Chapter 2
Before Treatment: Waste Reduction and Recycling

Waste management concerns now confronting the medical waste generator are largely reflective of the general movement toward minimizing the quantity of waste warranting disposal. Effective management of medical waste incorporates a waste reduction and recycling component where appropriate. These activities should be fostered via policy incentives.

This chapter explores the implications of applying a waste prevention and materials management approach (ch. 1) to medical wastes by considering "before treatment" approaches to controlling medical wastes. This exploration includes a discussion of careful on-site planning, and waste reduction and recycling opportunities in health-care facilities.

BEFORE-TREATMENT APPROACHES

Lessons from the management of other waste streams, notably hazardous waste and MSW, indicate that (as noted in ch. 1) a sound control strategy for waste management follows the basic steps of characterizing the waste stream in light of different treatment alternatives, segregating some wastes to facilitate management based on these characteristics, and looking "upstream" to discover any opportunities to reduce the volume and/or toxicity of waste. Achieving this strategy requires some form of planning to garner the necessary information for reduction and management decisions.

The value of *on-site management plans* or strategies appears to be gaining recognition as more medical and health-care facilities grapple with how to respond to increasingly complicated regulations for waste management (94). **Waste audits of some form are becoming more common in hospitals and other medical institutions.** The advantages of these waste audits or more comprehensive plans for a facility include using the information they provide not only to devise a strategy for compliance with environmental requirements, but also to determine the most cost-effective means to meet requirements without compromising the quality of patient care and to identify waste reduction, reuse, and recycling activities as well as other management options that could be adopted.

Every facility must tailor its own strategy based on its characteristics, but several areas should be addressed in any attempt to analyze waste options. First, the **definition and segregation of wastes** should be examined because facility standard operating procedures (SOPs) for waste segregation have a direct impact on type and cost of medical waste treatment. For example, sometimes when a facility designates "surgery waste" as infectious waste *all* waste from that department is managed as infectious waste, some of which could be managed as noninfectious (e.g., paper from the administrative area).

Second, the **types of products and packaging** (e.g., for wastes) used in the facility and their impact on the waste stream can be considered, without compromising infection control goals. For example, woven linens may be substituted for some applications of disposal linens with little risk of increased infection potential; and, based on preliminary data from the New York City Medical Waste Study, considerable reduction in the volume of waste and significant cost savings (see box B) (62, 63, 94). Careful purchasing might help reduce the level of toxic emissions from an incinerator. Finally, the **types of on-site versus off-site disposal options** available to a facility need to be considered from handling and management perspectives and their costs and risks compared.

WASTE REDUCTION

Source reduction, or prevention, of waste is defined by OTA as "activities that reduce the toxicity or quantity of discarded products **before** the products are purchased, used, and discarded" (116).[1] Source reduction can be achieved by: 1) manufacturers considering waste issues in designs of current and planned medical and health-care products and their packaging; and 2) consumers of medical and health-care products (e.g., hospitals) directing their purchasing decisions, product use, and the discarding of products toward waste reduction goals. The two fundamental characteristics of wastes that are the focus of reduction efforts are: **toxicity**, i.e., eliminating or finding benign substitutes for substances that pose risks when they are discarded; and

[1]A basic distinction is made between **prevention** and **management**, the latter occurring **after** waste is generated.

Box B—Disposables: Infection Control and Waste Management Implications

It appears that the use of disposables can be carefully tailored, from an infection control perspective, to those procedures where disposables have the greatest benefit (e.g., isolation situations). Based on a literature search of research to date, OTA found that handwashing is widely considered to be the most important barrier to transmission of infections (119, 53, 59, 61). A clear understanding of modes of infection transmission and the factors that affect it can ensure that the most effective infection control practices are undertaken (53, 59, 98, 105). Measures to control infections include handwashing, the use of sterile disposable items, and other measures (e.g., closed urinary drainage, intravenous catheter care, nontouch dressing techniques, and proper care of respiratory equipment and perioperative chemoprophylaxis) (119, 120, 53).

In some cases, the benefits of isolation (in which typically disposable, nonwoven polypropylene gowns and nonsterile latex gloves are used) have been demonstrated for reducing the incidence of nosocomial bacterial and fungal infection, particularly in cases of prolonged (more than one week) intensive care for a patient (64). Yet, often the sources of infections in hospitals are discovered to be related to misuse of medical equipment and person-to-person transmissions. In one London hospital, the investigation of a number of incidents of cross-infection with an antibiotic resistant infection (*Klebsiella aerogenes*) led to the conclusion that, "While many units practise [sic] almost ritual cleansing of selected equipment, and rely heavily on disposables, there are often circumstances when the misuse of simple ward equipment [in this case, contamination of portable suction apparatus] becomes an accepted routine with inevitable consequences" (37a).

Some infection control measures are proven and standard practices for every hospital, while others are supported by less extensive studies, and some proposed measures are not supported by study data (e.g., floor disinfection). A disposable item may be in any one of these categories regarding its value as an effective infection control measure depending on the particular item and its use. Studies have found, for example, that nonwoven disposable gown and drape fabrics were no better barriers to infection than reusable, woven, cotton gowns and drapes; and, in point of fact, the protective value as well as the transmission potential of gowns, shoe covers, and even masks has been questioned (50, 16, 59).[1] Potential volume reduction of disposable linens and medical apparatus could be considerable, perhaps between 30 to 60 percent depending on the specific health-care facility (63).

With other disposable items, e.g., some catheters and syringes (by diabetics), reuse is not a simple yes-or-no issue. Studies to date indicate that morbidity associated with reuse of cardiac catheters, for example, is low (46, 37, 60). With regard to the reuse of disposable syringes, it appears both safe and practical for diabetics to use disposable syringes and needles for more than one injection (4, 52, 23, 90, 46).[2]

Nonetheless, the practicality of reuse, given liability concerns and standard operating procedures for a particular health-care facility, may preclude reuse of particular medical items at an institutional level.[3] Certain disposable items though are advantageous over reusable items for various reasons including controlling infection, saving labor costs for processing, and minimizing exposure to hazardous chemicals used in chemical sterilization processes. The use (and reuse) of disposables can be considered on an item by item basis, in light of how they will be used, including consideration of infection risks and other factors associated with those risks. Some institutions are beginning to examine the opportunities for use of fewer disposables and other waste reduction options (see below).

---

[1]In any case, one study reports that linen poses a higher infection risk to laundry workers than to patients (21a).

[2]It should be noted that these studies focused on the reuse by the same patient, i.e., a diabetic, using the same syringe. Diabetic patients who used the same plastic disposable syringe (up to 7 days) were not found to develop infection at the site and little or no contamination of the syringes was found (23, 90).

The American Diabetes Association (ADA) in its Position Statement on Insulin Administration states that although manufacturers of disposable syringes recommend that they be used only once, most insulin preparations have bacteriostatic additives to inhibit growth of bacteria commonly found on the skin, and generally "it appears both safe and practical for the syringe to be reused if the patient so desires" (4). The syringes must be discarded when the needle is dull or if it becomes contaminated in some way. The ADA statement also discusses the importance of such practices as good personal hygiene and proper handling of syringes (i.e., procedures to recap a syringe safely) by patients.

[3]The potential for increased liability of a health-care facility using nondisposables v. disposables for different medical applications has been raised. OTA asked only one insurance company about this concern and was told that insurance companies insure for negligence and distinguish between real and perceived risk in such a way that the use of disposables v. nondisposables would not usually matter from a liability perspective. It was also noted that insurance companies do attempt to ensure that proper procedures are followed to help keep risks as low as possible (15).

quantity, i.e., changing the design or use of products to minimize the amount of waste generated when they are discarded.

For waste reduction, reuse, or recycling to occur within a medical facility, a waste audit that emphasizes characterization of the waste stream and development of a plan delineating necessary segregation techniques and education/training of the approach to be taken to the employees of the health-care facility is necessary. Currently, most health-care facilities resist waste segregation because of its perceived inconvenience and the difficulty of ensuring staff compliance. The increased costs associated with new regulatory requirements, however, are creating an economic incentive for greater waste segregation by health-care facilities.

From both volume and toxicity perspectives, the use of plastics in society is a focus of waste management concern. EPA's recent report on plastics in MSW found that plastics production has had an average annual growth of 10 percent for the last 30 years (132). The report also noted that "source reduction and recycling are the best way to reduce potential environmental impacts from plastic wastes" and discusses a number of activities EPA will undertake toward these ends. A higher percentage of plastics is contained in medical wastes than in MSW, approximately 20 percent (by weight) in medical wastes (and perhaps higher)[2] and slightly under 10 percent (by weight) in MSW (114, 116).[3] The medical community is projected to consume 2.4 billion pounds annually by 1994 (13).

As in general public use, plastics are utilized for both products and packaging. While single-use disposal plastic items are often preferable from an infection control perspective, other forces have stimulated the use of these products. For instance, to facilitate pricing patient procedures individually, disposable products are individually wrapped to make bookkeeping easier both internally and for third-party reimbursement. Certain internal practices within health-care institutions reduce waste even if they were not initially developed for this purpose. For instance, inventory programs that keep packaging and corrugated cardboard boxes out of the health-care facility, and often times discourage single-item packaging, can have a positive effect.

Photo credit: R. Guttman

Corrugated cardboard—including that used to specially package regulated medical wastes—can comprise a significant portion of a hospital's waste stream. Some hospitals have purchased balers to facilitate handling and marketing of reclaimed cardboard.

Procedural trays that are prepackaged by distributors reduce individual packaging and put all necessary products for a procedure within a single container.

The type of plastic used and its impact on waste treatment is one example of how waste reduction efforts focused on reducing certain emissions can link pretreatment and treatment management efforts. The higher concentrations of hydrogen chloride (HCl) in emissions, on average, from medical waste incinerators compared with MSW incinerators may be due to the higher levels of polyvinyl chloride (PVC) plastics in medical wastes. Almost all of the chlorine in these wastes is converted to HCl during the combustion process (assuming a high combustion efficiency). In this way, chlorinated plastics may contribute to the high emission rates of HCl and

[2]One recent survey of New York City hospitals found 26 percent of medical waste to be plastics (63).

[3]Yet, given that medical waste is a small percentage of MSW, it is likely that the *total* release of HCl from medical waste incineration is comparably lower (despite the higher concentration). In a local area, however, it could be a significant source of such emissions.

possibly the formation of dioxins (particularly if combustion efficiency is low) (114).

PVC plastics were reported to account for 9.4 percent of the weight of infectious wastes in one study of two Houston hospitals (cited in 139).[4] Concerns over hydrogen chloride generation through on-site incineration, as well as off-site, have begun to put pressure on the producers of plastic medical products to switch from polyvinyl chloride plastic to one that does not carry the same type of environmental concerns, such as polyethylene (51, 43). Unfortunately, because of certain physical characteristics, the PVC plastic is more desirable in certain products. Increased efforts to find alternate materials for products such as intravenous tubing should be encouraged. For other products, such as slide holders, trays, and garbage bags, manufacturers may be able to easily substitute materials (139, 43).

Sometimes there can be a direct tradeoff between the potential environmental harm caused by one management practice versus another. **For example, the issue of whether using disposable or reusable items is "better" can be difficult to determine. It will depend on which particular goal (e.g., infection control, convenience/labor savings, cost savings, safe waste management) is deemed most important regarding the product's use.** One example of where such a determination has to be made regards the use of products and equipment generating chlorofluorocarbon (CFC) emissions, which are used by the medical and health-care industry to sterilize reusable items for patient procedures.

The medical and health-care industry is responsible for less than 4 percent of the total amount of CFCs released to the atmosphere. Given the concerns over the association of CFCs with ozone depletion and possible global warming effects, the American Hospital Association has recommended that hospitals reduce consumption of all CFC-based products and chemicals used for sterilization purposes.[5] This reduction can be achieved through the use of disposables, but any significant growth in the use of plastics containing CFCs might negate overall CFC reduction. It may be that other solutions would avoid greater contributions to the medical and solid waste streams, e.g., the greater use of steam sterilization or other substitutions for CFC-dependent sterilization systems, or use of non-CFC, recyclable plastics (76, 129).

The increased use of disposables in health-care settings is widely acknowledged, if not well documented. Battelle recently has undertaken a project, Medpak, to study the consumption, use, and disposal of medical products and packaging by health-care facilities in order to assist health-care product companies to develop products, packages, and process concepts that would reduce the volume and cost of managing medical wastes by hospitals and other medical facilities (13).

The growth in the use of disposables in health-care settings is attributable to a number of converging factors in recent decades. These include:

1. increased concern over infection control;
2. decreased available nursing staff (and a need to provide more expedient treatment and more convenient clinical practices);
3. increased cost of health-care labor (and concern over the time needed to handle and sterilize reusable items); and
4. consideration of disposables as part of the general solid waste stream of the health-care facility (with, in the past, resultant low cost for handling and disposal) (94, 17).

One widely held presumption is that the use of disposables is important from the perspective of infection control. Nosocomial (hospital-acquired) infections are a serious concern in U.S. hospitals, with 2 to 15 percent of all in-patients acquiring them and millions of dollars spent to control them (37).

Yet, infection control studies do not indicate a constant and consistent reduction in nosocomial infections where disposables replace reusable products. Other factors also come into play (see box B). Competing concerns over the cost, and more recently the waste implications, of using large quantities of disposables in health-care facilities are now being raised, particularly for products that do not have a direct effect on infection control and patient care (e.g., disposable telephones).

[4]Types of plastics in products ordered by hospitals include: polyvinyl chloride, polyethylene, polypropylene, polystyrene, and polyurethane (139).

[5]Health risks to employees processing equipment via ethylene oxide sterilization also prompted concerns. Often equipment sterilized by this means, however, cannot be steam sterilized because damage to the equipment would result.

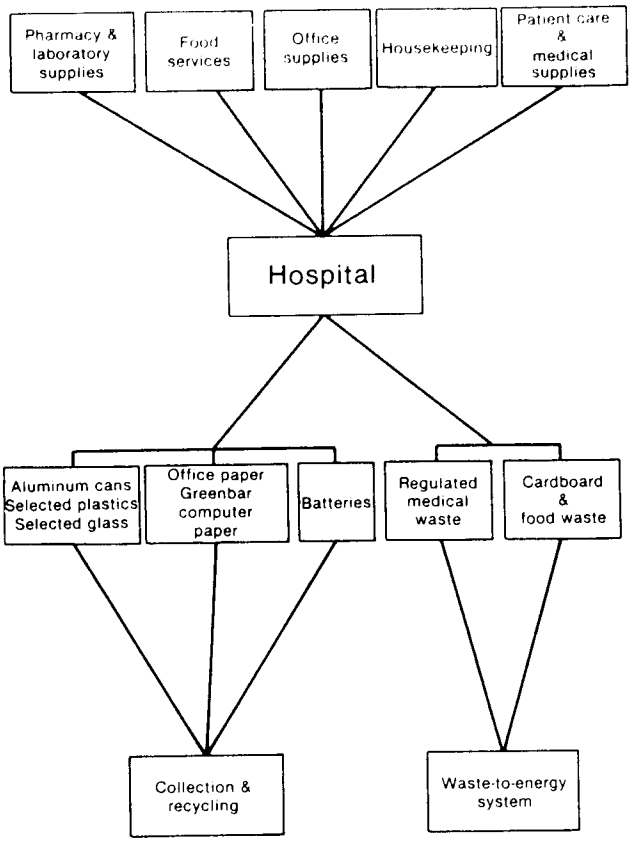
RECYCLING AND SOURCE SEPARATION PRACTICES

In addition to reduction efforts, source separation practices (i.e., segregation of materials as they are discarded based on their characteristics) that target particular materials/wastes for recycling and the most appropriate treatment method can lead to more environmentally sound medical waste management. Source separation before incineration or any other type of treatment has been shown to improve the operation of MSW incinerators, and the same may be true for medical waste treatment as well (116). Most health-care facilities segregate infectious and noninfectious waste streams, but separation of other items for recycling may also facilitate management efforts. Yet, any recycling efforts must also consider and address the potential of increased exposure to wastes to health-care workers and waste handlers from such management efforts.

A number of hospitals are adopting recycling programs as part of their waste management programs, although in the past little recycling has occurred by hospitals. A recent reported survey sponsored by the Greater Boston Chamber of Commerce found that hospitals were discarding tons of waste that could be reused or sold and were paying more than other businesses to dispose of noninfectious, commercial solid waste. Hospitals in this metropolitan area, including Massachusetts General Hospital and Beverly Hospital, however, have begun paper recycling programs (9).

Some health-care facilities are planning and developing comprehensive waste management programs, of which recycling is an integral part. For example, Bayfront Medical Center (a 518-bed acute-care community hospital) in St. Petersburg, Florida, has proposed a recycle-and-reclaim project in conjunction with its proposed waste-to-energy system (see figure 1). This system represents a comprehensive waste strategy designed to recycle materials as possible, effectively render infectious medical waste noninfectious, reduce the amount of waste going to a landfill, generate energy to power the hospital's laundry, and reduce some of the risks and costs associated with waste management (14).

Figure 1—Schematic of One Hospital's Proposed Segregation Categories and Comprehensive Medical Waste Management Approach



SOURCE: Bayfront Medical Center, St. Petersburg, FL.

Cardboard, food, and other general wastes can comprise as much as 85 to 90 percent of a hospital's waste stream, with pathological and infectious wastes comprising the rest (29, 12).[6] Some hospitals are beginning to focus on the nonpatient sources of wastes in their facility and target materials for recycling. For example, corrugated cardboard, computer paper, cans and bottles, and other items (which can contribute metals, particulates, and volatiles to flue gas emissions from incinerators) can be segregated for recycling. Batteries and other noncombustible items that can contribute air emissions of cadmium and lead from incinerators, or if state-of-the-art air pollution control equipment is in place can affect the ash, can also be segregated for more appropriate management efforts.

A Department of Energy study of three MSW incinerators found that presorting not only reduced uncontrolled emissions significantly, but also led to

[6]This estimate is based on hospital survey information reported by Cross (30), see also Cross data cited in (12).

better ash burnout and thereby cut ash volume by half and reduced its toxicity as well. Boiler efficiencies and increased disposal capacities also resulted (heat value increased by 25 percent with presorting) (109).[7]

The New York City Health & Hospitals Corp., as part of the regional planning effort for medical waste (see ch. 4), has undertaken waste audits of area health-care facilities; when the results are compiled they will set a target goal for reduction and recycling efforts. These types of activities may become more typically associated with efforts to establish treatment facilities.[8] It appears that the emphasis will be on recycling cardboard and other nonpatient wastes in these New York hospitals (71, 67). Recycling of corrugated and high-grade papers may achieve up to 20 percent waste reduction (62, 63). Yet, some items in the entrained regulated medical waste stream may become targets for reduction and recycling efforts as well. For example, based on the preliminary evaluation of the waste audits, disposable linens were a major component of this waste category (62, 63).[9]

An interesting finding is that the red bags and the shipping boxes themselves comprise the largest single component of the regulated waste stream (perhaps as much as 16 percent) (62, 63). Alternative forms of packaging that will reduce the volume and weight of the waste stream, as well as potentially some toxic components, may be considered provided they will ensure safe and adequate handling. For example, some reusable, versus disposable, sharp containers are available (62, 63).

The preliminary results of the New York City medical waste study indicate that the amount of regulated medical waste escaping the MWTA system may be as high as the amount actually captured by it. Further, the amount of nonregulated medical waste entrained in the regulated waste stream may be about 50 percent of the total captured medical waste (63). Importantly, weight, volume, and cost reductions are predicted to be achievable through better segregation, management, and accounting practices at the department levels of hospitals (51). Education is important to achieve the cooperation necessary to ensure successful changes in such practices.

Improved waste segregation can reduce the amount of regulated medical waste requiring disposal by 30 percent (43). Enlightened management practices can also dramatically affect the volume of waste requiring treatment—and influence the cost associated with managing that waste. For example, the true cost to dispose of medical wastes from different departments can be included in costs charged on a patient basis and become reimbursable under Medicare (see ch. 6). Other management controls that can improve options for waste reduction and recycling include internal controls over unused products and materials, bulk purchasing, and adoption where feasible of reusable products (e.g., food service items) (62, 63).

Beth Israel Hospital (a 1,000-bed major metropolitan hospital) in New York City is one of the first hospitals in that area to recently institute a recycling program.[10] The initial program involved recycling corrugated cardboard and office paper (including computer printouts and computer tab cards). The program will be extended to include newspapers, magazines, bottles, and cans. The hospital expects to recover approximately 13 tons of computer printout paper and computer cards and 300 tons of corrugated cardboard per year (28).[11]

Beth Israel purchased a baler to improve the ability to market the corrugated cardboard. It was expected to quickly pay for itself, given the anticipated savings in waste disposal costs of over $100,000 a year (based on avoided disposal costs) (28). Colorful collection folders given to workers for their desks, collection bins placed near photocopying machines and related work stations, and posters and flyers explaining the goals and logistics of the recycling program are all part of the educational and

[7]Medical waste incinerators burn a higher Btu value waste than municipal solid waste incinerators (10,000 Btu v. 5,000 Btu). Medical waste itself has been presorted and does not contain the material that one sees in solid waste that lowers Btu value, increases toxicity, etc. (43). Again, the importance of good segregation practices is underscored.

[8]Efforts such as these could significantly reduce the volume of the area's waste stream and will need to be taken into consideration when sizing an incinerator (or alternative treatment method) for the region.

[9]OSHA indicates that its proposed standard prohibits the use of reusable sharps containers, but it may amend this provision if comments on the proposal and evidence indicate that no added occupational hazard is associated with the use of reusable containers (55).

[10]Other hospitals in the New York City area also have adopted recycling programs. These include Lenox Hill Hospital, Lutheran Medical Center, Metropolitan Hospital Center, and Doctors' Hospital (28).

[11]The participating areas of the Hospital are: management information center, materials management, supply room for pathology, receiving for pathology, central supplies, pharmacy, housekeeping, storeroom

Photo credit: R. Guttman

Increasingly hospitals are adopting recycling programs to help reduce the volume of waste requiring disposal.

publicity efforts associated with the Beth Israel Recycling Program (67).

The Iroquois Healthcare Consortium, located in northeastern New York, has implemented an aggressive effort to educate its 56 member facilities and assist them in developing and implementing comprehensive recycling programs. The region's success stories include the Albany Medical Center, which currently recycles over 350,000 pounds of cardboard, paper, glass, aluminum cans, and plastic annually. The region has also developed successful programs working closely with local government. In Otsego County, New York, the A.O. Fox Hospital and Mary Imogene Bassett Hospital are two community hospitals that have worked closely with county officials to develop and implement an effective program now being used as a model in the development of the region's recycling program (94).

In several areas of the country, commercial wastes from institutions such as health-care facilities are included in community recycling programs. In these situations, the special nature of the medical waste stream should be taken into account by local planners (e.g., the lower percentage of paper content in hospital wastes than in wastes from some other commercial facilities). Again, health-care facilities will need to ensure proper worker education and training, necessary so that separation practices for recycling will not pose increased hazards to workers.

Recycling efforts by hospitals have been inhibited in some cases by the lack of available markets and in some cases by discrimination against discarded medical materials. For example, in New York State glass intravenous (IV) bottles are not a category of regulated medical wastes, but hospitals report they are unable to successfully market the glass for recycling because it is perceived to be infectious/medical waste (94).

This underscores the need for greater education efforts and better understanding of the nature and actual public health risks posed by the various components of the medical waste stream. In part to address this need, the Iroquois Healthcare Consortium held a meeting sponsored by hospitals at the Albany Medical Center in June 1990 to discuss opportunities and existing programs for recycling certain materials from the medical waste stream (94).

Obviously, some items (e.g., most sharps) in health-care settings are not likely candidates for recycling or reuse, but a surprising volume of materials in health-care settings have reduction, recycling, and reuse potential. For example, a new company (a joint venture of Standard Textile Co. and Marriott Food & Service Management) was recently announced that will offer hospitals recyclable, protective, sterile surgical linen packs. The company claims the specially designed barrier fabric products (e.g., surgical drapes and gowns) will be highly protective and safely recycled at a cost lower than disposables (69).

The importance of product *packaging* on the total waste stream can also be significant and a focus of waste reduction efforts. Health-care facilities can hold medical product manufacturers accountable for reductions in packaging and for constructing products that use recycled materials and/or that are reusable or recyclable (65).

Some organizations encourage the recovery of medical items that would otherwise be discarded. For example, sometimes more than one disposable kit is opened in order to use just a part of it for a procedure, or items are opened and then not used. Rather than being discarded, sometimes these items are stored, resterilized (if necessary), and then sent overseas for use there. Outmoded medical equipment that can still be used in other countries is also sometimes sent (139, 84). (It should be noted that no governmental guidelines exist currently to ensure the safety of these practices.)

An organization in Texas, the Medical Benevolence Foundation Presbyterian Medical Mission Fund, is one such organization that collects equipment from medical facilities in the United States to send to developing countries where it will be used (139). A network of surgical nurses supporting this type of "recycling" is being organized in Oakland, California (84). The group, called RACORSE Network (Recycling, Allocation, and Conservation of Operating Room Supplies & Equipment), hopes to facilitate efforts to direct needed medical supplies overseas that would otherwise be discarded here.[12]

[12]Legal implications of this activity and its safety are being reviewed by the group. The goal of RACORSE is to help make the practice safer by establishing recommended protocols (84).