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RESEARCH ARTICLE

CARBON EMISSION REDUCTION ASSOCIATED WITH UTILISATION OF TELEHEALTH IN OUTPATIENT CLINICS IN AN AUSTRALIAN QUATERNARY HEALTH SERVICE

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ABSTRACT

OBJECTIVE:

To assess the impact of implementing telehealth in outpatient clinics on the carbon emissions associated with the delivery of health care.

DESIGN & SETTING:

Retrospective cohort study in large metropolitan quaternary referral health service from January 2021 - December 2022. Participants: All patients who attended an outpatient clinic appointment during the study period, either in-person, via telehealth or via telephone.

MAIN OUTCOME MEASURES:

The estimation of carbon emissions in tonnes (t) of CO2-equivalent (CO2-e) associated with in-person and telehealth appointments based on emissions associated with travel, telehealth platform usage and N95 mask usage.

RESULTS:

There were 571,121 outpatient clinic appointments during the study period. Of the appointments, 251,458 (44%) were conducted remotely, resulting in an estimated reduction in 3,629t of CO2-e emissions in the two-year period. Telehealth consultations in this time contributed 4.5t of CO2-equivalent emissions. The total emission usage of telehealth clinic was only 0.12% of emissions generated from face-to-face clinic appointments.

CONCLUSION:

Telehealth offers the opportunity of substantial carbon emissions reduction within the healthcare sector, while also providing cost and time-saving benefits for healthcare services and patients. Limitations include generalisation of transportation modes and the retrospective nature of the data collection.

KEYWORDS

telehealth, healthcare, carbon emissions, outpatient clinics

INTRODUCTION

According to the World Health Organisation, climate change is the most significant threat to global health [1] and addressing this challenge has also been described as the greatest global health opportunity [1-3]. Climate change impacts the environmental determinants of health; through extreme weather patterns, declining biodiversity, the spread of vector-borne disease, and reduced food and water security [1, 2, 4].

The Australian healthcare sector contributed 7% of Australia's total carbon dioxide emissions in 2014-15, producing 35,772 kilotonnes of carbon dioxide equivalent emissions (CO2-e) [5]. We are one of the most carbon-intense healthcare sectors in the world [6] and the bulk of these emissions arise from clinical care delivery rather than building energy use [7]. There are no direct data on the proportion of the Australian health system's carbon footprint that can be attributed to patient travel, however in the UK, patient travel makes up 5% of the of the National Health Service's carbon footprint [8]. Given the larger land mass of Australia compared with the UK, it is safe to estimate that patient travel contributes at least 5%, if not more, to our health system's carbon footprint.

There is an urgent need for the healthcare sector to take action to reduce its environmental impact. In response to this, prominent health bodies, the Australian Medical Association (AMA) and Doctors for the Environment Australia (DEA), have called on the Australian healthcare sector to reduce its carbon emissions to net zero by 2040, with an interim emission reduction target of 80% by 2030 [9]. Guidelines published by the World Health Organisation for healthcare organisations to improve environmental sustainability and climate resilience include recommendations for the use of new technology, including telehealth, to provide sustainable healthcare and reduce the environmental impact of the healthcare sector [10].

Almost one third of Australia's population live in regional or remote areas [11]. The tertiary and quaternary healthcare centres in metropolitan cities service a significant geographical area, including regional and remote communities. Attending appointments from regional or remote areas has significant environmental impact due to the carbon emissions associated with the long travel; and is often expensive. As a result, regional and rural communities experience health inequity and difficulties with accessing timely specialist healthcare [12-14]. Telehealth is a viable means to reduce barriers to accessing specialist care for regional and remote communities and negates the need for patient travel, with an associated reduction in carbon emissions [4].

With the advent of the global COVID-19 pandemic, there has been rapid growth in the use of telehealth as a key strategy to enable healthcare delivery while limiting face-to-face contact between healthcare providers and clients [12]. The existing literature suggests that for appropriately selected patients, telehealth as modality can lead to comparable clinical outcomes, high satisfaction and improved attendance [12-18].

The existing body of literature on the benefits of telehealth in reducing carbon emissions in the provision of healthcare is promising. However, most prior reports involve individual departments and clinics rather than whole organisations. In this retrospective cohort study, we explore the impact on carbon emissions of implementing telehealth across a large quaternary health care service in Melbourne, Australia.

METHODS

STUDY SITE

The Royal Melbourne Hospital is a major metropolitan, quaternary referral and teaching hospital, operating approximately 800 beds, and over 47 different specialist clinics. It is one of two major trauma referral centres in Victoria and one of Australia's leading public hospitals. Patients are referred to the Royal Melbourne Hospital from across southern New South Wales, Victoria, and Tasmania. The telehealth platform used by the health service is Healthdirect Video Call service.

During the period of study, individual clinics determined whether patients would be seen via telehealth, telephone or face-to-face.

STUDY POPULATION AND DATA COLLECTION

This study was approved as a quality assurance project by the Melbourne Health Ethics Committee (QA2022144). Data were extracted from the hospital's data warehouse using structured query language (SQL). This included administrative information such as date of appointment, appointment delivery modality (telehealth, telephone, face-to-face), clinic and speciality, patient's post code, and Australian Statistical Geography Standard (ASGS)

Remoteness Structure's Remoteness Areas according to postcode [19]. All outpatient clinic appointments at the Royal Melbourne Hospital from January 1st 2021 until December 31st 2022 were included. Appointments that were scheduled but the patient failed to attend (either in-person or remotely) were excluded.

ENVIRONMENTAL OUTCOME ANALYSIS

The distance between the patient's home and the Royal Melbourne Hospital site was calculated using geographic coordinates obtained from the patient's residential post code and the hospital.

Based on the Australian National Transport Commission 2021 data of vehicle emissions intensity for light vehicles, which accounted for 91% of cars sold in 2021, the average CO2 emission rate was determined to be 146.5g/km travelled [20]. The distance of a round trip between the patient's coordinates was utilised to calculate the CO2 equivalent emissions (CO2e) per visit if the patient had attended the appointment in person instead of via telehealth or telephone.

Previous studies have calculated the energy consumed in the use of telehealth platform patient and clinician electronic devices as well as backend cloud hosting infrastructure for a video call consult [17, 18, 21]. Based on the calculations and work from Blenkinsop et al [17] and Aslan et al [22], we calculated the total electricity usage (including the upload and download requirements for a 1080p HD video for the consultation) for two users was 3.67 gigabytes (GB) per consultation. The energy intensity was 6.7 GB x 0.015 kWh/GB = 0.05508kWh [22]. Utilising the Australian Government's National Greenhouse Account Factor of 0.68kg CO2-e/kWh [23], one 36-minute telehealth consultation was responsible for 37.25g CO2-e.

During the period of this study, which in part coincided with the COVID-19 pandemic, it was hospital policy for all patients, visitors and staff members to wear N95 masks in clinical areas including outpatient clinics. The range of published life cycle inventory (LCI) results in recent literature demonstrates a median representative value of 65g CO2-e for each single N95 respirator mask consumed [24-26]. One mask per visit was assumed in the calculation in case the clinician was conducting the telehealth clinic from within the healthcare service and thus wearing a mask. As a secondary assessment, the possible cost reduction from reduced mask usage associated with telehealth was also considered. Procurement services identified that the cost of 100,000 N95 masks was $149,000 or $1.49 per mask.

RESULTS

During the period of the study, 571,124 outpatient clinic consultations were attended, of which 319,666 (56%) were conducted face-to-face, 120,333 (21%) were conducted via telehealth, and 131,125 (23%) were conducted via telephone, as demonstrated in Figure 1. The majority of patients who attended an outpatient clinic (either face-to-face, via telehealth or via telephone) were from metropolitan areas and lived within 25km from the hospital, as outlined in Tables 1 and 2.

FIGURE 1: PERCENTAGE OF CLINIC CONSULTATIONS CONDUCTED FACE-TO-FACE, VIA TELEHEALTH OR VIA TELEPHONE DURING THE JANUARY 2021-DECEMBER 2022 PERIOD.

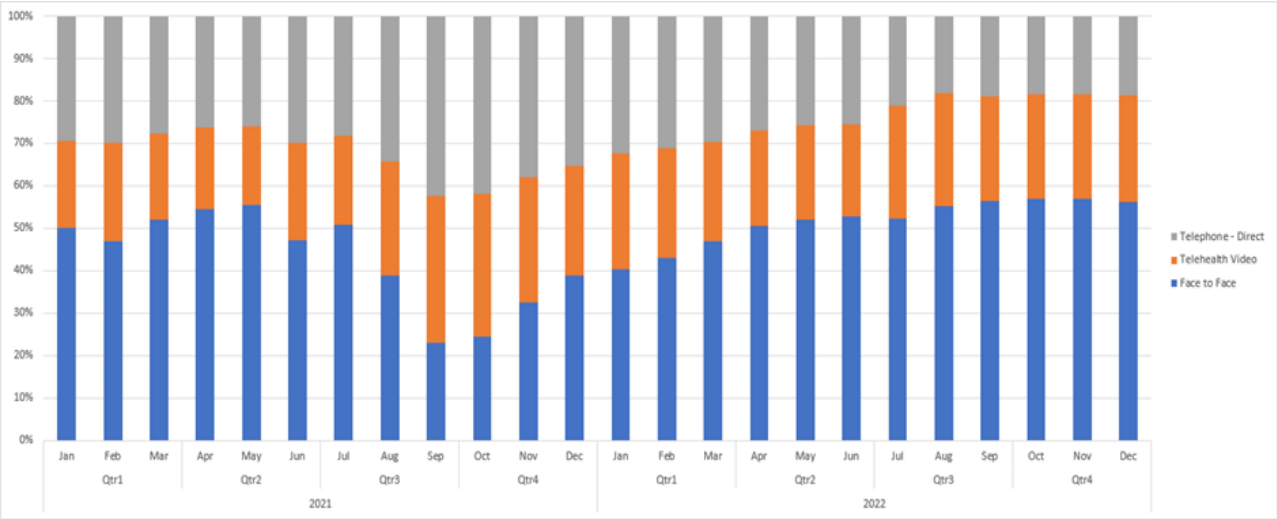

TABLE 1: PERCENTAGE OF ATTENDEES OF CLINIC CONSULTATIONS CONDUCTED FACE-TO-FACE, VIA TELEHEALTH OR VIA TELEPHONE DURING THE JANUARY 2021-DECEMBER 2022 PERIOD CLASSIFIED BY DISTANCE OF PATIENT'S ADDRESS TO THE HOSPITAL.

Distance of residential address from the Hospital (km)	Number of patients	Percentage (%)
0-25	411272	73.45
25-50	68660	12.26
50-100	27022	4.83
100-200	29230	5.22
>200	23780	4.25

TABLE 2: PERCENTAGE OF ATTENDEES OF CLINIC CONSULTATIONS CONDUCTED FACE-TO-FACE, VIA TELEHEALTH OR VIA TELEPHONE DURING THE JANUARY 2021-DECEMBER 2022 PERIOD CLASSIFIED BY PATIENT'S REMOTENESS AREA.

Remoteness Area (RA)	Number of patients	Percentage (%)
Major Cities of Australia (RA0)	484180	84.78
Inner Regional and Outer Regional Australia (RA1 and RA2)	75486	13.21
Remote and Very Remote Australia (RA3 and RA4)	298	0.05

SAVED EMISSIONS ASSOCIATED WITH AVOIDED TRAVEL TO CLINICS

The average return distance between patient homes and the hospital was 76.84km (1.67km-6,588.83km). The total travel distance averted through use of telehealth and telephone was 24,769,006km, which equates to 3,629 tonnes CO2-e saved.

CARBON EMISSIONS ASSOCIATED WITH TELEHEALTH CONSULTATION

The average length of a call on the telehealth platform was 36.6 minutes across 120,333 telehealth consultations, equating to 78,123 hours of telehealth consultations. This equates to 4,482,404g or 4.5 tonnes CO2-e.

Due to a lack of data of telephone consultation length, the CO2e of telephone consultations could not be calculated.

REDUCTION IN EMISSIONS RELATED TO N95 USAGE.

Given that 251,458 appointments occurred remotely, this avoided requirements for patient usage of N95 masks and thus reduced emissions associated with mask usage by 16.3 tonnes CO2-e. Additionally, the reduction in the usage of N95 masks during the period of the study led to a saving of at least $311,811 for the health service.

DISCUSSION

We have demonstrated that the utilisation of telehealth has significant net carbon emission savings. Based on our findings, we estimate the carbon emissions associated with telehealth clinics is 0.12% of the emissions of face-to-face clinics. The total travel distance averted through the use of telehealth and telephone is equivalent to 517 times the circumference of the equator.

Several previous studies have also demonstrated that the use of telehealth services leads to substantial carbon emission reductions associated with healthcare, largely due to avoidance of patient travel to and from outpatient appointments [4, 15-18]. However, these primarily involved individual departments or clinics rather than across an entire health service. Additionally, the majority of these studies were conducted in the UK, which has comparatively less geographical dispersion than Australia, where nearly one-third of the population live in remote or rural areas [11] and thus might face more significant challenges regarding travel-related carbon emissions.

The time frame of this study in a pandemic era allowed for a unique additional area of carbon emission reduction assessment in that the use of telehealth reduced usage of

N95 masks. The assumption of one mask per clinic visit likely under-represents the carbon emissions reduction from avoidance of mask usage as it doesn't account for the patient having a support person attending the clinic with them (our local patient survey data has shown that 25% of patients brought a support person with them to clinic in 2021/2022), nor clinicians working remotely not wearing masks. Even in early 2024, face-to-face clinic appointments at the Royal Melbourne Hospital still required patients and support persons (as well as clinicians) to wear a standard surgical mask, so this carbon saving remains relevant in the current early post-pandemic setting.

There are additional benefits that have occurred due to the utilisation of telehealth. Literature published by Dao et al [27] reviewed survey data captured in 2020 from patients in the same health service as this study who utilised the telehealth platform. The average patient living in a metropolitan area saved $76.60, and in regional areas $229.82 for attending their clinic appointment via telehealth instead of face-to-face; while the median total cost was AU$153.20 saved for each patient [27].

There are limitations of our study, namely the generalisation of the mode of transportation to calculate the emissions. Given the retrospective nature of the data collection, assumptions were made to facilitate the analysis, considering car only travel and average journey times under normal driving conditions. Factors such as road type, route taken, time of travel, weather conditions, specific vehicle types and means of transport (such as via car, train, taxi, plane, bicycle or walking) were not included in the analysis. Our carbon emission calculation is an estimation based on the average passenger vehicle emissions data in Australia. Additionally, telephone consultation length was not available for our patients, which prevented the calculation of associated CO2e, thus impacting the overall net emission estimation results as 20% of clinic consultations occurred via telephone. This is also seen in previous similar studies [4].

The timeframe of this study was intentionally extended beyond the period of COVID-19 related lockdowns and travel restrictions that occurred in 2020-2021 in Victoria, Australia. Whilst it is possibly a limitation of the study that it was conducted during a pandemic leading to an increase in the utilisation of telehealth, it is unlikely that we overestimated the opportunity for carbon emission reductions given there has been consistent demonstration that telehealth is a viable option for providing outpatient medical care in both primary and secondary care settings, especially in the management of chronic diseases [4].

CONCLUSION

Taking into consideration the significant impact of climate change on health outcomes at an individual and global level, as well as the significant contribution of the healthcare industry to carbon emissions, it is imperative for health services to take action to reduce carbon emissions. We have demonstrated that at an institutional level, the scale of emission reduction using telehealth for outpatient clinics is significant and should be considered a mainstay of clinical operation in a post-pandemic era in the appropriate clinical setting.

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