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RESEARCH LETTER

Quantification of Recyclable Peritoneal Dialysis Plastics in a Home Dialysis Program–An Opportunity for Resource Stewardship

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INTRODUCTION

Climate change is the greatest threat to human health. An estimated 4.6% of global annual greenhouse gas emissions arise from health care.[1] Rising temperatures and heat stress can cause dehydration, resulting in stone disease, acute kidney injury, and chronic kidney disease.[2]

Therapies for people living with kidney disease can affect our air, land, and water by contamination from pharmaceuticals, dialysate, leachate from plastics, manufacturing processes, or atmospheric carbon pollution. Dialysis therapies, with large consumption of energy, water, and single-use plastics, are among the most significant sources of carbon emissions in clinical care.[3] There is a paucity of data on plastic consumption of peritoneal dialysis (PD), especially automated PD. A UK report described continuous ambulatory PD with 4 daily exchanges generating 0.94 kg of polyvinyl chloride (PVC) plastic waste per patient per day.[2] Similar data for automated PD is lacking.

Quantifying PD plastic waste is important because it provides information for planning recycling initiatives and determining the carbon footprint of PD. We performed a cross sectional audit of all PD prescriptions in a single-center home dialysis program in British Columbia, Canada, then weighed all recyclable material with sensitive scales to quantify the amount of nonbiohazardous recyclable plastic waste generated by both PD modalities.

RESULTS

Individual weight of recyclable PD waste, both polypropylene (PP) and PVC, are shown in Supplementary Table S1. PD therapy of an average continuous ambulatory PD patient performing 4 exchanges generated 58.76 g and 222.88 g of recyclable PP and PVC plastic, respectively per day. Automated PD therapy (4 exchanges at night with a day fill) generated 74.49 g of PP recyclable plastic with the Home Choice machine compared with 88.57 g with the AMIA machine daily, and 272.48 g of PVC plastic waste with Home Choice and 323.4 g with AMIA machine daily.

Table 1 demonstrates the plastic waste generated per patient per year by modality plus carbon emission reductions were these materials recycled. Yearly therapy for an average continuous ambulatory PD patient generated 21.4 kg of recyclable PP plastic and 81.4 kg of recyclable PVC plastic. If recycled versus landfilled, 0.02 metric tons and 0.08 metric tons of carbon dioxide equivalent (MTCO2e), respectively would be saved. Similarly, yearly therapy for an average automated PD patient generated 27.19 kg and 32.33 kg of recyclable PP waste from Home Choice and AMIA machines respectively. If recycled versus landfilled, 0.02 and 0.03 MTCO2e respectively would be saved. Were the 99.46kg and 118.04 kg of recyclable PVC plastic arising from Home Choice and AMIA recycled, emissions reductions of 0.10 and 0.12 MTCO2e would be realized.

The annual recyclable PP waste from PD at our center was 2053.38 kg (Supplementary Figure S1A). This amounts to 24,503.44 kg province-wide annually. The annual nonbiohazardous recyclable PVC waste from PD at our center was 7640.54 kg (Supplementary Figure S1B). In British Columbia, Canada, this amounts to 92,069.81 kg.

Table 1. Weight of PP and PVC per patient per year

	CAPD		APD			
	PP	PVC	PP		PVC	
			PD modality		PD modality	
			Home choice	AMIA	Home choice	AMIA
Per d (grams)	58.76	222.88	74.49	88.57	272.48	323.4
Per yr (Kg)	21.45	81.35	27.19	32.33	99.46	118.04
Carbon emissions saved by recycling vs. landfill per patient per year	0.02	0.08	0.02	0.03	0.10	0.12

APD, automated peritoneal dialysis; CAPD, continuous ambulatory peritoneal dialysis; PD, peritoneal dialysis; PP, polypropylene; PVC, polyvinyl chloride

Supplementary Table S2 shows carbon emission reductions if annual British Columbia, Canada PD associated plastic waste was recycled, versus landfilled, as determined by the WARM waste reduction model. If PD PP waste was recycled, 21.99 MTCO2e would be saved, which amounts to annual emissions of 5 passenger vehicles.[4] If annual British Columbia, Canada PVC waste was recycled (vs. landfilled), 95.66 MTCO2e would be saved, equivalent to annual emissions of 20 vehicles.[4]

It is estimated that 369,000 people worldwide currently receive PD therapy.[5] Table 2 shows PP and PVC estimates of recyclable plastic waste and carbon emissions saved were recycling undertaken globally for worldwide PD therapies, using an assumption that all patients receive continuous ambulatory PD therapy with 4 exchanges per day. Worldwide, annual recyclable PP and PVC waste from PD is estimated at 7.91 million and 30 million kg respectively; if recycled 7101 MTCOe and 31,295 MTCOe would be saved, equivalent to annual emissions of 1508 and 6645 vehicles respectively.[4]

DISCUSSION

This is the first study, to our knowledge, that looked at recyclable plastic waste from PD therapies. The annual volume of recyclable plastic generated by PD is significant, in a single patient ranging from 21.5 kg to 32.3 kg (modality dependent) for PP plastic, and 81.4 kg to 118 kg for PVC.

Using our data, conservative estimates of worldwide PD recyclable PP and PVC plastics are staggering, exceeding 7 million kg and 30 million kg, respectively. By comparison, these weights approximate that of 2 and 8 full Olympic size swimming pools, respectively.

Fossil hydrocarbons are used to produce plastics, and CO_2 is emitted from their eventual decomposition, both contribute to global warming[6] irrespective of disposal by landfill, incineration, or recycling. Despite the lower carbon emissions from recycling, our analysis demonstrates a disappointingly small greenhouse gas emission reduction were all eligible PD plastics recycled versus landfilled, equivalent to the removal of emissions generated by 8100 vehicles per year.

A planetary health approach to kidney care prioritizes prevention and maximized uptake of transplantation or nondialysis conservative care, when appropriate, then optimal stewardship of dialysis resources. Stewardship strategies should include optimized recycling infrastructure and program-level spent plastics retrieval for recycling, such as occurs in urban areas in Australia and New Zealand.[7] Manufacturers should eliminate the use of labeling, inks, or glues that may impair recyclability, and reconsider the routine use of dialysate bag outer plastic wrap. Novel bioplastics, such as those made from cellulose or alginate, particularly if reprocessed in circular fashion, should be developed. Novel dialysis systems with point-of-care dialysate generation to avoid emissions associated with transport are an innovative way to reduce the carbon emissions of PD therapy.[8]

Our study has several limitations. There was a small amount of residual dialysate in the bags that added weight. Single-center data were used to extrapolate for provincial results. Greenhouse gas emission factors were taken from waste reduction model, based on the US data, thus may be inaccurate in Canadian or other international settings. Further, the waste reduction model substitutes mixed plastics for PVC emissions reduction owing to lack of PVC specific data.

Table 2. Carbon emissions reductions if PD plastics recycled worldwide, Canada and USA presuming all patients receive CAPD therapy

Region	Annual PP plastic (Kg or metric tons)	MTCO2e saved if PP recycled (vs. landfilled)	Annual emissions from X passenger vehicles saved if PP recycled	Annual PVC plastic (Kg or metric tons)	MTCO2e saved if PVC recycled (vs. landfilled)	Annual emissions from X passenger vehicles saved if PVC recycled
Canada	55,643.13	49.93	11	211,057.55	220.02	47
USA	482,649.07	433.07	92	1,830,715.20	1908.60	405
World data	7,914,090.6 kg = 7914.1 tons	7101.2	1508	30,018,592.8 kg = 30,018.6 tons	31,295.63	6,645

CAPD, continuous ambulatory peritoneal dialysis; PD, peritoneal dialysis; PP, polypropylene; PVC, polyvinyl chloride MTCO2e, carbon dioxide equivalent.

Importantly, these data should not be used to promote one dialysis modality over another because our analysis does not permit modality comparison nor does it capture comprehensive plastic use or overall environmental effects. Finally, we do not provide information on noncarbon environmental effects of dialysate plastics, including the significant toxicity of PVC constituents, manufacturing, and leachate.[9]

As health care professionals in an era of climate crisis, we ought to steward dialysis materials carefully and aid our patients in doing so. In our center, PD patients and providers are voicing dissatisfaction regarding single-use plastic waste. Our health region, British Columbia, Canada serves over 5 million people and possesses a recycling infrastructure, yet lacks formal collection of the nearly 25,000 kg of PP and over 90,000 kg of PVC plastics from PD therapies, with recycling left to the discretion and capability of each patient.

We plan to use these findings to appeal for improved medical plastic recycling options. We encourage readers to perform similar analyses and begin formulating their own plans for resource stewardship of dialysis materials. The nephrology community has both opportunity and obligation to reframe kidney care provision though a prevention lens. We call on industry and regulators to aid kidney patients and care providers in meaningfully reducing single-use plastic waste.

DISCLOSURE

All the authors declared no competing interests.

SUPPLEMENTARY MATERIAL

Supplementary File (PDF)

Supplementary Methods.

Figure S1A. Annual nonbiohazardous recyclable PP waste.

Figure S1B. Annual nonbiohazardous recyclable PVC waste.

Table S1. Individual weights (g) for PD PP and PVC recyclable plastic waste.

Table S2. Carbon emissions reductions if PD plastics recycled in British Colmbia, Canada.

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