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A Systematic Review of The Impact of Telehealth Utilization in the United States of America's Healthcare System on the Environment

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ABSTRACT

This study is designed to investigate the impact of telehealth utilization in the United States of America's healthcare system on the environment to inform both healthcare and environmental policies. This study followed the PRISMA guidelines for systematic review analysis. As part of the literature search, and the selection of the articles, publications, and papers for the study's analysis; the data collection procedure considered the first and second authors of the completed simultaneous electronic and ancestral searches for peer-reviewed articles by using these online databases, which includes: Medline, EMBASE, Web of Science, Greenfile, and Google scholar as well as advanced Google scholar for all articles in the English language that evaluated the impact of telemedicine on the environment. With the help of Boolean search technique and experts' reviews, 20 articles were included in this study. This study finds that some of the types of telecommunication methods use in healthcare system include the following services: Body Area Networks (BANs), video-conferencing, website, telephone consultations, and other mobile application technology. In the literature, it was observed that telehealth utilization rapidly expanded during the onset of the COVID-19 pandemic and further continues to provide critical access to health care services to patients within and outside United States of America. Again, it was underscored in this study that some of the positive effects of telehealth use include but not limited to the following: (1) reduction in greenhouse gas emissions resulting from both patients and staff reduced travels, (2) reduction in waste production associated with each consultation through reduced patient and staff travel, (3) reduction in greenhouse gas and waste product associated with reduced equipment use, particularly through the reduction in raw materials needed, (4) air pollutant emission savings, and (5) reduction in sanitation required per consultation. Above all, some of the negative effects of telehealth use include but not limited to the following: (1) increased energy use associated with greater digitization, (2) The expansion of digital health increase demand for devices contributing to the environmental burden of electronics, (3) Inadequate resources to effectively handle e-waste leads to pollution of local environments, creating significant health risks, (4) the production and disposal of wearable technologies, robotics and devices used to facilitate telehealth (i.e. smartphones, tablets, laptops, etc.) cause environmental degradation, and (5) Raw materials (such as—iron, aluminum, gold, mercury, cyanide, etc.) required to produce telehealth technologies or devices require large mining operations leading to land and environmental degradation.

Keywords: Telehealth, Environment, Digital Health, Video-Conferencing, Telemedicine, Healthcare System, Utilization, Technologies, Greenhouse-Gas, Pollution, and Emissions

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INTRODUCTION

Telehealth, which is sometimes called telemedicine—allows patients health care providers to care for them without an in-person office visit. Telehealth is done primarily online with internet access on your computer, tablet, or smartphone (Health Resources & Services Administration, 2021). According to Telehealth.HHS.gov (n.d.), there are several options for telehealth care, and they include: (a) talking to your health care provider live over the phone or video chat, (b) sending and receive messages from your health care provider using secure messaging, email, and secure file exchange, and (c) by using remote monitoring so your health care provider can check on you at home. For example, a patient might use a device to gather vital signs to help your health care provider stay informed on your progress (Telehealth.HHS.gov, n.d.; Health Resources & Services Administration-HRSA, 2021).

The use of telehealth or telemedicine, or remote clinical consultations, was limited in most countries across the globe before the COVID-19 pandemic, which held back by regulatory barriers and hesitancy from patients and providers (Organization for Economic Co-operation and Development-OECD, 2023). In early 2020, as COVID-19 massively disrupted in-person care, governments moved quickly to promote the use of telemedicine, including the United States of America. As a result, the number of teleconsultations skyrocketed, playing a vital role in maintaining access to care, but only partly offsetting reductions in in-person care (OECD, 2023). The COVID-19 pandemic made governments to promote the use of telemedicine through changes in providers' payment systems by not even recognizing its long-time impact on the environment. Since the onset of the COVID-19 pandemic, eight countries in addition to United States of America (i.e. **Belgium, Czech Republic, England, Estonia, Hungary, Korea, Latvia, and Luxembourg)** have begun covering real-time (synchronous) teleconsultations through government/compulsory schemes (Organization for Economic Co-operation and Development, 2023).

Since the introduction of the telehealth to the U.S. healthcare system, the telehealth use in the United States grew significantly within the first three months of the COVID-19 pandemic (i.e. January – March 2020), providing access to critical health services, enabling communication between health care providers and patients, and remote monitoring of conditions through the use of synchronous (see Figure 1 for more details), real-time modalities via audio-only or internet-based video on mobile phones and digital devices as well as asynchronous methods (e.g., store and forward and patient portals) (Health Resources & Services Administration, 2021; Koonin et al., 2020).

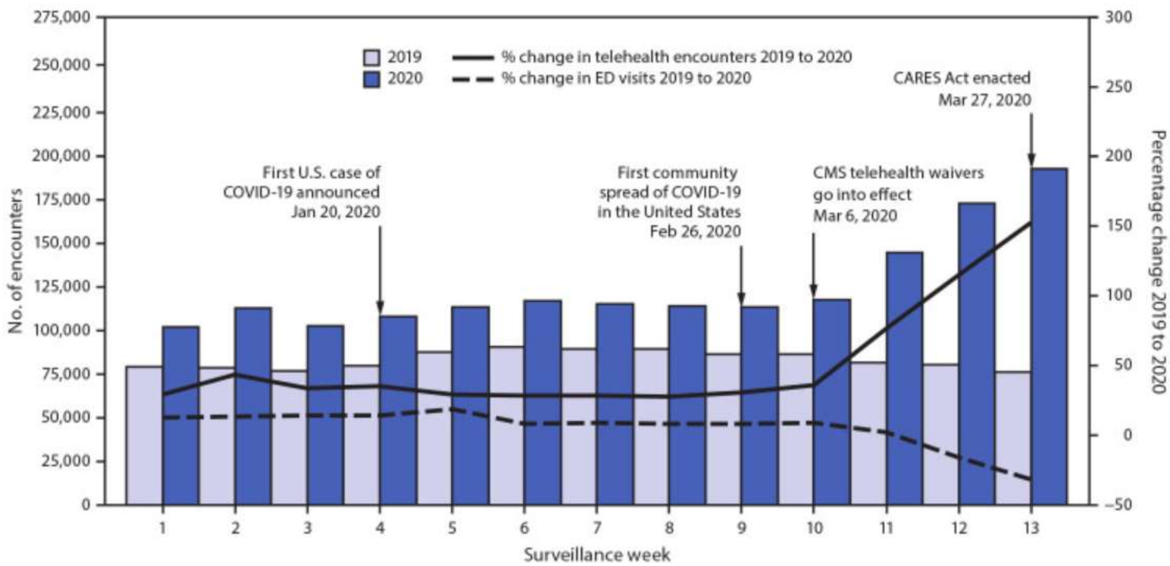

Figure 1: Percentage in Telehealth Encounters in USA between 2019 and 2020
(Source: Koonin et al., 2020).

Very importantly, telehealth used in the last half of 2020 remained high (see Figure 1 for more details), accounting for 30.2% of all health center visits during June – November 2020 (Center for Disease Control and Prevention, 2020; Demeke et al., 2021). Surprisingly in April 2021, the national telehealth utilization rate among adults ages 18 years and older was at 27%, which is lower than early pandemic telehealth use, but then declined to 22% by mid-late 2021 based on an earlier ASPE study (see Figure 2 for more details). Figure 2 further shows trends in the percentage of adults and children that had used telehealth services in the prior four weeks (Rabbani & Chen, 2023).

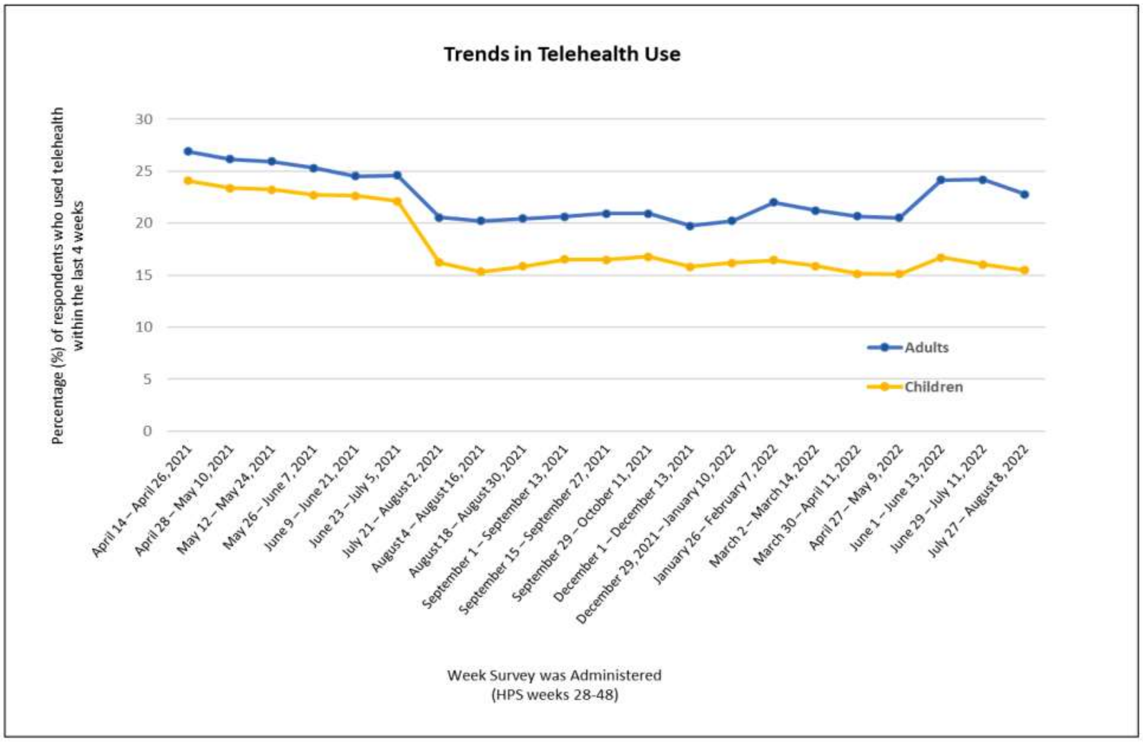

Figure 2: Percentage of Adults and Children Utilization of Telehealth Services-April 2021-August 2022. (**Source:** ASPE-Assistant Secretary for Planning and Evaluation, 2023).

According to the Office of Health Policy (2023), telehealth utilization rapidly expanded during the onset of the COVID-19 pandemic and continues to provide critical access to health care services. Lee et al. (2023) argued that the updated trends show a steady use of telehealth with a slightly higher proportion of video-based versus audio-only services by March 2022; however, disparities persist in populations and across insurance types. Additionally, analyses of commercial claims have shown that telehealth services were mostly rendered by social workers and primary care and psychiatry/psychology clinicians, with more than a quarter (26%) of claims for psychotherapy delivered through telehealth (FAIR HEALTH, 2022). However, while evidence on patient preferences regarding modality and the impact of telehealth on quality of care and patient outcomes is still being explored, equitable access to telehealth services – particularly synchronous, real-time video telehealth – remains a significant concern and potential barrier to health care during the pandemic (White-Williams et al., 2022). Also, the importance and the perceived effects of the use of telehealth services on the global environment has not yet been fully examined.

Meanwhile, it is an undeniable fact that health care services contribute greatly to energy consumption and waste production in general. According to Pichier et al. (2019), healthcare can account for up to 5% of a country's annual carbon footprint. Also, Naylor and Appleby (2012) reported in the literature that the NHS in England contributes 25% of the carbon emissions of the public sector and 4% of the total emissions for England. Prior to the 2012 report, the NHS Sustainable Development Unit (2009) argued that the sources of healthcare emissions include building energy, procurement and travel. In addition, Ravindrane and Patel (2022) also argued in the literature that health care services have considerable impacts on the environment through the production of greenhouse gases and air pollutants. Ravindrane and Patel (2022) further argued that changes to health care service provision are needed to mitigate these impacts, and further proposed that telemedicine usage may be one of the tools to help minimize this environmental impact through reductions in travel. Despite the importance of telehealth use across the globe, and the perceived impact of the production and utilization of healthcare services on the environment, yet little or no study has been designed to investigate the impact of telehealth utilization in the United States of America's healthcare system on the environment to inform both healthcare and environmental policies.

LITERATURE REVIEW

Types of Telehealth Use

There are several types of telehealth or telemedicine services used across the United States health care system, and some other part of the world, especially in Europe and Asia. Some of the types of telecommunication methods use in healthcare system include the following services: Body Area Networks (BANs), video-conferencing, website, telephone consultations, and other mobile application technology.

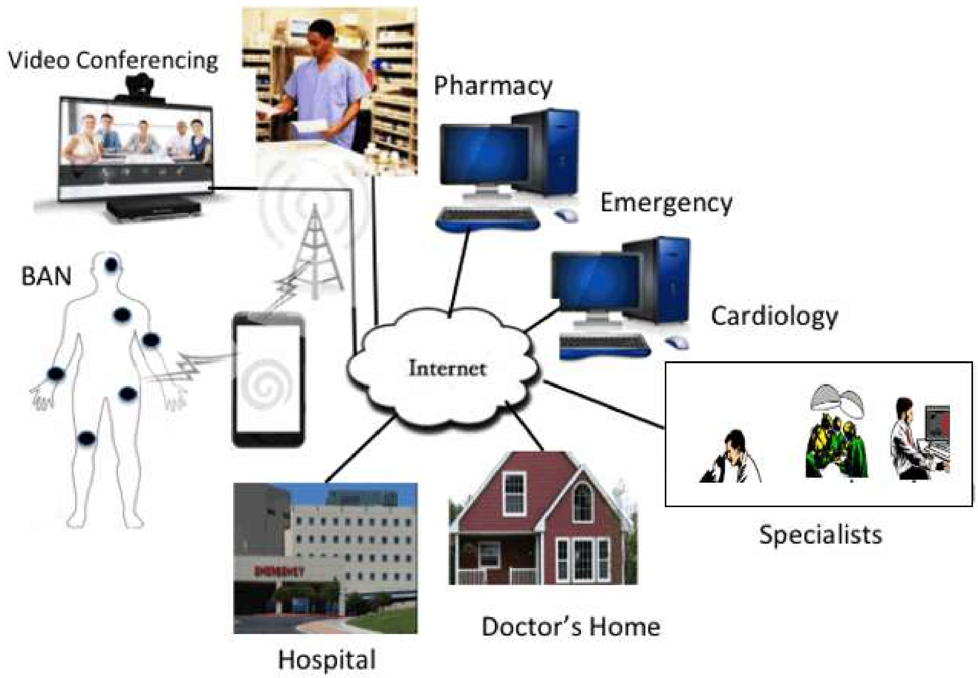

Figure 3: Types of Telehealth Used and Services

(**Source:** Authors modification of Lav Gupta's diagram for BAN and Associated System)

According to Gupta (2014), Body Area Networks (BANs) consist of implanted (inside the body) or worn (over the body) tiny health monitoring sensor nodes for recording vital body parameters and movements of the patient and communicating them to the medical facilities for processing, diagnosis and prescription (Gupta, 2014). These networks are known by various names, such as Body Area Networks (BANs), Body Area Sensor Networks (BASNs) and Wireless Body Area Networks (WBANs) (Gupta, 2014). These BANs provide long term health monitoring of patients under natural neurological and physiological conditions without constraining their normal activities.

Video conferencing is a communication method between one or more parties via the internet (Bell, 2019; Rush et al., 2018). For much of its history, such online meetings were made via special app-platforms, requiring both parties to invest in specialized proprietary hardware and install specialized software (Bell, 2019; Rush et al., 2018). Video conferencing technology is a spatial barrier breaker. By using video conferencing, healthcare service providers can meet patients who are located far away, in remote locations, or patients who are immobile and cannot visit health care facilities. Importantly, the multimedia in-person interaction allows doctors and nurses to interact with patients effectively, thereby allowing them to receive high-quality medical services (Bell, 2019). Meanwhile, **teleconsultations** via telephone or videoconference are an effective alternative to face-to-face consultations for many patients attending primary care and mental health services (Alnornoz, Sia, & Harris, 2021). Teleconsultations have the potential to deliver time-efficient and lower-cost interventions at a distance while improving access to healthcare (Alnornoz, Sia, & Harris, 2021; Rush et al., 2018).

In a study conducted by Ravindrane and Patel (2022), they underscored in the literature that most telemedicine services included in their review used videoconferencing rather than telephone consultations. Also, most of the studies evaluating the emissions produced through using telemedicine units used videoconferencing, so it is not possible to determine whether services using videoconferencing have greater environmental impact than those using telephone consultations, according to Ravindrane and Patel (2022). The choice between video and telephone consultations may have an impact on quality of patient care. Video consultations may provide higher quality consultations by being more similar to face-to-face consultations. Specifically, as video allows for non-verbal communication and some aspects of physical examination. A systematic review by Rush et al comparing telephone and videoconferencing consultations found that videoconferencing was comparable or better than telephone consultations at reducing the number of unnecessary healthcare consultations (Ravindrane & Patel, 2022; Rush et al., 2018). It resulted in increased accuracy of diagnosis, treatment decisions and fewer physician-related medication errors. However, consultation duration was longer than for telephone consultations (Rush et al., 2018; Ravindrane & Patel, 2022).

METHODS AND MATERIALS

Of all the 20 papers included in this study, 16 were cross-sectional design with elements of modelling to estimate environmental impacts, while four (4) of papers used mixed method research design. This study follows the PRISMA guidelines for systematic review analysis. As part of the literature search, and the selection of articles, publications, and papers for the study's analysis, the data collection procedure considered the first and second authors of the completed simultaneous electronic and ancestral searches for peer-reviewed articles by using these online databases, which includes: Medline, EMBASE, Web of Science, Greenfile, and Google scholar and advanced Google scholar for all articles in the English language that evaluated the impact of telemedicine on the environment. An initial search strategy was developed for Medline which was adapted for EMBASE, Web of Science, Greenfile, and Google scholar.

So, with the help of Boolean search indicators, "or", "and" and "not" the following search terms: 'carbon' and 'telemedicine', 'carbon' and 'telehealth', 'pollution' and 'telehealth', 'environment' and 'telemedicine' and 'environment' and 'telehealth' were entered into databases. The total search yielded 4,643 results and all duplicates were removed. The initial search results yielded about 1,503 relevant articles on Medline, 1,000 on EMBASE, 600 on Web of Science, 40 on Greenfile, and 1,500 on both Google scholar and advanced Google scholar. Based on the large number of authors using the terms like "Telehealth", "Telemedicine", and "Environment" in numerous ways, an abstract filter was also applied to the selection criteria.

The study further widens the scope of the search to minimize the sampling of the selected articles by focusing on the positive and negative effects of telehealth use on environment. This particular search yielded about 350 articles through the help of abstract filters. After the abstract filtration to reduce the size of the articles' selections, the researcher uses the two concepts, "Telehealth" and "Environment" to determine whether those remain articles meet the inclusion criteria, and 45 articles were chosen for inclusion. The researcher gave the 45 articles to two different telehealth experts, and one Health Informatic professor with knowledge in telehealth utilization at the University of Denver to further review the 45 articles independently in order to ensure the reliability and validity of the analysis (or results). As a result of the three independent reviews by experts in the field, and a completed total of three ancestral searches resulted in 20 articles for final inclusion. Therefore, a total sample of 20 articles/publications which met the inclusion criteria were used for the purposes of the review analysis.

RESULTS AND DISCUSSION

General Findings

Figure 4: Factors Affecting Telehealth Energy Consumption

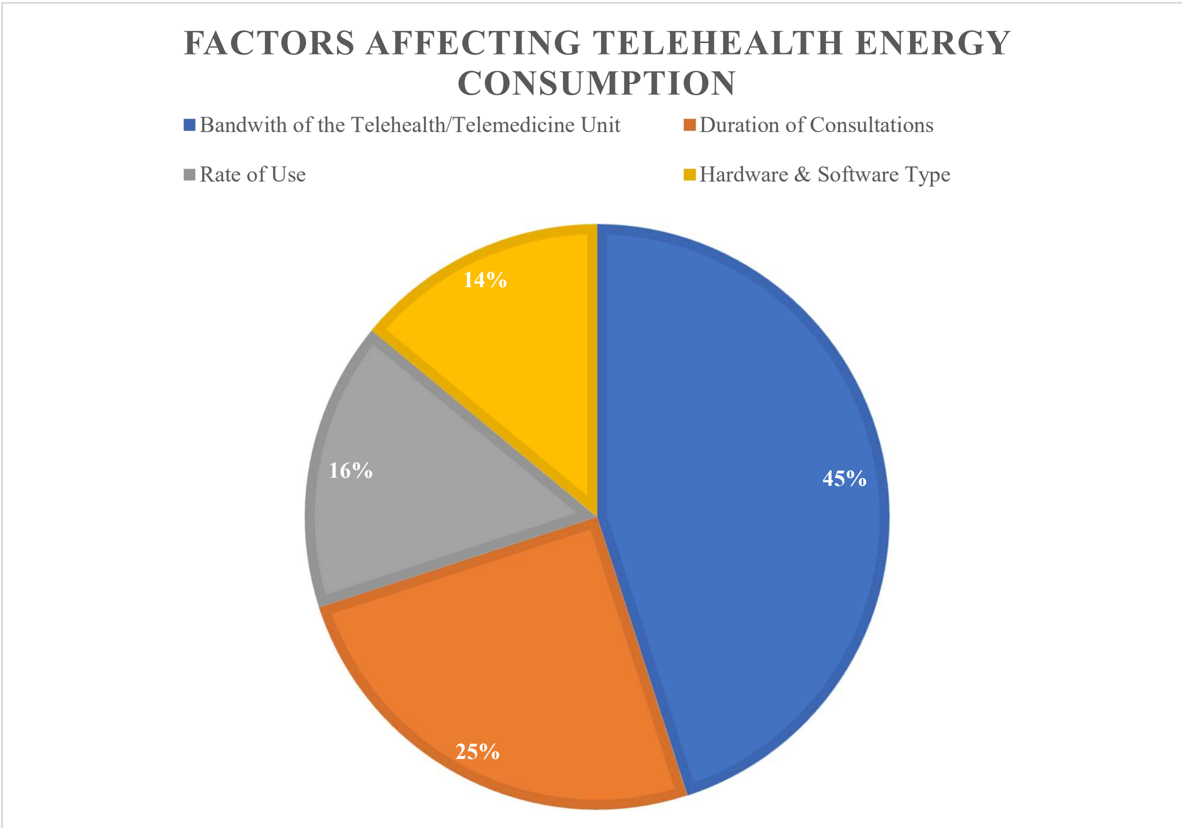

Figure 4 is used to present analysis of factors or variables that affected telehealth energy consumption both in United States of America and across the globe. Based on the datasets, variables affecting telemedicine energy consumption included the following (a) bandwidth of the telemedicine unit, (b) duration of consultations, (c) rate of use, and (d) hardware and software type (see Figure 4 for more details). Figure 4 reveals that about 45% of the factors affecting telehealth energy consumption could be attributed to "Bandwith of the Telehealth Unit", while 25% of the factors affecting telehealth energy consumption could be attributed to the "Duration of Consultations" associated with a particular type of telehealth use. Finally, based on the dataset, about 16% of the factors affecting telehealth energy consumption could be attributed to the "Rate of Use", while about 14% of the factors affecting telehealth energy consumption is attributed to the "Hardware and Software Type".

Figure 5: Positive Effects of Telehealth/Telemedicine Use on Environment: Environmental Impacts of Reduced Travels

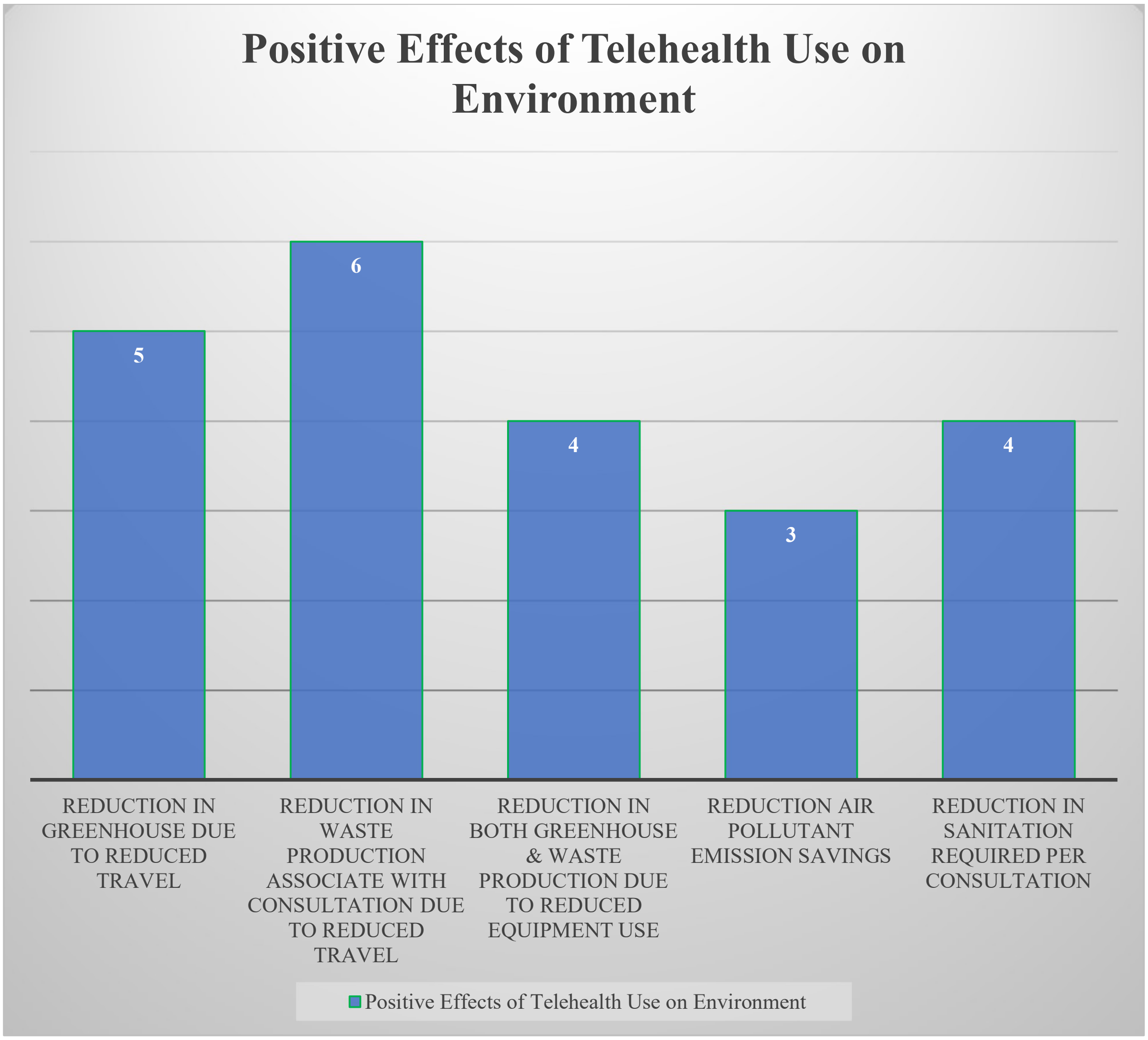

Figure 5 presents the potential benefits or positive effects associated with the use and production of telehealth or telemedicine. Some of the potential positive effects include but not limited to the following: (1) reduction in greenhouse gas emissions resulting from both patients and staff reduced travels, (2) reduction in waste production associated with each consultation through reduced patient and staff travel, (3) reduction in greenhouse gas and waste product associated with reduced equipment use, particularly through the reduction in raw materials needed, (4) air pollutant emission savings, and (5) reduction in sanitation required per consultation (see Figure 5 for more details). Based on the systematic review data, it was observed that five (5) researchers, representing 25% of the selected articles explicitly stated that "reduction in greenhouse gas emissions resulting from both patients and staff reduced travels" is one of the positive effects or impacts associated with the production and utilization of telehealth or telemedicine (see Figure 5 for more details). From Figure 5, about six researchers representing 30% of the total articles included in this study (i.e., Beswick et al., 2014; Connor et al., 2011; Dullet et al., 2017; Holmner et al., 2014; Dorrian et al., 2009; Purohit, Smith & Hibble, 2021) concurrently argued that one of the positive effects or impacts associated with the production and utilization of telehealth or telemedicine in the healthcare space is associated with the "reduction in waste production associated with each consultation through reduced patient and staff travel".

Also, four other researchers, representing 20% of the selected articles (i.e., Connor et al., 2019; Miah et al., 2019; Oliveira et al., 2013; Paquette et al., 2019) underscored in the literature that one of the positive effects or impacts associated with the production and utilization of telehealth or telemedicine in the healthcare space is associated with the "reduction in greenhouse gas and waste product associated with reduced equipment use, particularly through the reduction in raw materials needed". Again, Figure 5 revealed that three researchers, representing 15% of the total articles selected foe the study's analysis underscored in the literature that "air pollutant emission savings" form part of the positive effects or impacts associated with the production and utilization of telehealth or telemedicine in the healthcare space of the United States of America. Finally, four other researchers, representing 20% of the selected articles (i.e., Dorrian et al., 2009; Purohit, Smith & Hibble, 2021; Oliveira et al., 2013; Paquette et al., 2019) underscored in the literature that "reduction in sanitation required per consultation" is one of the positive effects or impacts associated with the production and utilization of telehealth or telemedicine in the healthcare space in the United States of America.

Figure 6: Negative Effects of Telehealth/Telemedicine Use on Environment

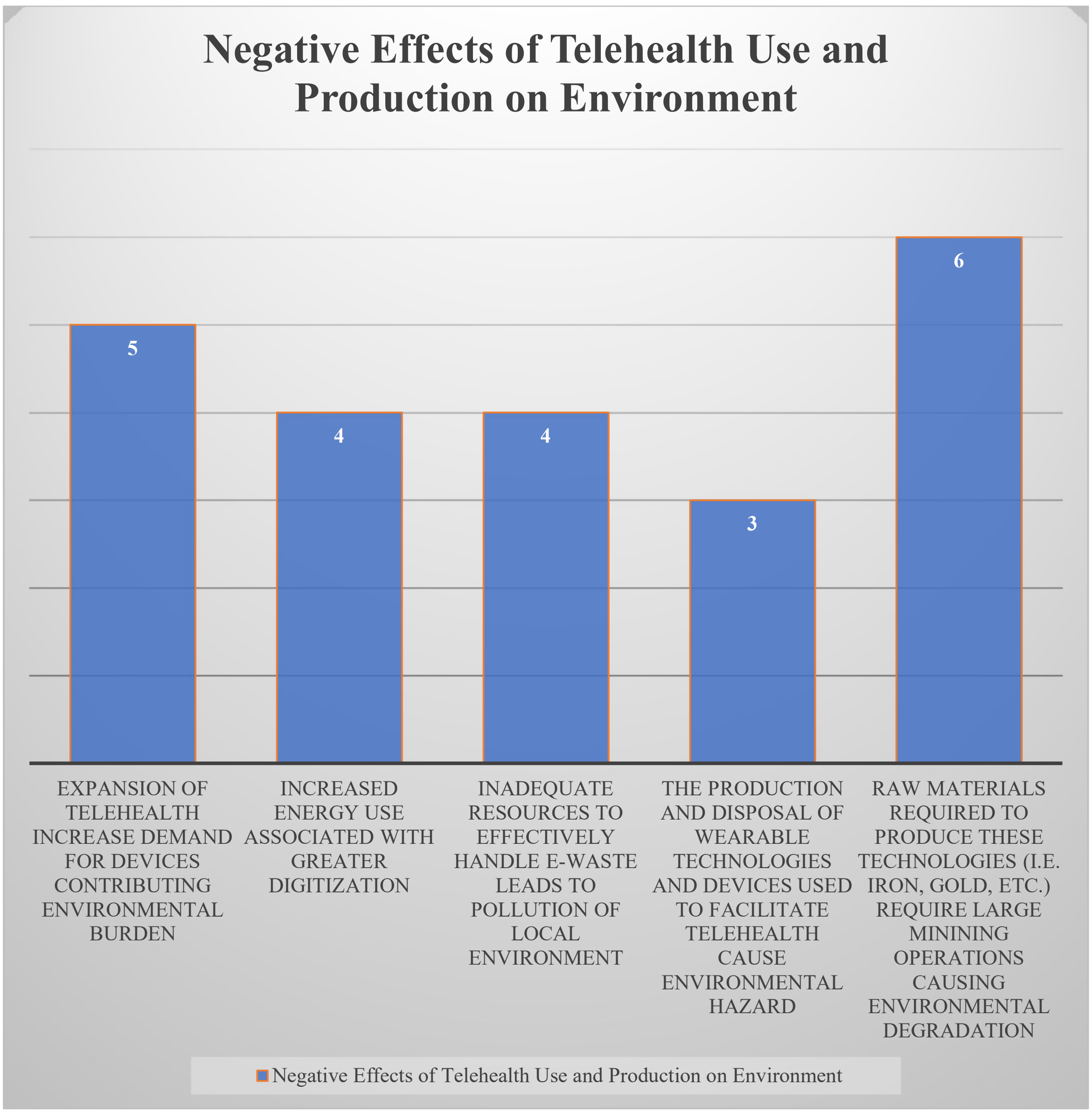

Figure 6 reveals that some of the potential negative effects associated with the use and production of telehealth or telemedicine include but not limited to the following: (1) increased energy use associated with greater digitization, (2) The expansion of digital health increase demand for devices contributing to the environmental burden of electronics, (3) Inadequate resources to effectively handle e-waste leads to pollution of local environments, creating significant health risks, (4) the production and disposal of wearable technologies, robotics and devices used to facilitate telehealth (i.e. smartphones, tablets, laptops, etc.) cause environmental degradation, and (5) Raw materials (such as— iron, aluminum, gold, mercury, cyanide, etc.) required to produce these technologies (i.e. smartphones, tablets, laptops, etc.) — require large mining operations leading to land and environmental degradation (Olabi, Abdelkareem & Jouhara, 2023).

Based on the review, it was observed that researchers of 5 (25%) articles explicitly stated that "the expansion of digital health increase demand for devices contributing to the environmental burden of electronics" is one of the negative effects or impacts associated with the production and utilization of telehealth or telemedicine (see Figure 6). It was further observed that four researchers representing 20% (includes Belkhir & Elmeligi, 2018; Scoville-Simonds, Jamali, & Hufty, 2020; Thompson, 2021; Knawy et al., 2020) explained in their research that one of the negative effects or impacts associated with the production and utilization of telehealth or telemedicine is "increased energy use associated with greater digitization". Again, four other researchers (i.e., Belkhir & Elmeligi, 2018; Maphosa & Maphosa, 2020; Rucevska et al., 2015; Scoville-Simonds, Jamali, & Hufty, 2020) concurrently argued that one of the negative effects or impacts associated with the production and utilization of telehealth or telemedicine in the healthcare space is associated with the "inadequate resources to effectively handle e-waste leads to pollution of local environments, creating significant health risks".

Furthermore, Figure 6 revealed that three researchers (Adamson, 2017; Thompson, 2021; Host, Turner, & Muir, 2018), representing (15%) underscored in the literature that "the production and disposal of wearable technologies, robotics and devices used to facilitate telehealth (such as smartphones, tablets, laptops, etc.) cause environmental degradation" which in effect form part of the negative effects or impacts associated with the production and utilization of telehealth or telemedicine in the healthcare space of the United States of America. Finally, it was observed from the literature that six researchers (Belkhir & Elmeligi, 2018; Maphosa & Maphosa, 2020; Rucevska et al., 2015; Scoville-Simonds, Jamali, & Hufty, 2020; Thompson, 2021; Knawy et al., 2020) representing 30% of the datasets, argued that "Raw materials (iron, aluminum, gold, mercury, cyanide, etc.) required to produce the telehealth technologies or devices require large mining operations leading to land and environmental degradation" also form part of the negative effects or impacts associated with the production and utilization of telehealth or telemedicine in the healthcare space of the United States of America.

CONCLUSION AND POLICY IMPLICATIONS

This systematic review study has demonstrated the potential for telemedicine to reduce greenhouse gas emissions and other air pollutants through reduced travel, and also showed the potential negative effect associated with the production and utilization of telehealth technologies or devices. Also, it was observed from some of the review articles that some of the potential benefits were seen in both rural and urban settings, across a range of clinical specialties, and using telephone and videoconferencing, this practice will go a long way to improve upon the rural health. Even though the literature reveal that the magnitude of the benefit associated with telehealth use was dependent on the energy consumption of the telemedicine systems, number of patients, mode of transport used and distance of travel avoided, yet the use of the telehealth in the healthcare space has helped many rural residents got access to quality healthcare. The study therefore recommends that if more efficient and cost-effective telehealth technologies are being adopted and implemented as part of the means for healthcare delivering and accessibility, then this will go a long way to help improve upon the populations' access to quality health care services and outcomes. Also, since telemedicine has the potential to reduce American health care spending by decreasing problems like medication misuse, unnecessary emergency department visits, and prolonged hospitalizations, therefore the expansion of more efficient telehealth technologies will minimize healthcare cost and also lead to cost- saving. In the nutshell, the study further recommends that the expansion of the Telehealth use will provide access to resources and care for patients in rural areas or areas with provider shortages, which in effect will help improve efficiency without higher net costs, reduces patient travel and wait times, and allows for comparable or improved quality of care.

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