Carbon Footprint of In-center Hemodialysis in US

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Introduction

- Paris agreement adopted in 2015 set a global goal to limit global warming below 2 degrees Celsius and strive to achieve 1.5°C level.[1] Health care accounts to 4.4-4.6% of global greenhouse gas emissions.[2] The United States (US) health care is the top emitter worldwide, responsible for around 25% of the sector's global carbon footprint.[2] From 2010–2018 the US health care greenhouse gas emissions increased by 6%.[2]
- Within the health sector, the nephrology, kidney disease specialty, has remarkably negative environmental impact due to dialysis. In 2018, there were more than 3.3 million patients worldwide on the maintenance dialysis and the number is expected to reach 5 million by 2025.[3] Furthermore, given that not all patients with chronic kidney disease (CKD) have access to dialysis, the projection of maintenance dialysis patients would be higher.[4]
- There have been eco-dialysis initiatives worldwide to tackle the challenge of environmental damage caused by CKD.[4] In the United Kingdom (UK), Green Nephrology movement was established in 2009 that promotes sustainable kidney care practice.[5] NephroCare centers in France showed significant decrease in water and power consumption as well as careful waste production over 13 years (2005–2018).[6] In Australia, 25% of 71 public dialysis facilities in the state of Victoria reused reverse osmosis reject water for other purposes such as watering gardens or flushing toilets.[4] The first global meeting discussing "Green Nephrology" was held in 2018 conference in the US. Although sustainability trend in nephrology has started in some countries, there is still much that needs to be done to reduce carbon footprint of dialysis.[4]

Resource use burden of dialysis

- One of the wasteful parts of dialysis is water usage. Source water is first purified from contaminants and inorganic irons before it can be used for the treatment. During the filtration of water around 50-67% of amount is rejected by the system. As a result, a single treatment can use around 500 liters of water.[3] HD is energy intensive as well, with the heating of water and typically 4-hour usage of hemodialysis (HD) machine thrice weekly per patient.[7] Furthermore, hot disinfection of the loop and dialysis machines are the most power-hungry procedures.[8]

Objectives

- Report the carbon footprint of HD in countries for which estimates are identified in published literature
- Estimate the carbon footprint of in-center (IC) HD in the US

Methods

Targeted literature review on CO_2 emission of HD

- Searches were conducted on PubMed and Google scholar
- Additional references were identified by snowballing
- References presenting estimates for carbon footprint of HD were reviewed and extracted

Calculation of CO_2 emission of ICHD in the US

Epidemiology

- Number of prevalent patients was derived from The US Renal Data System (USRDS).[9] In 2019, 87% of dialysis patients were on ICHD, while 2% and 11% received home HD and peritoneal dialysis (PD), respectively. Only ICHD patients (N=492,096) were included in the calculation.

Travel

- Besides patients' travel to HD unit, we considered staff travel as well. Staff to patient ratio was assumed to equal that of California state level: one dialysis nurse per every 12 patients, and one dialysis technician per every 4 patients.[10]
- Travel distance to an HD facility, 2.9 miles, is based on the data of 66,676 US HD patients.[11] We assume thrice per week treatment.[7] The CO_2 of 2.9 miles driving (estimated consumption of 0.13 gallons of gasoline) is equivalent (Eq) to 1.2 kg CO_2 emissions as calculated using Greenhouse Gas Equivalencies Calculator provided by United States Environmental Protection Agency (EPA).[12]

Energy use

- Average of per treatment power usage in two facilities in Australia (12.0 kWh and 19.6 kWh)[3] and electricity usage per session in France (16.26 kWh)[6] is converted to CO_2 equivalent using 2020 US electricity emission factor of 0.85 pounds of CO_2 per kWh.[13]

Procurement

- We include pharmaceuticals and medical equipment in the calculations for emissions related to procurement. In Australia, these categories represent 96% of total emission related to procurement of dialysis units.[20]
- Lacking representative data from US dialysis clinics, we used input for per patient procurement levels from Australian data[20] and adjusted it for the difference in prices using hospital price levels reported by OECD.[17] To calculate emission, we used UK pharmaceuticals and medical equipment emission factors, 0.45 and 0.54 kg CO_2 Eq per dollars, respectively[20].
- We excluded carbon footprint of water and waste management, which together accounted for 11.1% and 4% of total carbon emissions of HD in Australia[20] and in the UK[7], respectively.

Results

CO_2 emission of HD in identified sources

Table 1. CO_2 emissions of dialysis in different countries

Country	Definition of outcome	Key assumptions	Estimated CO_2 emission value	Largest components
UK [7]	Annual carbon footprint per patient	Standard HD for 4 hrs, thrice weekly	3,818 kg CO_2 Eq	**Procurement** – medical equipment, consumables (36.6%), energy use (20.8%), patient travel (19.6%)
China [18]	Annual carbon footprint per patient for at-home PD	Daily dialysate dose of 8 liters	1,400 kg CO_2 Eq	**PD**– dialysate solution and packaging materials (79.4%), waste disposal (8.3%), electricity (5%)
Morocco [19]	Annual carbon footprint in Co2 Eq - for a HD unit - per patient	Conventional HD thrice weekly for patients	- 408.98 tonnes for a HD unit - 5,110 kg CO_2 Eq per patient	Electrical energy consumption (28%), equipment purchase and services (27%), staff and patients travel (22%)
Australia [20]	Annual carbon footprint per patient	Setting is a suburban satellite dialysis unit providing conventional HD thrice weekly for patients	10,200 kg CO_2 Eq	**Procurement**– pharmaceuticals (35.7%), medical equipment (23.4%), energy (18.6%)

CO_2 emission of ICHD in the US

- We calculated carbon footprint of ICHD treatments considering three main sources of emission:[7] 1) travel; 2) treatment and building energy use; 3) procurement for 492,096 ICHD patients in the US.[9]

Figure 1. Sectoral distribution of CO_2 emission of ICHD in US

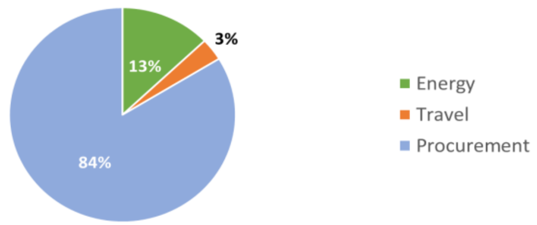

Table 2. Annual CO_2 emission of ICHD provision in the US

Sector	Tonne CO_2 Eq for all patients	Kg CO_2 Eq per patient
Energy	**472,183**	**959.5**
Travel	**122,827**	**249.6**
Patient	92,120	187.2
Staff	30,707	62.4
Procurement	**3,064,501**	**6,227.4**
Total	**3,659,511**	**7,436.6**

Discussion

- Per patient estimates identified for the annual carbon footprint of HD ranged from 3,818 kg CO_2 Eq in UK[7] to 10,200 kg CO_2 Eq in Australia[20]. Per patient annual emission was lower for PD: 1,400 kg CO_2 Eq in China[18].
- We estimated the annual CO_2 emission per ICHD patient to be 7.4 tonnes in the US, accounting for a total of 3.7 million tonnes for the country
- While subject to limitations due to the lack of US data for certain inputs, our calculation demonstrates the magnitude of the carbon footprint of HD in the US

Recommendations for mitigating environmental impact of HD[6,8,21,22]

- Favor public transport options for health care staff and patients
- Reduce water consumption by increasing the efficiency of water purification systems and recycling of reject water
- Reduce energy use by investing in energy efficient technologies for dialysis devices and care facilities and use energy from renewable sources
- Encourage manufacturers to design their dialysis care product lifecycle with a circular, cradle-to-cradle approach in mind
- Strengthen efforts to reduce, reuse, and recycle materials used in relation with HD, including adequate triaging of contaminated and non-contaminated items
- Consider alternative therapies to in-center HD (home HD or PD), incremental HD, and telemedicine
- Adopt strategies to delay kidney failure by slowing disease progression and potentially by introducing regenerative kidney therapies in the future
- Raise awareness of the importance of lifestyle and diet in preventing dialysis and spread the culture of environmentally conscious care choices among patients, caregivers, device manufacturers, and policy makers

References

1. EU Commission. Paris Agreement. Report of the Conference of the Parties to the United Nations Framework Convention on Climate Change (21st Session, 2015: Paris). Accessed 20 April 2022.
2. Eckelman M, et al. Health Care Pollution And Public Health Damage In The United States: An Update. December 2020. https://www.healthaffairs.org/doi/full/10.1377/hlthaff.2020.01247. Accessed 20 April 2022.
3. Barraclough KA, Agar JWM. *Nat Rev Nephrol*. 2020;16(5):257-268.
4. Moura-Neto JA, et al. J Bras Nefrol. 2019;41(4):560-563.
5. The National Kidney Federation. Green Nephrology. www.kidney.org.uk/green-nephrology#:~:text=By%20calling%200800%20169%200936,ringing%20the%20Helpline%20telephone%20number. 2020. Accessed 20 April, 2022.
6. Bendine G, et al. Nephrol Dial Transplant. 2020;35(12):2154-2160.
7. Connor A, et al. *Hemodial Int*. 2011;15(1):39-51.
8. Wieliczko M, et al. *Int Urol Nephrol*. 2020;52(3):519-523.
9. USRDS. Incidence, Prevalence, Patient Characteristics, and Treatment Modalities. https://adr.usrds.org/2021/end-stage-renal-disease/1-incidence-prevalence-patient-characteristics-and-treatment-modalities. 2021. Accessed 20 April, 2022.
10. Rastogi A, Chertow GM. Clin J Am Soc Nephrol. 2018;13(7):1110-1112.
11. Pattharanitima P, et al. *Kidney360*. 2021;2(12):1908-1916.
12. US EPA. Greenhouse Gas Equivalencies Calculator | US EPA. www.epa.gov/energy/greenhouse-gas-equivalencies-calculator#results. 2015. Mar 2022. Accessed 20 April, 2022.
13. US EIA. How much carbon dioxide is produced per kilowatthour of US electricity generation? www.eia.gov/tools/faqs/faq.php?id=74&t=11#:~:text=In%202020%2C%20total%20U.S.%20electricity,CO2%20emissions%20per%20kWh. 2020. Accessed 20 April, 2022.
14. Farbstein E. How to calculate supply chain emissions based on science. Normative. https://normative.io/insight/how-to-calculate-supply-chain-emissions/. 2021. 22 Sep 2021. Accessed 20 April, 2022.
15. GHG. Category 1: Purchased Goods and Services. https://ghgprotocol.org/sites/default/files/standards_supporting/Chapter1.pdf. 2020. Mar 2022. Accessed 20 April, 2022.
16. Levin DI, et al. 2020 Outlook: Dialysis Clinics and ESRD. HealthCare Appraisers,. https://healthcareappraisers.com/2020-outlook-dialysis-clinics-and-esrd/. 2020. 6 Mar 2020. Accessed 20 April, 2022.
17. OECD. Health care prices and Purchasing Power Parities. www.oecd.org/health/health-purchasing-power-parities.htm#:~:text=PPPs%20are%20calculated%20by%20first,health%20care%2C%20or%20GDP. 2020. Accessed 20 April, 2022.
18. Chen M, et al. *Int Urol Nephrol*. 2017;49(2):337-343.
19. Mtioui N, et al. *Ther Apher Dial*. 2021;25(5):613-620.
20. Lim AE, et al. *Aust Health Rev*. 2013;37(3):369-374.
21. Piccoli, Giorgina Barbara, et al. "Green nephrology and eco-dialysis: a position statement by the Italian Society of Nephrology." *J. Nephrol.* 2020;33(4): 681-698.
22. Gauly, Adelheid, et al. "Advanced hemodialysis equipment for more eco-friendly dialysis." *Int Urol Nephrol.* 2021;1-7.

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