Co_2-e, with the majority of savings occurring in urban areas. The findings provide a critical addition to the business case for digital and data-led health transformation, aligning economic, clinical, and environmental benefits to support the transition to sustainable, low-carbon healthcare systems.

Keywords. Sustainability, virtual health, emissions measurement, data.

1. Introduction

The healthcare sector is a significant contributor to global greenhouse gas emissions, with studies reporting the mean ratio of healthcare system emissions to total national emissions at 4.9% (minimum 1.5%; maximum 9.8%) [1]. This substantial carbon footprint exacerbates climate change and poses direct threats to public health, including increased respiratory and cardiovascular disease incidence and heightened vulnerability to extreme weather events [2]. Addressing the environmental impact of healthcare delivery is therefore essential for both planetary and human health.

The business case for investment in digital health has primarily focused on its ability to improve efficiencies and deliver better outcomes for patients, providers, and the fiscal bottom line [3]. However, the environmental benefits of digital health technologies are less understood. Virtual health services, such as telehealth, telemedicine, and remote care, provide an opportunity to deliver high-quality care with a lower environmental cost [4]. By reducing patient and provider travel and minimising physical resource use where

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clinically appropriate, through reduction in clinical supplies and diagnostic interventions used in face-to-face consultations, these services enable more sustainable healthcare delivery [5].

Importantly, virtual services also address inequities in access to care, particularly for rural, remote, and socioeconomically disadvantaged populations. By reducing barriers to access and supporting earlier intervention, virtual services may reduce decompensation of illness and the need for high-acuity care [6]. Despite these advantages, while social and economic benefits evaluations are standard, environmental metrics remain almost entirely absent from the cost-benefit analyses of digital health investments. Integrating such metrics could significantly strengthen the business case for scaling virtual care services.

In this context, Healthdirect Australia, a national provider of virtual health services, offers a valuable case study. This study applies a recently developed multi-modal emissions measurement framework to Healthdirect's 2023-24 triage data to quantify the environmental impact of its services. The findings provide critical insights into the role of virtual care in promoting low-carbon healthcare systems and inform strategies to scale the integration of such models into mainstream healthcare delivery.

As healthcare systems worldwide face rising complex and competing challenges — reducing their environmental impact and per capita costs; attracting and retaining workforce; and improving patient care and equity. Virtual health services present a practical and scalable pathway to achieving these goals. This study contributes to the evidence base, supporting the transition to more sustainable and equitable healthcare delivery models.

2. Method

We analysed service usage data for Healthdirect Australia from the 2023-24 financial year. Non-identifiable, aggregated call data was extracted from Healthdirect's business intelligence platform, QLIK, including the following variables (Table 1).

Table 1. – Call data extract specification

Variable	Descriptor
Original intent of the caller	Callers are asked what they would have done if they had not called the service – e.g. go to emergency department
Final outcome after triage	This is the recommendation of what the caller should do after the triage with Healthdirect and includes directives to access a variety of health services, including self-care supported with clinical information and digital tools.
Postcode	Residential postcode of the subject of the call.
Jurisdiction	Australian state or territory designation.
Modified Monash Model (MMM) classification	The Modified Monash Model is a refined version of the Australian Standard Geographical Classification - Remoteness Areas (ASGC-RA) system [8]. It offers a more detailed classification of geographical areas to reflect the challenges healthcare providers face in rural and remote setting.

2.1. Data Cleaning

Records missing required variables were excluded but saved for later estimation using average values. Of the 964,278 calls in the 2023-24 financial year, 2.5% lacked the criteria for detailed analysis. To estimate emissions for these, an average emission factor—representing the estimated CO_2-e emissions avoided per call—was applied based on an average of the jurisdiction specific data.

2.2. Data Processing

The data that meet the inclusion criteria was split into eight jurisdiction-specific raw datasets for each Australian state and territory. Microsoft Excel was used to undertake the data processing and assessment of the data to estimate the associated emissions impact for those calls to the services.

To analyze the 2023-24 Healthdirect service data, several key data processing steps were undertaken. Original intents and final outcomes were first grouped into categories based on endpoint clinical service types, resulting in seven defined categories:

- Ambulance,
- Emergency Department (ED) Presentation,
- General Practitioner (GP) Consultation,
- Other Healthcare Provider (OHCP) Consultation,
- Virtual Consultation – Audio,
- Virtual Consultation – Video, and
- Self-Care.

Pivot tables were then created to summarize total call volumes, organized by original intent, final outcome, and geographic remoteness classification under the Modified Monash Model (MMM).

Calls with "unknown" or "prefer not to say" original intents were redistributed proportionally, reflecting the distribution ratios of known intents within each jurisdiction. Similarly, final outcomes categorised as "See GP" were divided into in-person and virtual consultations using ratios assumed based on the national average of virtual-to-in-person GP consultations. This redistribution ensured a comprehensive representation of the call data. The processed data was then used to construct a call volume matrix that mapped original intents to final outcomes.

This matrix provided the foundation for the emissions calculations, and calculates the avoided emissions based upon a combination of changes to patient travel and use of clinical supplies and the emissions cost associated with the delivery of the virtual call (5). The emissions impact of the service was determined using the Net Emissions Impact formula, established in the multi-modal emissions framework currently under review for publication (7):

Net Emissions Impact $= VOL \times (e(FO) + e(VC) - E(OI))$

Where:

- **VOL**: Volume of calls for each pathway,
- **E (FO)**: Emissions of the final outcome clinical pathway,
- **E (VC)**: Emissions of the virtual consultation, and
- **E (OI)**: Emissions of the original intent clinical pathway.

Due to the lack of data linkage to evaluate the long-term outcomes of callers who did not state a clinical original intent, this study conservatively focused on calls where the caller explicitly identified an initial intent to seek clinical care. This included cases where the caller indicated their original intent, had they not called Healthdirect, would have been to call an ambulance, attend an emergency department, see a general practitioner, or consult another healthcare professional (categorized as "other HCP"). Focusing on these calls provided the most robust estimates of emission impacts and measurable environmental benefits.

For FY 2023-24, 56% of all Healthdirect calls were identified as having an original clinical intent and form the basis of this study.

3. Results

During FY 2023-24, Healthdirect calls with an identified original intent to visit a clinical service resulted in an estimated emissions saving of 1.845 kilotonnes (kt) of CO_2- e.

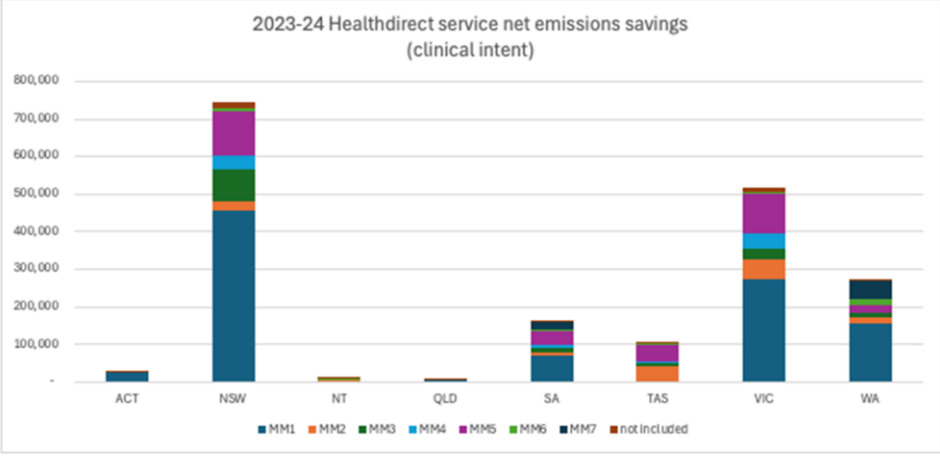

Figure 1: Healthdirect emissions avoided for clinical intent triage calls received in 2023-24 by geographic region and remoteness.

The majority of avoided emissions (69%) were from urban and regional areas classified as Modified Monash Model (MMM) 1–3.

Rural areas (MMM 4 and 5) contributed 23%, while remote and very remote areas (MMM 6 and 7) accounted for 6% of the total avoided emissions.

New South Wales recorded the highest avoided emissions, achieving 728.7 tonnes of CO_2e (40% of the total). Victoria followed with 504 tonnes (28%), and Western Australia contributed 15% (274 tonnes). The remaining states and territories, including South Australia, Tasmania, the Northern Territory, and the Australian Capital Territory, accounted for the remainder of the savings. Significant variation is seen across the jurisdictions due to differences in mode of transport such as public and active transport use, age and fuel type of passenger vehicles, access and availability of services and maturity in implementation and adoption of virtual care pathways.

On average, each clinical triage call to Healthdirect avoided 1.64 kilograms (kg) of CO_2e. Emissions savings per call varied across jurisdictions, reflecting differences in

travel distances, service availability, and population density. South Australia had the lowest average savings at 0.93 kg CO_2e per triage call, while Tasmania achieved the highest at 3.33 kg CO_2e

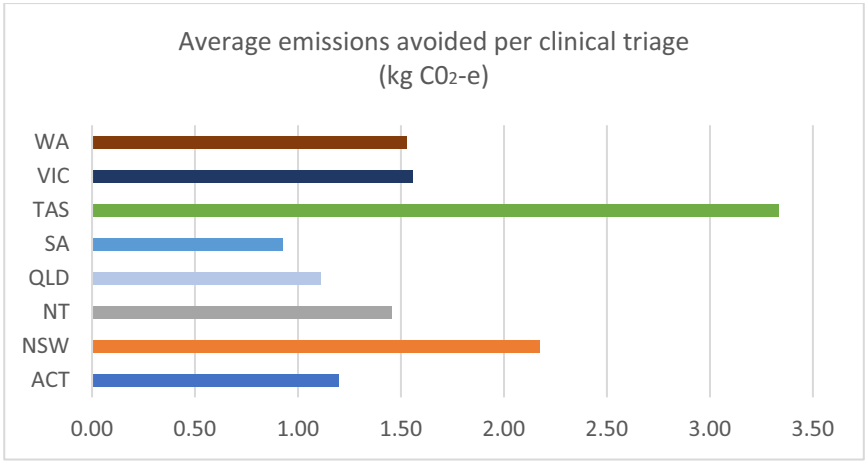

Figure 2: Average emissions per service interaction to Healthdirect by jurisdiction.

4. Discussion

This study highlights the potential for virtual health services to demonstrate measurable reductions in emissions, providing valuable support for organizations facing increasing requirements to report and reduce their carbon footprints. The findings reveal that the majority of emissions savings occur in urban areas, where populations and healthcare services are most concentrated. However, in rural and remote areas, long-standing barriers to accessing care often leads to delayed diagnoses and higher-acuity care needs [6]. While these challenges are well-documented, this study introduces an environmental perspective to complement the established social and economic arguments for scaling virtual health services in underserved areas. By improving access to timely advice, support, and care, virtual health services could help reduce reliance on higher-acuity interventions, which carry substantial economic, social, and environmental costs. Importantly, these findings align with key global priorities, particularly Sustainable Development Goal 3 (Good Health and Well-Being) and SDG 10 (Reduced Inequalities) [9]. By reducing barriers to care and enhancing equitable access to healthcare, virtual services have the potential to address inequities while simultaneously contributing to environmental sustainability.

This study primarily focused on short-term emissions savings through reduced patient travel and optimized care pathways. However, future research should investigate the longer-term impacts of virtual care, particularly how early interventions might prevent disease progression and avoid the need for resource-intensive, high-acuity care. Such work could provide deeper insights into the role of virtual health in addressing access and equity challenges while achieving broader environmental benefits.

A key consideration for policymakers and organizations is the integration of emissions metrics into national greenhouse accounting frameworks. Currently, while

governments provide emissions factors to help organizations calculate their carbon footprints, these frameworks lack emissions factors specific to virtual health services. The results of this study could support the inclusion of such factors in the future, enabling organizations to better quantify and report the environmental benefits of virtual care. This integration would provide a more comprehensive picture of healthcare-related emissions and support the consistent application of emissions metrics in policy and practice.

5. Conclusion

Virtual health services, as demonstrated in this study, represent a critical component of sustainable healthcare systems. By delivering high-quality care with lower environmental costs, they align with the growing demand for transparency and accountability in emissions reporting. The inclusion of environmental metrics alongside economic and clinical outcomes provides a more holistic framework for evaluating digital health investments. As healthcare systems globally seek pathways to decarbonization, virtual care offers a practical and impactful strategy for achieving low-carbon, equitable care delivery. This study provides a strong foundation for further exploration and integration of emissions impact data into health system planning and policy development.

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