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Don't Waste the Medical Waste: Reducing Improperly Classified Hazardous Waste in a Medical Facility

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Summary

Hospitals in the United States generate over one million tons of waste each year, approximately a quarter of which is classified as hazardous medical waste. There are environmental, infectious, and financial burdens associated with this waste, and those burdens increase significantly when the waste is hazardous. Managing waste can be difficult, but training is an effective approach to reducing waste. We conducted a quality improvement project at the Johns Hopkins Hospital Pathology Core Laboratory from 2015 through 2017. We hypothesized that improved staff training is an effective way to reduce the amount of general waste in a medical facility that is incorrectly classified as hazardous. Two interventions were identified and implemented, the first being a series of classroom-based training sessions and the second being a simple informational poster that was displayed over waste bins. The impact of the training and posters was measured by two surveys that were performed before and after the interventions. The first survey was a web-based instrument that was completed by laboratory staff, while the second survey was observational and measured how many bins contained improperly disposed waste. Some of the data from these interventions supports the hypothesis. The observational survey, in particular, recorded an increase in proper waste disposal from 7.5% to 71.9% following the classroom intervention. Future studies can help determine if these improvements can be increased and sustained over time by assessing the cost and benefit of different interventions and measuring how long the gains from each can be sustained.

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Introduction

Every day, workers in healthcare facilities face decisions about whether an item is hazardous medical waste (HMW) or general waste. A healthcare worker at home does not hesitate when throwing away a used bandage, diaper, or tissue; the same person at work, however, can struggle when deciding whether the bandage, diaper, or tissue is hazardous. Does the decision change if the bandage is from a person with HIV, the diaper is from a baby suffering from a campylobacter infection, or the tissue is from a patient with the flu?

Healthcare waste is an all-encompassing term (1). It does not only include hospitals, labs, and research facilities, but also includes doctors' offices, nursing homes, and home health care (1). Between 75% and 90% of healthcare waste comes from administrative offices, kitchens, and housekeeping services, and is not fundamentally different from general waste that comes from homes or office buildings (1). The remaining waste is considered hazardous, and can fall into several categories, including: sharps (e.g. needles, pipettes), infectious waste (e.g. soiled bandages), pathological waste (e.g. tissue, body parts), pharmaceutical waste (e.g. expired medications), chemical waste (e.g. laboratory reagents, disinfectants), radioactive waste (e.g. unused materials from radiotherapy), and others (1).

The environmental, infectious, and financial scope of HMW is enormous. A 500-bed general hospital located in a U.S. metropolis will generate nearly six tons of waste every day, with more than one-quarter of that being HMW (1). According to the World Health Organization (WHO), intentional reuse of, or accidental punctures from, used needles and syringes that were improperly disposed caused more than 23 million infections of the Hepatitis B virus, Hepatitis C virus, and/or HIV in the year 2000 (2). The disposal cost of HMW can be more than 16 times greater than the cost of general waste (3).

It is difficult to visualize the environmental impact of six tons of waste, the amount that is produced by one hospital in one day; it is significantly more difficult to scale this visualization to a national or annual level. The American Hospital Association lists 5,627 registered hospitals with a total of 902,202 beds, while Becker's Hospital Review says that, on average, 61% of hospital beds are occupied (4, 5). The WHO shows that average waste per bed can range from about 2 to 24 pounds, while Practice Greenhealth, an organization that

Figure 1. Educational poster that was hung near waste bins in the hospital lab as a training intervention. The 18"x24" posters were printed in color and laminated to help ensure they would not be damaged.

grew from a pollution-reduction initiative between the U.S. Environmental Protection Agency (EPA) and the American Hospital Association, estimates 29 pounds of waste per staffed bed (1, 6). If one assumes that every occupied hospital bed generates about 10 pounds of waste, hospitals nationwide produce over 2,750 tons of waste each day, or more than 1,000,000 tons of waste annually, including 250,000 tons of HMW.

The microbiological implications of hospital waste also demonstrate the importance of reduction. The WHO notes that HMW can infect patients, healthcare workers, and the general public, and can spread hazardous microorganisms into the environment (2). People can be exposed to diseases through improperly discarded vaccinations, radioactive waste, chemical waste, blood, or tissue (2). Drinking water can become contaminated by HMW that is not properly managed, particularly in poorly constructed landfills. Additionally, outdated incinerators and those that operate below temperatures of 850 degrees Celsius can release toxic gases and residue into the air, including dioxins, furans, and heavy metals (2).

There are also financial implications to hospital waste. Disposing of HMW is much more expensive than regular waste, yet hospitals commonly treat regular waste as if it was hazardous. Disposing of one ton of general waste typically costs 60-160 dollars, compared to 400-1,000 dollars for a ton of medical waste and up to 4,000 dollars for a ton of radioactive or chemical waste; a ton of recyclable waste, meanwhile, typically only costs about 20 dollars for disposal (3).

If understanding the environmental, infectious, and financial impact of hospital waste is the first step toward improvement, then the second step is identifying specific actions that can help reduce waste. According to Windfeld and Brooks, the most effective way to reduce HMW is to produce less of it, a goal that can be accomplished by teaching healthcare workers the differences between HMW and general waste (7). A multi-year project at the Johns Hopkins Hospital achieved a 57% reduction in its annual production of HMW, an accomplishment that is attributed to staff education and awareness about differentiating between HMW and general waste (8). A comprehensive improvement initiative at a tertiary-care hospital in the Middle East achieved a 58% reduction in incinerated infectious waste by using a plan that included mandatory training for all staff (9). A similar initiative in the US in the early 1990s responded to then-new regulatory changes by achieving a significant reduction in HMW production and its related disposal costs (10). Meanwhile, a Canadian hospital included staff education as part of its waste reduction initiative, and reduced HMW from 18.5% to 7.9% of total waste (11).

Elliott Windfeld, one of the researchers who found that the best way to control waste is to produce less, suggested that an effective approach for this experiment might be to focus on better education of healthcare workers. He noted that workers who are unsure whether or not an item is HMW err on the side of placing it in the infectious bin, and that teaching these employees creates the potential to lower waste disposal costs (12). Ray Jessen, the Comprehensive Waste Stream Manager at Intermountain Healthcare, also suggested that education could be an effective intervention. Jessen discussed initiatives at Intermountain – including in-person education and computer-based training – that aimed to teach employees not to throw items like Starbucks cups or pizza boxes into the HMW bins. Because of these efforts, the health system was able to reduce HMW from about 12% of the total waste stream to about 5-6% (13).

Rushbrook and Zghondi of the WHO also support staff education, and recommend that medical and infection control staff should use flyers and posters with plain language and compelling graphics to teach staff members about proper waste disposal (14). They also state that staff members need to be trained on how to classify waste before they can be held accountable for their performance (14).

We hypothesized that staff training is an effective way to reduce HMW by decreasing how much general waste is incorrectly classified as hazardous. We gathered two sets of baseline data: one from a survey on staff knowledge of waste disposal, and the other from direct observations of waste bins to determine if they contained any improperly classified items. After two training interventions consisting of a brief, didactic course and educational posters hung above waste bins in the laboratory, a second set of survey and observational data was collected to measure the effectiveness of the interventions. The experiment was performed in the Johns Hopkins Hospital Pathology Core Laboratory, as the senior author is an educator in this facility, and because laboratories typically generate a high volume of waste (15). Two of three key measures – staff awareness of educational posters and waste bins containing no improperly disposed items – showed statistically significant improvement and supported the hypothesis, while one key measure was inconclusive due to design flaws in the data collection process.

Results

The experiment began by gathering two sets of baseline data: one from a survey on staff knowledge of waste disposal, and the other from direct observations of waste bins to determine if they contained any improperly classified items. Two training interventions were performed: staff members were asked to attend a brief, didactic course during the workday, and new posters were hung above waste bins in the laboratory **(Figure 1)**. A second set of survey and observational data was collected to measure the effectiveness of the interventions. Two survey questions and the observations were identified as the key measures.

The first key measure was a survey question that asked, "Are there posters reminding you of where to throw away certain items?" Prior to the intervention, there were waste-oriented posters in the lab, but they had been displayed for an indefinite period of time and were not consistently placed over waste bins. The null hypothesis was that the interventions would not increase awareness of educational posters in the lab. On the initial survey, 58.76% of staff members were aware of waste-oriented educational posters in their work area, while on the post-intervention survey, that number increased to 83.7%. A chi-square test for independence was performed to see if the distribution of responses changed between the initial survey and the follow-up survey, and the result was significant with χ^2 = 14.29, p = 0.00079. The follow-up survey showed an increased awareness of educational posters, and only 16% of respondents answered either "no" or "I don't know" to this question after educational interventions (**Figure 2**).

The second key measure was a survey question that asked, "What items do you put in the red bins with black bottoms? Please select all appropriate items below." The question contained a list of potential waste items that a staff member might encounter in the lab, with a single checkbox next to each item that was selected for positive responses. A mix of items from each type of bin was included on the list. Nine items that were highlighted in the didactic training and/or the educational posters were analyzed **(Figure 1)**. The null hypothesis was that staff members' understanding of correct disposal techniques would not increase for these nine items. Both the pre- and post-intervention surveys showed that many staff members were unsure how to handle certain types of waste, particularly specimen bags and used tissues after a bloody nose (**Figure 3**). Note that this facility has separate workflows for disposal of specimen bags, so specimen bags do not belong in the HMW bins. Raw data for post-intervention responses on seven of the nine items showed improvement over initial responses (**Figure 3**). These improvements, however, do not reject the null hypothesis. Due to the survey design, staff members could respond to more than one question, there was no way to differentiate between an unanswered question and a negative response, and there was no composite score for each respondent. These issues limited the ability to accurately analyze the data. Each item was analyzed individually by performing a chi-square test for independence: eight of the nine items did not reject the null hypothesis (in each case, p > 0.20), and one item did not have sufficient responses for analysis.

The third key measure was the observational data. The observations were timed so that the visible contents of 40 waste bins were observed before the didactic

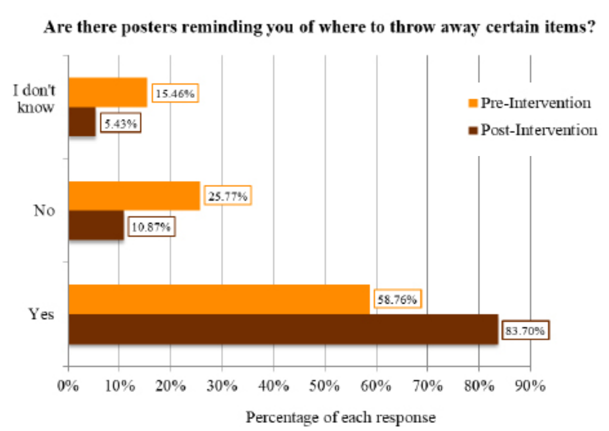

Figure 2. Staff members' self-reported awareness of educational posters, pre- and post-intervention (n = 97 and 92, respectively). A chi-square test for independence was performed. The resulting χ^2 of 14.29 and p-value of 0.00079 suggests that there was a significant increase in awareness of educational posters after the intervention.

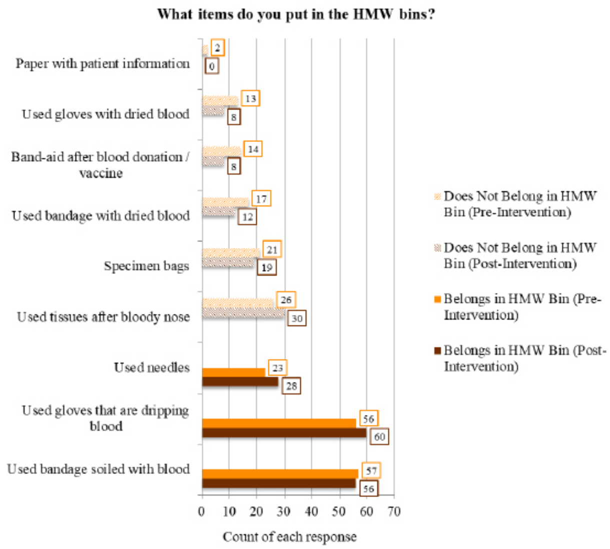

Figure 3. Staff members' identification of items that belong in the HMW bin, pre- and post-intervention (n = 83 pre-intervention, 79 post-intervention). Solid bars and hashed bars indicate items that, respectively, do and do not belong in the HMW bins, while numbers indicate positive responses stating an item is HMW. High numbers next to solid bars and low numbers next to hashed bars indicate better classification of HMW. Limitations in the survey design prohibited thorough statistical analysis. Chi-square tests for independence were performed on eight of the nine individual items, and in each case, the p-value is greater than 0.20.

training and the visible contents of 32 waste bins were observed post-intervention, for a total of 72 observations over 12 non-consecutive days during summer 2016 (**Figure 4**). Before the didactic training, 3 of the 40 observed bins contained no improperly classified waste, for a success rate of 7.5%. After the didactic training, 23 of the 32 observed bins contained no improperly sorted items, for a success rate of 71.9%. A chi-square test for independence was performed to see if a post-intervention decrease in errors occurred, and the result was significant with χ^2= 31.93, p = 1.6E-8.

Discussion

The purpose of this project was to reduce the amount of HMW produced in a medical facility, and the hypothesis was that staff training would be an effective way to achieve the purpose. Some, but not all, of the data supported the hypothesis.

The statistically significant improvement of the third key measure – the observational data – is arguably the most important finding from this study. Almuneef and Memish stressed the importance of measuring the actual behavior of staff, not simply their intellectual knowledge, and noted that audits were a key factor in the project's success (9). Because of the timing of the interventions (discussed later in this section), this is the only measure that can be related entirely to one intervention, the face-to-face training. The observational data from this experiment suggests that staff understood and complied with the instructions that were presented in the face-to-face training. This indicates that didactic staff training is an effective approach to reducing the amount of improperly classified HMW. While didactic training is certainly more time- and resource-intensive than some other educational initiatives, the respective pre- and post-intervention success rates of 7.5% and 71.9% suggest that didactic training should be a part of any waste reduction plan. It is also important to note that staff participation in these training sessions was entirely voluntary (although it was strongly encouraged), whereas many successful interventions in the literature have required mandatory training.

Although the results of the second key measure show promise, the null hypothesis cannot be rejected with the existing data. The survey design and results raise concerns of a type II error, in that the failure to reject the null hypothesis could be a false negative. To resolve this issue, future surveys should still ask about individual items, but should also capture either a positive or negative response for each item (rather than only capturing positive responses) and should generate an overall score for each respondent that can be averaged and compared pre- and post-intervention. The improvement in the observational data suggests that staff members did gain an improved understanding of which items belong in the HMW bins, and supports the possibility that a redesigned survey could lead to the rejection of the null hypothesis. This question warrants additional investigation.

The first key measure asked, "Are there posters reminding you of where to throw away certain items?" and was intended to assess whether staff had grown "blind" to existing posters and signage about waste disposal. The staff's awareness of posters clearly increased after the interventions. This is an important finding that is consistent with Rushbrook and Zghondi's observation that the separation of general waste from HMW is a simple concept that can be easily understood by employees (14). Posters provide an inexpensive, consistent, and asynchronous avenue for training that can accommodate different learning styles and target specific professional levels. The posters in this experiment were created by a high school student with no training in graphic design, yet staff awareness of the posters still increased. Future studies and interventions can build on this success by experimenting with different poster designs, changing posters regularly to see if awareness increases, and targeting different poster content to specific audiences.

The implications of this project are relevant to leaders at virtually any medical facility, whether

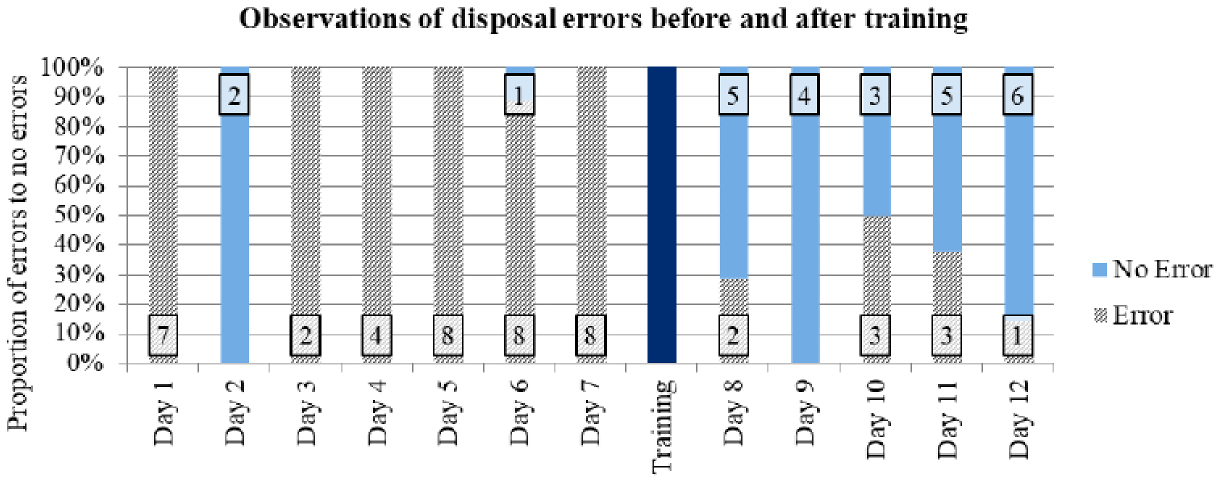

Figure 4. Waste bin observations. Each bin that contained one or more improperly disposed items is represented by a hashed grey "error" column, while each bin that contained no improperly disposed items is represented by a solid blue "no error" column. The dark blue line represents the training intervention. A chi-square test for independence was performed. The resulting χ^2 of 31.93 and p-value of 0.00000016 suggests that there was a significant decrease in improperly disposed HMW after a face-to-face training intervention.

they struggle with waste management or they have successfully implemented waste reduction initiatives and want to make additional improvements. This study suggests that detailed, department-specific education can be effective in reducing waste, which makes the study particularly relevant to organizations where certain departments are struggling with waste reduction, or where hospital-wide initiatives have been inconsistently adopted across departments. The methods used in this study also have implications for medical facilities where waste reduction initiatives have failed: education that is easy to understand and visual can help reduce HMW. Finally, any medical facility that is surveyed by oversight organizations like The Joint Commission or the Center for Medicare and Medicaid Services (CMS) – and particularly those that consistently receive waste-related findings during these surveys – might benefit from the methods used in this study.

One of the most important implications of this experiment, however, is that waste-reduction plans can still be effective even if they are small and inexpensive. The total cost of this project was a few hundred dollars for printing posters, and all of the educational interventions were designed and presented by a student researcher. Our costs did not include time from the student researcher, the mentor, or the staff members, but for organizations with limited cash, the costs of similar interventions are minimal, particularly if volunteers or existing staff coordinate the activities. Given that per-ton disposal costs for general waste can be as little as 60 dollars while HMW can be as much as 1,000 dollars, even small reductions in HMW can have a positive return on investment (3). This project also shows that department-specific interventions can be effective, so organizations with limited resources can use this information to target departments with high volumes of HMW. Not every organization can afford a comprehensive waste reduction strategy, but simple and low-cost interventions can still lead to improvement.

There were some limitations of this project. The sample sizes were small, particularly for the observational data, and were limited by the fact that the student researcher was not a full-time member of the organization. However, the observation process followed recommended healthcare improvement methodologies, which include an allowance for small sample sizes (16). In accordance with hospital policies and infection control practices, the observational data was limited to items that were visible in the waste bin. Additionally, the observations were performed by a single person, so it is possible that bias could exist in the observational data. Limitations of the survey tool became apparent during the baseline data collection, but we opted to continue using the tool so that pre- and post-intervention questions would be consistent. Because the population of laboratory workers (approximately 250 people) was invited to voluntarily take both the pre-intervention and post-intervention surveys, the use of a consistent tool potentially benefitted respondents who participated in both surveys: these workers could have learned about waste management through the actual surveys rather than through the interventions, but given the length of time between surveys, this risk appeared minimal.

One additional limitation that warrants discussion is the timing of major steps in the project. The visual observations of waste bins and the face-to-face training sessions all occurred in July and August 2016, the educational posters were hung in late September, and the post-intervention staff survey was administered in December. The timeline introduces the possibility that the observational improvements could have benefitted from the close proximity of the face-to-face training and the visual observations of waste bins, while the post-intervention staff survey could have suffered from the time gap between the interventions and the survey. Additionally, because the post-intervention staff survey occurred after both the face-to-face training and the educational posters were implemented, the data cannot be stratified to compare the effectiveness of each intervention; this study can only conclude that the combination of classroom training and posters are effective.

Acknowledging these limitations, the findings from the experiment are consistent with the recommendations of Windfeld and Brooks, who found that reducing the production of medical waste was the best way to control its impact, and Rushbrook and Zghondi, who stated that educational materials should use graphics and plain language to teach staff members what to do and how to do it (7, 14).

There are many next steps that can further test the hypothesis and build upon the successes of the study. Almuneef and Memish noted that the results of waste audits need to be shared directly with staff and supervisors in order to maximize improvements (9). Direct feedback was beyond the scope of this experiment, but one possible way to expand and sustain the outcomes could be to give regular reports to staff and supervisors in different areas of the hospital so that they can increase training of staff as necessary. Didactic training appears to be an important component of any waste reduction plan, so future investigations could seek the optimal mix of didactic training, posters, handouts, and hands-on education. Almuneef and Memish relied on lectures and printed handouts, while Intermountain used computer-based training as one way to reach their 33,000 employees (9, 13). An initiative that identifies an optimal mix of educational approaches and provides replicable techniques and materials could have an enormous impact on reducing HMW. Another possible next step would be to examine the impact of small, department-specific interventions as part of a hospital-wide waste-reduction campaign. Waste can vary dramatically on different units of a hospital, so department-specific education could be an opportunity to complement the more general education that comes from large-scale training initiatives.

Methods

This is a multi-year project under the mentorship of the Education and Staff Development Coordinator at the Johns Hopkins Hospital Pathology Core Laboratory. The project began with a literature review that focused on demonstrating the impact of HMW and identifying successful practices in other organizations. Based on this review, training was selected as the focus of the project due to its low cost, ease of implementation, and effectiveness. Iterative improvement cycles were planned, using the Plan-Do-Study-Act (or PDSA) improvement methodology that is embraced by the Institute for Healthcare Improvement and other quality leaders in healthcare (16). The study followed appropriate guidelines from the U.S. Department of Health and Human Services and the Johns Hopkins Medicine Institutional Review Board to ensure there were no activities involving human subjects (see below).

Institutional Review Board Approval

After researching regulatory information from the US Department of Health and Human Services (HHS) and Johns Hopkins Medicine, it was determined that this study would be framed as a quality improvement project rather than a research project. HHS notes that "most quality improvement efforts are not research subject to the HHS protection of human subjects" (18). Additionally, the HHS law that protects human subjects clarifies the differences between quality improvement and research. For example, it states that activities involving human subjects are exempt from research laws if they focus on "comparison among instructional techniques (or) curricula" and if research involving the use of survey procedures does not allow individuals to be identified (19). The Office of Human Subjects Research at Johns Hopkins Medicine determines that when a project helps "an established program in achieving its objectives and the information gained from the evaluation will be used to provide feedback to improve that program, the activity is not human subjects research" (20). The Johns Hopkins Institutional Review Board also offers a flowchart to help determine if an experiment should be classified as research or quality improvement: the description of this project terminated at an endpoint marked "IRB submission not required" (21). Because of this guidance – including the facts that the work was process oriented, no staff or patients were at risk, no patient data was used, and all staff remained anonymous – no Institutional Review Board input or approval was required.

Waste Disposal Survey

Using the Duke University Initiative on Survey Methodology as a guide, a short instrument was designed to quantitatively and qualitatively measure the staff's baseline knowledge of waste disposal (17). A seven-question survey tool was developed using Survey Monkey, and in spring 2016, a link was emailed to approximately 250 staff members and leaders in the lab, 97 of whom completed the anonymous voluntary survey. In late autumn 2016, after the interventions were complete, the tool that was used to gather baseline data was again emailed to approximately 250 workers in the lab, and 92 staff members completed the voluntary post-intervention survey. The pre- and post-intervention data was then analyzed using chi-square tests for independence, due to how the categorical data was gathered during the surveys and observations.

Observational Survey

An observational survey was also developed to quantitatively measure improperly disposed waste. The pre-intervention observational survey involved 40 visual observations of waste bins over seven non-consecutive days in summer 2016, including documentation of what type of waste (if any) was improperly disposed.

Waste Disposal Training Interventions

A 15-minute face-to-face training intervention was prepared and delivered to staff in the lab, with four live presentations as well as a recorded version for asynchronous training. Following the face-to-face didactic training, an additional 32 observations were performed over five non-consecutive days. A subsequent intervention was then prepared, with simple, informational posters being designed and placed over waste bins; the color-coding on the poster corresponded with the color of the different waste bins, with the intent of helping staff reduce the instances of improperly disposed HMW (**Figure 1**).

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