The Journal of Climate Change and Health 4 (2021) 100070

Contents lists available at ScienceDirect

The Journal of Climate Change and Health

journal homepage: www.elsevier.com/joclim

Research article

Improving environmental sustainability in outpatient clinics: Lessons from a waste audit

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ARTICLE INFO

Article History:
Received 11 August 2021
Accepted 6 October 2021
Available online 9 October 2021

Keywords:
Medical waste
Medical audit
Recycling
Waste management
Climate change
Environmental pollution
Physiatry
Pain Management
Physical Medicine and Rehabilitation

ABSTRACT

Background: The healthcare industry is the second leading contributor of waste in the United States. While there are multiple examples of medical waste audits in the literature, few were conducted in outpatient settings. The objective of this study was to utilize a waste audit to identify key waste generators in an outpatient practice and start immediately reducing waste and greenhouse gas emissions.
Materials and methods: This was a cross-sectional, observational study wherein waste from a total of 31 randomly selected encounters from December 2020 through June 2021 in the Physical Medicine & Rehabilitation Sports and Spine clinics of an academic center was collected and weighed, and key waste generators were identified.
Results: The outpatient surgical center produced the most waste per patient encounter (1,758 g), followed by in-clinic procedure visits (379 g per encounter). Clinicians who performed in-clinic procedures using pre-packaged procedure kits produced an estimated 819.5 kg more waste annually than those who selected individual sterile components for their procedures.
Discussion: By identifying and developing interventions that target key waste generators, such as reducing the use of pre-packaged injection kits, we demonstrate how outpatient offices can immediately reduce waste. In doing so, we demonstrate the significant potential environmental savings of such measures.

1. Introduction

Producing greater than 4 billion pounds of waste annually, the healthcare industry is the second leading contributor of waste in the United States (US), behind the food industry [1,2]. Through the manufacturing and shipping of supplies, the fossil fuels required for waste transportation, and the emissions generated by waste incineration and landfills, this waste contributes to the 10% of carbon emissions and 9% of harmful non-greenhouse air pollutants the healthcare industry is responsible for annually in the US [3]. Reducing medical waste will thus be critical to addressing the healthcare sector's contribution to climate change.

One example of a practice-level sustainability measure is the conduction of waste audits. A waste audit is a survey of a facility's waste stream used to determine the amount and types of waste generated [4–6]. Waste audits, which may be conducted once or multiple times at varying intervals to track the effectiveness of interventions or meet regulatory requirements, generally aim to collect, weigh, and categorize all waste produced by a facility during a specified time frame [4–6]. The data from waste audits can be used to improve proper waste segregation and identify key waste generators which can then be targeted for reduction [4–6].

While there are multiple examples of medical waste audits in the literature, few were conducted in outpatient settings. Instead, most audits were conducted in operating rooms (ORs) [7–10] or inpatient settings [11,12]. Outpatient visits per capita increased by more than 25% over the past 20 years, and outpatient offices are now responsible for nearly as many emissions as hospitals [13,14]. Some analysts expect outpatient visits to grow by 20% between 2020 and 2030 [13,15], making ambulatory care the second fastest-growing industry overall behind home healthcare services [16]. As ambulatory services are clearly rapidly increasing, the lack of literature on outpatient waste audits presents both a research gap and an opportunity for more sustainable health practices.

Declaration of interests: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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https://doi.org/10.1016/j.joclim.2021.100070
2667-2782/

Waste audits conducted in inpatient settings have found that medical waste is often missorted [8,12,17]. Medical waste is divided into four types of waste streams: solid waste, regulated medical waste (RMW), pharmaceutical waste, and recyclable waste [18,19]. Solid waste does not undergo treatment prior to being disposed of in the landfill, while RMW is treated or incinerated, which is costly and environmentally taxing. Two-thirds of healthcare-associated waste is solid waste, while around 8% is RMW [20]. Interestingly, studies have found that up to 90% of OR waste is considered to be non-infectious and non-regulated, and almost 60% of anesthesia-generated OR waste and ICU waste could be recycled [10,11,19]. The financial costs of segregated waste disposal vary substantially. Hazardous waste disposal costs 10−20 times more than non-hazardous waste disposal [19]. Recyclable waste generally costs around 4 times less than solid waste to dispose ($0.01/Ib versus $0.04/Ib), and 14 times less than biohazard waste ($0.01/Ib versus $0.28/Ib) [8,21,22]. Improperly sorting waste thus costs money, misallocates resources, and contributes to environmental pollution.

Simple educational campaigns have been shown to improve proper waste segregation. A waste segregation educational campaign and waste audit conducted in the anesthesia workplace of 35 ORs at a tertiary care medical center resulted in a greater than 3.5-fold decrease in regulated medical waste compared to pre-intervention baseline, a 65% increase in correctly segregated regulated waste, and a cost savings of $28,392 annually [8]. Other studies of waste segregation educational campaigns have demonstrated annual cost savings ranging from $823 for small facilities to around $100,000 in larger ones [8,19,21].

Proper waste segregation is only one of several ways to reduce medical waste. Waste can be reduced upstream, before it is produced, or downstream, after it has been produced. Upstream waste reduction strategies include assessing and consolidating the supply chain, reducing materials in pre-packaged kits, using reusable supplies, and changing provider practices to use fewer supplies [23,24]. Downstream waste reduction includes proper waste segregation and recycling [8,24].

The health consequences of medical waste range from the infectious or toxic potential of improperly sorted hazardous waste [25,26] to the health consequences of climate change from the greenhouse gas (GHG) emissions generated by medical waste [26,27]. Both the manufacturing and shipping of medical supplies as well as the transportation of healthcare waste to landfills and incinerators generates carbon dioxide (CO2) [28]. Landfills, where most healthcare waste ends up, produce CO2, methane, and nitrous oxide, all potent GHGs [27]. For example, a 2009 review of the health effects of global waste management found that landfills were responsible for 33% of methane emissions in the European Union in 1994 [27]. Medical waste incineration can release both CO2 and, if not properly performed, heavy metals and hazardous dioxins which can contaminate environmental food and water supplies [25].

Clearly, sustainability practices present a myriad of cost and health benefits. The objective of this study was to utilize a waste audit of the Physical Medicine and Rehabilitation (PM&R) Sports and Spine clinics at an academic medical center to determine the amount of waste produced by visit type and identify key waste generators to target for further waste-reduction interventions. The study had a practical goal of immediately reducing clinic waste and GHG emissions.

2. Materials and methods

This was a cross-sectional observational study utilizing a waste audit to identify and target key waste generators in an outpatient clinic. With institutional support through a quality improvement (QI) platform, a multidisciplinary, inter-specialty “Green Team” was created that included residents, graduate students, faculty, nurses, clinic managers, senior facilities managers, and a waste specialist. Members of the Green Team were selected from a cohort within a structured institutional quality improvement program that had selected improving the environmental sustainability of outpatient clinics (entitled “Greening the Clinics”) as one of several annual QI projects on which to focus. The Green Team met approximately monthly for 30−60 min to discuss progress and strategize next steps, and presented progress quarterly to the larger institutional QI team. The Green Team was based loosely on the My Green Doctor (MGD) model, which is a free, non-profit, online practice management program designed to immediately improve the environmental sustainability of outpatient practices. The MGD model contains meeting-by-meeting guides that incorporate around 10 min of sustainability discussion into regular practice management meetings. These guides present options for easy and immediate changes to improve practice sustainability [29].

After discussion, the PM&R Sports and Spine outpatient clinics were selected to pilot the waste audit. These clinics are staffed by 7 attending-level providers as well as two nurse practitioners and supporting residents. The goal of this audit was to identify key waste generators to target for interventions, and to quantify the environmental impact of waste produced by these clinics.

The waste audit protocol was designed in consultation with a waste specialist with experience conducting healthcare waste audits (see appendix A). Clinic providers and staff were trained by the primary author in the standardized protocol. Specific days were selected for the audit to be conducted based on clinic visit mixture, schedule, and staffing. Patients scheduled during the specified day were randomly selected for inclusion in the audit. Trained providers used labeled collection receptacles to collect all wastes, such as paperwork, gloves, exam table paper, and procedural supplies, after the completion of each clinic visit. Due to logistical difficulties, biohazard waste, sharps, and pharmaceutical waste were excluded. This waste was then weighed using a kitchen scale. In total, waste from a total of 31 randomly selected encounters from December 2020-June 2021 was collected and weighed. Appointments included new patient visits, follow up visits, electromyography (EMG) visits, in-clinic procedures, and outpatient surgical center (OSC) procedures. In-clinic and OSC procedure visits were predominantly ultrasound or fluoroscopically guided peripheral joint injections. Total annual clinic in-person patient volume numbers from the calendar year 2020 were obtained using Edge Reporting, which is a software tool that tracks clinic appointments and can be used to automatically generate a census. These clinic volume numbers were then used to extrapolate the estimated amount of annual waste produced by visit type.

The cost of the procedure kits ($14.15 per kit) was compared to the total cost of typically-used individual procedure components (estimated $1.19 for 4 $\times$ 4 gauze, two 5cc sterile syringes, one 18-gage 1.5-inch needle, and one 25-gage 1.5-inch needle). Items typically used by kit-users (but not included in the kit) that were also used in the individual component set-up (sterile gloves, chlorhexidine swab, spinal needle, and sterile ultrasound cover and gel pack) were not included in the price calculation, as there is no price differential between the two set-up protocols for these items.

Using the data from the waste audit, educational materials including PowerPoint presentations and flyers were created to increase knowledge of the environmental impacts of current clinic practices and to promote sustainable changes. Eleven presentations were given over the academic year at clinic management meetings, faculty and resident meetings, grand rounds, institutional QI meetings, and an annual QI symposium. All presentations were given virtually and lasted 5−20 min in length. Based on feedback from Green Team discussions, interactive elements were incorporated into the presentations, such as using virtual polling software to conduct real-time surveys of the audience’s attitudes towards clinic sustainability interventions.

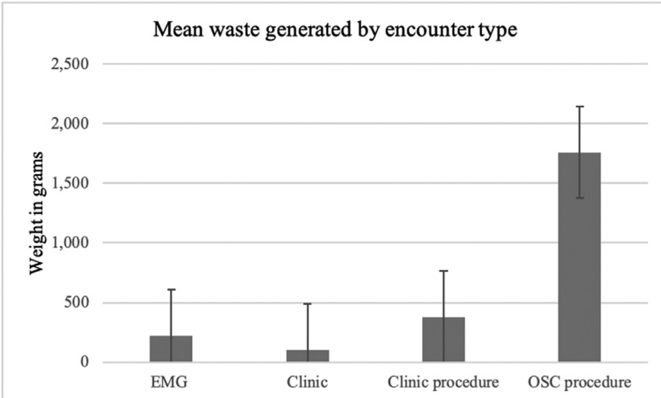

Fig. 1. Mean weight in grams of waste generated by encounter type. EMG= electromyography, OSC= Outpatient surgical center.

3. Results

Waste from a total of 31 patient appointments was collected and weighed. Data are presented as mean ± standard deviation. The mean weight of waste produced by per clinic visit was 101.6 *g* ± 28.33 g, per in-clinic procedure visit was 378.75 *g* ± 168.23 g, and per OSC procedure visit was 1758 g (SD unavailable as all waste was weighed at one time upon the end of the procedure day) (Fig. 1). Upon further analysis, clinicians who performed in-clinic procedures using pre-packaged procedure kits produced a mean of 459 *g* ± 126 g of waste per procedure, compared to 230 *g* ± 134 g per procedure produced by clinicians who selected individual sterile components for their procedures. Six (out of seven) providers in the clinic almost always used procedure kits, while only one provider usually selected individual sterile components for procedures. Thus, this difference in procedural supply selection resulted in an estimated additional 819.5 kg of waste generated annually by the use of procedure kits for in-clinic procedures, which contributes over 1550 kg of CO2 annually [30]. Conservatively assuming that all waste from the kits was sorted into the regular waste stream and not biohazard, the additional cost of waste disposal for kit use is an estimated $680 annually. Moreover, the cost of individual procedure kits ($14.15) is nearly 12 times greater than the cost of individual items (estimated $1.19), leading to an estimated additional annual cost of $67,135 for kit use when including waste disposal costs.

After adjusting for the total annual number of appointments for each visit type, the OSC produced the most estimated annual waste (2723 kg), despite representing by far the smallest number of annual visits (Fig. 2). In-clinic procedure visits produced the second largest estimated total amount of waste annually (1356.3 kg), despite representing far fewer visit numbers than regular clinic visits.

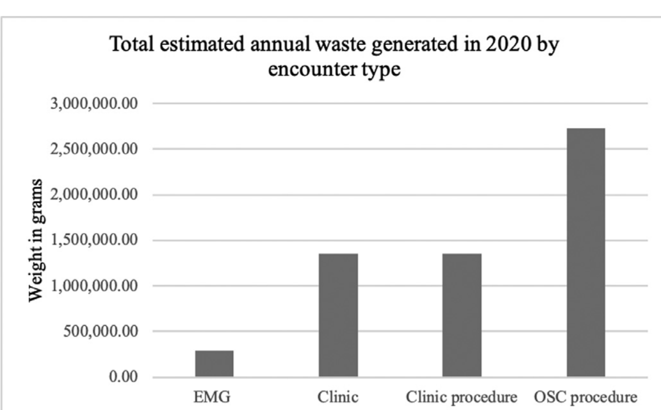

Fig. 2. Total annual estimated weight in grams of waste generated based on patient volume by encounter type. EMG= electromyography, OSC= Outpatient surgical center.

As detailed above, educational presentations were conducted in a variety of settings, with attendees ranging in number from 10 to >60 and including varying numbers of medical students, residents, attendings, nurses and physician extenders, practice and facility managers, medical assistants, and leadership including hospital executives. Live polling of 25 respondents during one educational presentation showed that 76% were interested in engaging in sustainability initiatives, 14% were possibly interested, and only 10% were not interested. Sixty-four percent of respondents ranked their interest in sustainability initiatives as a 4 or 5 on a 5-point scale where 1 indicated no interest and 5 indicated maximum interest (Fig. 3). In addition, the educational campaigns generated commitment from 1 PM&R sports clinician to abort transitioning to procedure kits, and from another to embark on discussions with our supply company to reduce the number of unnecessary items in kits.

4. Discussion

Our study demonstrated how a simple waste audit can highlight practice-specific waste inefficiencies and drive interventions to reduce waste and improve sustainability in the outpatient setting. Differences in supply selection for clinic-based procedures accounted for a nearly two-fold difference in waste produced for the same procedure. Due to reluctance from recycling companies to accept waste that appeared clinical in nature, none of the waste produced by these procedures is currently recycled. Thus, this difference in practice contributes to nearly a ton of additional waste in the landfill and costs in excess of $67,000 annually. The economic and environmental cost of

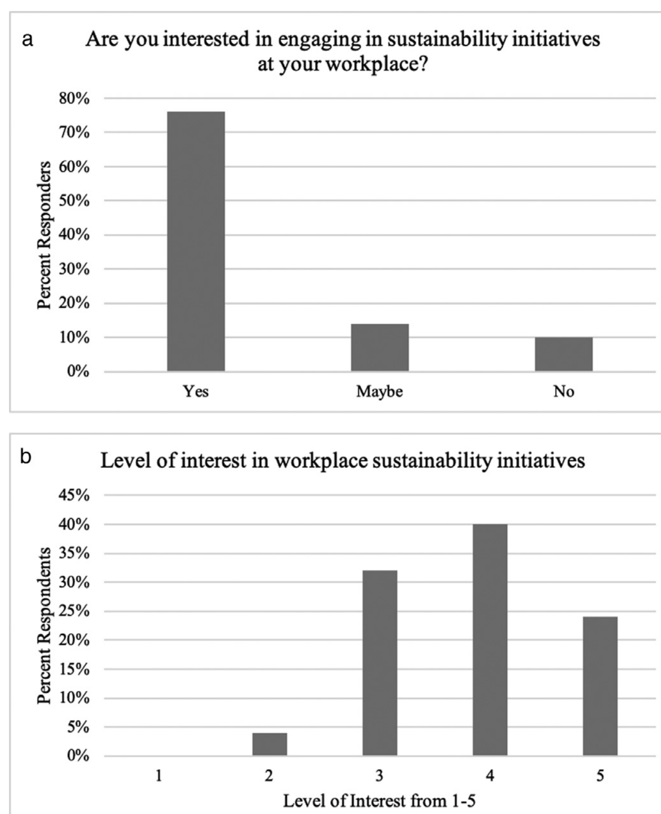

Fig. 3. a. Percent of respondents interested in engaging in workplace sustainability initiatives. **b.** Level of interest in engaging in workplace sustainability initiatives. One indicates no interest and five indicates maximum interest. Polling was conducted among 25 people in real-time using an online polling application during an educational presentation to a group of clinic managers, providers, and supporting staff.

disposal of this extra waste highlights the importance of upstream waste reduction.

This clinic-specific finding also demonstrates how a waste audit can identify and expand upon sustainable practices already in place that otherwise would have been overlooked. This type of waste audit can be easily replicated in other outpatient clinics, which by nature of differences in specialty and practice patterns will likely identify additional waste generators. Understanding these waste generators is the first step in waste reduction.

This study also highlights how once waste generators are identified, interventions targeting these generators can be designed. For example, negotiations are currently underway with recycling providers to implement limited recycling in procedure rooms in order to reduce downstream waste. Recycling requires less energy, decreases the utilization of forests, mined metals and oil, and reduces greenhouse gas by decreasing the amount of waste disposed of in landfills [31]. Educational campaigns, which have previously been shown to be effective in driving behavioral changes in waste segregation studies [12,23], prompted several providers to spontaneously examine their waste generating practices and commit to lowering their waste footprint. Polling during these campaigns revealed the high level of interest in sustainability measures held by staff (Fig. 3), which in turn paves the way for expansion of the project. Next steps include repeating the waste audit once the above measures have been instituted to quantify the effectiveness of these interventions and to expand the project to the entire orthopedics department.

Prior waste audits have emphasized the importance of institutionalizing sustainability measures to prevent effectiveness attrition [8]. Multidisciplinary discussions amongst the Green Team generated several ideas on how to maximize and institutionalize sustainable behavior. Two central themes emerged: 1) make it easy, and 2) provide incentives.

For example, we can draw from the concept of “nudge” theory, in which the best choices are made the easiest by designing environments that trigger automatic cognitive processes [32]. To facilitate the use of individual kit components instead of pre-packaged kits, an assembly line could be set up in clinic procedure rooms where the practitioner can simply grab one item from each bucket. Rarely used items would be confined to the end of the line, thus forcing the practitioner to decide if these items are necessary. To reduce improper use of the biohazard container, it could be made relatively inaccessible compared to recycling and regular trash.

Perhaps the most effective way of institutionalizing sustainability is to incentivize practitioners and employees. Some examples of monetary incentives include returning cost savings from waste reduction measures to staff members or tying bonus or promotion structures to sustainability metrics. Non-monetary incentives include formally recognizing sustainability leaders, centering team bonding activities around sustainability practices, and fostering friendly competition amongst employees to obtain the highest waste reductions.

Limitations of this study include the exclusion of biohazard, sharps, and pharmaceutical waste due to logistical challenges, thus our data are likely an underestimate of the true amount of waste generated by these clinics. In addition, as waste from a sample of encounters was extrapolated to the total annual number of patient visits, the total annual waste data represents an estimate of true waste. As this waste audit was conducted at a large academic institution, both the process and results will be different compared to alternative practice settings. For example, the project had the support of an established institutional QI program, which provided pre-arranged structured feedback and facilitated the formation of multi-disciplinary Green Teams. While this structured support was helpful, the bureaucratic load of such a complex institution made identifying decision makers within the hierarchy of the institution challenging, and made some interventions unrealistic. For example, changes to thermostat or water temperature required the approval of multiple high-level committees. Different practice settings will no doubt face different barriers and levels of support.

In summary, the healthcare industry is the second leading contributor of waste in the US [1]. Outpatient centers, which have lagged in the waste-audit literature, are recommended to also examine their own practices to reduce their contributions to waste and climate change. We demonstrate how outpatient offices can immediately reduce waste and provide suggestions on how to institutionalize sustainability. In doing so, we demonstrate the significant potential cost and environmental savings of such measures.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.joclim.2021.100070.

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