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The cost of a catheter: An environmental perspective on single use clean intermittent catheterization

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Methods: We estimated the prevalence of CIC use in the United States using a neurogenic population, consisting of persons with multiple sclerosis, spina bifida, and spinal cord injury. We measured catheter samples to obtain the amount of waste per catheter.
Results: At least 300 800 persons in the United States perform CIC for neurogenic bladder management. Assuming five catheterization events per day, the amount of waste generated by single-use CIC is between 26 500 to 235 400 pounds or 22 600 to 564 000 liters per day, depending on catheter model.
Conclusions: Single-use CIC may generate up to 85 million pounds or 206 million liters of waste annually, equivalent to more than 26 000 cars or 80 Olympic-sized swimming pools. Laid end-to-end, there is enough catheter length circumscribe the world more than 5.5 times. The most common materials used in catheter construction have little to no degradation once in a landfill. Given the unproven clinical benefit of single-use catheterization, the environmental impact and alternatives should be considered.

KEYWORDS
catheter, clean intermittent catheterization, environment, waste

1 | INTRODUCTION

Annually, approximately 258.5 million tons of municipal waste are produced in the United States, roughly half of which ends up in landfills. Despite efforts to increase the use of sustainable materials, the average American is responsible for 2.33 pounds of landfill waste every day. The degree to which household medical waste contributes to this is not known, however commonly used materials, such as rubber and plastic, contribute 14.7 and 25.2 million tons each year, respectively.[1] While no data currently exists, catheters used in clean intermittent catheterization (CIC) may potentially be significant contributors to urologic waste.

For patients with neurogenic bladders, such as those with traumatic spinal cord injury, multiple sclerosis, and spina bifida, CIC is considered the gold standard in bladder management. Until recently, four catheters per month were provided by most insurance policies for CIC with the expectation that they would be washed and reused. However, in 2008, following changes put forth by the Department of Veterans Affairs in 2007, Medicare amended their policy to reimburse for single-use CIC (up to 200 catheters/month). Subsequently, most insurance carriers followed suit, covering up to 2400 catheters per year. The primary reason for the policy change was an assumed decrease in risk of urinary tract infection (UTI) with single-use catheters, compared to catheter reuse.[2,3] However, while electron microscopy shows that irregularities do develop on the internal and external surfaces of reused catheters,[4] an actual decrease in UTI rates has not been demonstrated. Further, if such a relationship does exist, the degree to which each reuse of a catheter increases the risk of UTI is unknown.

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Given the paucity of evidence demonstrating superiority of single-use catheters with respect to UTI rates, policy changes may have increased the waste generated by persons performing CIC up to 50-fold, without exerting a clinical benefit.[5,6] In this study, we seek to determine the environmental impact of single-use CIC in the United States.

2 | MATERIALS AND METHODS

We conservatively estimated the prevalence of CIC use in the United States by identifying the three largest groups of persons with neurogenic bladder that require CIC. These include patients with multiple sclerosis,[7] spina bifida,[8] and traumatic spinal cord injury.[9] In addition to being the most common neurologic diagnoses associated with CIC use, these diagnoses have reliable data on population size and CIC utilization. Rates of CIC use in each population were indentified[10–14] and from these estimates we were able to calculate the number of persons performing CIC for neurogenic urinary retention. Due to a paucity of published data, we were unable to include other groups who perform CIC (both for neurogenic and non-neurogenic urinary retention). These groups include patients with underactive bladder, diabetic cystopathy, bladder outlet obstruction, and other neurologic diseases.

Commercial catheter samples were then weighed and submerged in water to obtain the amount of waste generated by each catheter in both weight and volume. The samples tested included the ConvaTec GentleCath, Coloplast SpeediCath Compact Plus, Bard Clean-Cath, Coloplast Self-Cath, Cure Catheter, Bard All-Purpose (red rubber), Bard Urological (Tiemann model), Bard Magic3, Hollister VaPro, Bard Touchless Plus, Bard Magic3 Touchless, and Lofric Primo. The potential daily waste was calculated for each catheter system assuming all persons in our projected population performed CIC five times per day. This frequency was chosen, as most neurogenic patients are recommended to catheterize four to six times per day. To determine the environmental impact of catheter materials, we performed a literature review of the primary materials used in catheter construction and their degradation properties.

3 | RESULTS

The number of persons with multiple sclerosis in the United States is estimated to be 400 000,[7] of whom 7.9% perform daily CIC.[10] Thus, the estimated number of persons in the United States with multiple sclerosis who perform CIC is 31 600. The population of spina bifida in the United States is estimated to be 166 000,[8] with CIC use in 85-94%.[11,12] This left us with an estimate of 141 100 persons with spina bifida performing self-catheterization. Finally, the traumatic spinal cord injury population is estimated to be 282 000,[9] with an estimated 77% unable to volitionally void after their injury.[14] Based on data that 59%[13] will be managed with CIC, the anticipated spinal cord injury population performing CIC is 128 100. When combined, we project that at least 300 800 persons in the United States are performing daily CIC for neurogenic bladder management, with an estimated 1.5 million catheters used each day (Table 1).

The aforementioned catheter models were examined by weight and volume. The weight of these individual systems ranged from 8 to 71 grams and their volumes ranged from 15 to 375 mL. When anticipating five CIC events per day, the potential daily waste generated ranged from 26 500 to 235 400 pounds or 22 600 to 564 000 liters (Table 2). It should be noted that several of the more sophisticated "touchless" systems include drainage bags, vinyl gloves, and other materials, which significantly increase overall waste generation.

The most commonly used materials in catheter construction are silicone, polyvinyl chloride (PVC), and latex.[15] Historically, latex was the most commonly used catheter material, but due to concerns about allergic reactions, specifically in the spina bifida population,[16] PVC and silicone catheters are much more common today. Additionally, one catheter in our samples was composed of polyurethane and another was composed of a polyolefin-based elastomer. While silver, Teflon, and other antimicrobial compounds are sometimes used as coating agents,[17] their use is not ubiquitous and is unlikely to change overall degradation properties or provide substantial mass to any catheter.

Given that catheter degradation in soil or landfill conditions has not been studied, we broadened our search for any use of PVC, silicone, latex, polyurethane, or polyolefin in degradation studies. The majority of CIC catheters are made of PVC, a common component in vinyl and plastic products. PVC itself does not undergo any significant degradation in landfill conditions.[18] Silicone is used less frequently for CIC. It is a synthetic polymer designed to be inert and stable, ideal for indwelling devices and implants. The degradation of silicone is debated, but the established understanding is that it is inert and

TABLE 1 Prevalence of CIC use

	Size of population in US	Rate of CIC use (%)	Estimated CIC users
Multiple sclerosis	400 000	7.9	31 600
Spina bifida	166 000	85	141 100
Spinal cord injury	282 000	45.4	128 100
Total			300 800

TABLE 2 Catheter samples

Name	Size (Fr)	Catheter material	Weight in package (grams)	Water displacement in package (mL)	Potential daily waste in pounds	Potential daily waste in liters
ConvaTec GentleCath	14	PVC	8	25	26 500	37 600
Coloplast SpeediCath Compact Plus, Female	14	Polyurethane	9	15	29 800	22 560
Bard Clean-Cath	14	PVC	10	25	33 200	37 600
Coloplast Self-Cath	14	PVC	10	30	33 200	45 120
Cure Catheter	14	PVC	10	25	33 200	37 600
Bard All-Purpose	14	Latex	12	40	39 800	60 160
Bard Urological, Tiemann Model, Coude Tip	14	Latex	13	25	43 100	37 600
Bard Magic3	16	Silicone	17	75	56 400	112 800
Lofric Primo	14	Polyolefin-based elastomer	26	50	86 200	75 200
Hollister VaPro	14	PVC	28	125	92 800	188 000
Bard Touchless Plus Unisex	14	PVC	62	375	205 600	564 000
Bard Magic3 Touchless	14	Silicone	71	300	235 400	451 200

does not degrade.[19] It is notable that soil studies using a silicone spray have shown that some silicone polymers may degrade in a matter of weeks to months,[20] however solid silicone objects (such as catheters) are unlikely to degrade to any substantial degree, even over a span of a century or more. Of commonly used materials, latex is the least commonly used catheter material for CIC today. Of these, latex is the closest to a "natural" substance as it may be harvested from trees or made synthetically. Rubber (latex) takes 50-80 years to degrade once in the environment.[21] Polyurethane, used only in a single female catheter in our samples, may decompose as certain species of fungi and bacteria can biodegrade it. However, results of polyurethane breakdown in landfill and composting models are conflicting, with reports of degradation ranging from months to not at all.[22–24] Lastly, polyolefin was used in a single catheter model (Lofric) and is touted to have a "lower environmental strain" during its lifecycle.[25] Traditional polyolefins are known to have poor degradation properties, degrading <0.5% in 100 years. However, research into additives has shorted the degradation time, ranging from months to years in some cases.[26,27] We were unable to determine the specific polyolefin used to make the Lofric catheter and there is no available data in regard to actual catheter degradation. Despite the interesting properties of these final two materials, it appears that the most commonly used materials for CIC either do not degrade at all or take nearly a century at minimum (Table 3).

4 | DISCUSSION

The potential environmental waste generated by single-use CIC is substantial, with 9.7 million to 85.9 million pounds of waste created each year in the United States alone. This is equivalent to more than 26 000 cars or 330 passenger jets. From a volume perspective, between 8.2 million and 206 million liters of waste are generated, the latter equivalent to more than 80 Olympic-sized swimming pools or 1900 semi-truck trailers. Further, if assuming that catheters are the standard 16 in. in length, there is enough length used in the United States alone in one year to circumscribe the world more than 5.5 times. Further exacerbating the negative environmental impact is the fact that degradation of catheters is poor, with the clear majority unlikely to significantly degrade in our lifetime.

TABLE 3 Primary catheter materials

Material	Relative prevalence	How long it takes to degrade
PVC	Most common	Does not degrade
Silicone	Common	Likely does not degrade significantly
Latex	Less common	50-80 years
Polyurethane	Least common	Unknown (months vs does not degrade)
Polyolefin	Least common	Months to centuries (depends on additives)

Despite the massive amount of non-biodegradable waste created and fact that catheters are packaged as "single-use," there is no definitive evidence to support the practice of using a new sterile catheter for each catheterization. The most widely cited reason for the transition of catheter reuse to single-use CIC, is a presumed increase in UTI risk with reuse of catheters. Two studies have examined the published data on this issue. The first study performed a metanalysis of seven trials, which showed no significant difference in UTI rates between single and multiuse CIC. In the same paper, a subanalysis of three trials to account for modern UTI definitions again found no significant difference in UTI rates.[5] The second paper reviewed published studies and guidelines on the issue, but was able to cite only expert opinion without data to support the assumption that reuse of catheters is associated with an increased risk of UTI.[6] The lack of data calls into question the cost-effectiveness of single-use CIC, which assumes that a reduction in UTI-related adverse events will offset the increased material costs.

Despite a lack of evidence to support single-use CIC, it is unlikely we will return to a period of universal catheter reuse in the foreseeable future. For many patients, the convenience of not needing to clean catheters or worry about having clean catheters available should be respected. Further, many patients refuse to consider catheter reuse as they have been told by medical professionals that it increases the risk of urinary tract infections. In addition, some catheter models (such as those that include a single-use drainage bag) cannot be reused. Given these obstacles, changes to make single-use CIC more environmentally friendly should be strongly considered.

From the rise of reusable grocery bags to the ubiquitous use of biodegradable packing peanuts, our society has successfully made changes over the last few decades based on environmental concern. The current climate of environmental consciousness is ideal for making lasting change to the practice of CIC and could reduce our "catheter footprint." To help achieve this goal, the use of the biodegradable materials in catheter construction should be considered. In fact, a female catheter made entirely from cornstarch already exists (Emteva[28]). However, this specific product is currently only available in Europe after failing in the United States marketplace (potentially due to increased stiffness). Increased use of polyurethane or polyolefins (which are currently available) could be considered, but degradation properties remain unclear, and would require further study before being endorsed for this purpose. An alternative to biodegradable materials would be recycling currently used materials. At present, catheters are treated as hazardous waste and have been excluded from recycling consideration. However, latex, PVC, and silicone are recyclable when used in other products. Hence, the creation of facilities equipped to safely recycle used catheters would immediately begin to reduce the waste burden associated with CIC use.

Our study is limited as we are only able to address the scope of the problem within one country (the United States), though diagnoses associated with CIC are seen worldwide. Additionally, we are using very conservative estimates regarding the use of self-catheterization, as we cannot account for many other groups that are known to use CIC (eg, diabetic cystopathy, bladder outlet obstruction, and underactive bladder, amongst others), as little CIC-related epidemiologic data for these groups exist. As a result, it is likely we are underestimating the true scope of waste generation. Despite these limitations, we have identified the most reliable published data for our populations. Regarding materials and degradation, complete lists of materials used in catheter construction are not publicly available and there are no studies on degradation of actual catheters in either soil or landfill conditions. Finally, it should be noted that, despite evidence suggesting that single-use CIC does not decrease UTI rates, the quality of data is not robust and further studies are needed before any definitive statement can be made. Nonetheless, our study provides a novel look into how a specific health care issue relates to the environment and raises awareness of the problem.

5 | CONCLUSIONS

Single-use CIC in the United States generates between 9.7 million and 85.9 million pounds or 8.2 million to 206 million liters of waste annually. The most common materials used in construction of catheters (latex, PVC, silicone) have poor degradation properties at best. As there is no published study to support the assumption that single-use CIC is associated with a lower risk of UTI compared to catheter reuse, the negative environmental impact of single-use CIC should be considered when deciding self-catheterization policy. Alternatives, such as allowing for catheter reuse, recycling catheters, or using biodegradable materials in catheter construction should be researched and implemented.

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This work has not been published before and is not under consideration for publication elsewhere

CONFLICTS OF INTEREST

No relationships to disclose.

AUTHORS' CONTRIBUTION

All authors contributed to the conception and design, drafting, and revising the manuscript for important intellectual content, and gave final approval for submission.

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