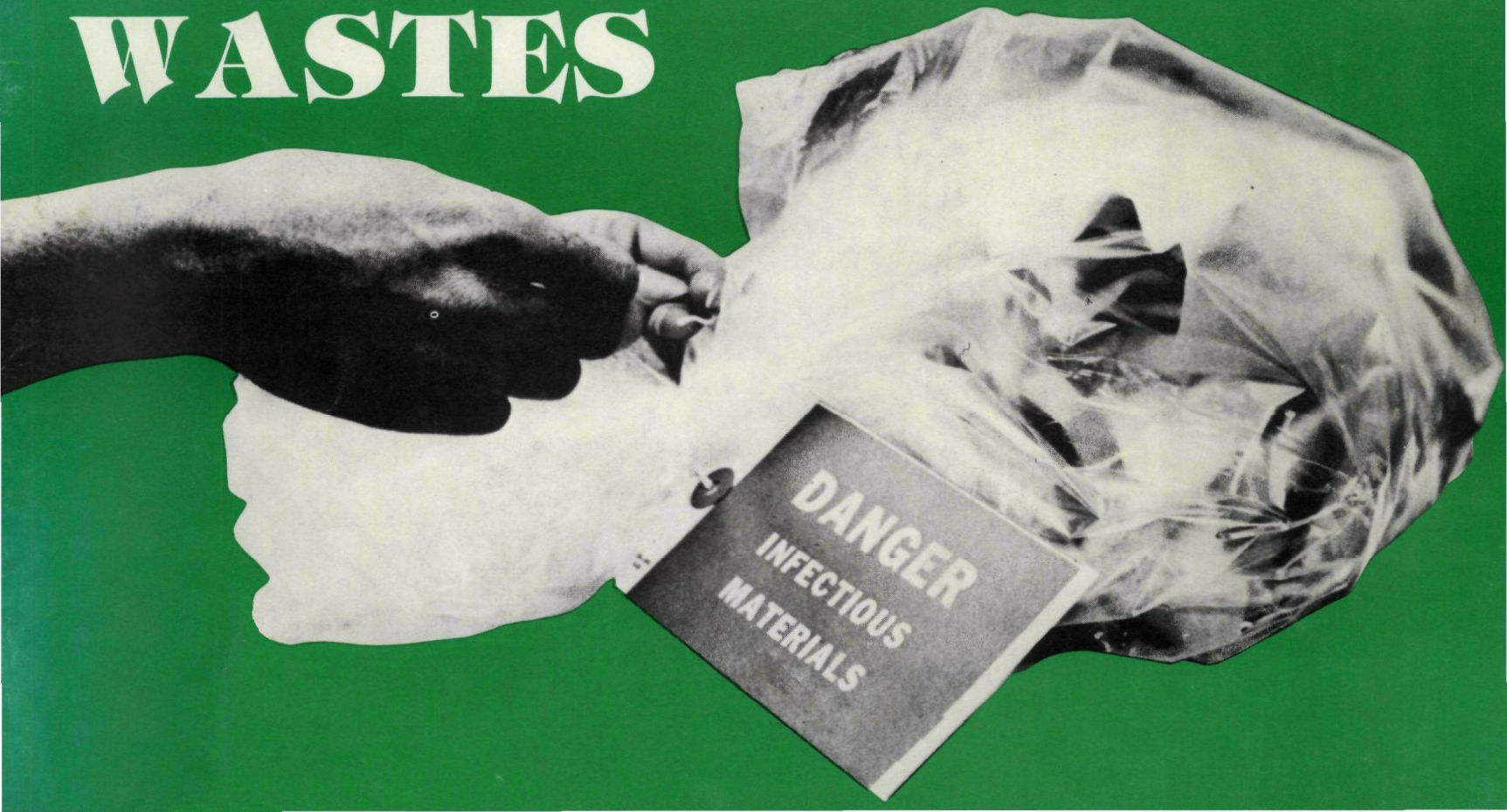
HOSPITAL WASTES



COVER PHOTOGRAPH, showing one of the many special waste handling practices necessary in hospitals, is courtesy of the American Hospital Association.

This summary report (SW-129) is based on studies made by the University of Minnesota under grant no. EC-00261, by the University of West Virginia under grant no. EC-00265, and by the County of Los Angeles under grant no. EC-00164. It was written for the Federal solid waste management program
by IRENE KIEFER

U.S. ENVIRONMENTAL
PROTECTION AGENCY
1974

An environmental protection publication (SW-129) in the solid waste management series.

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

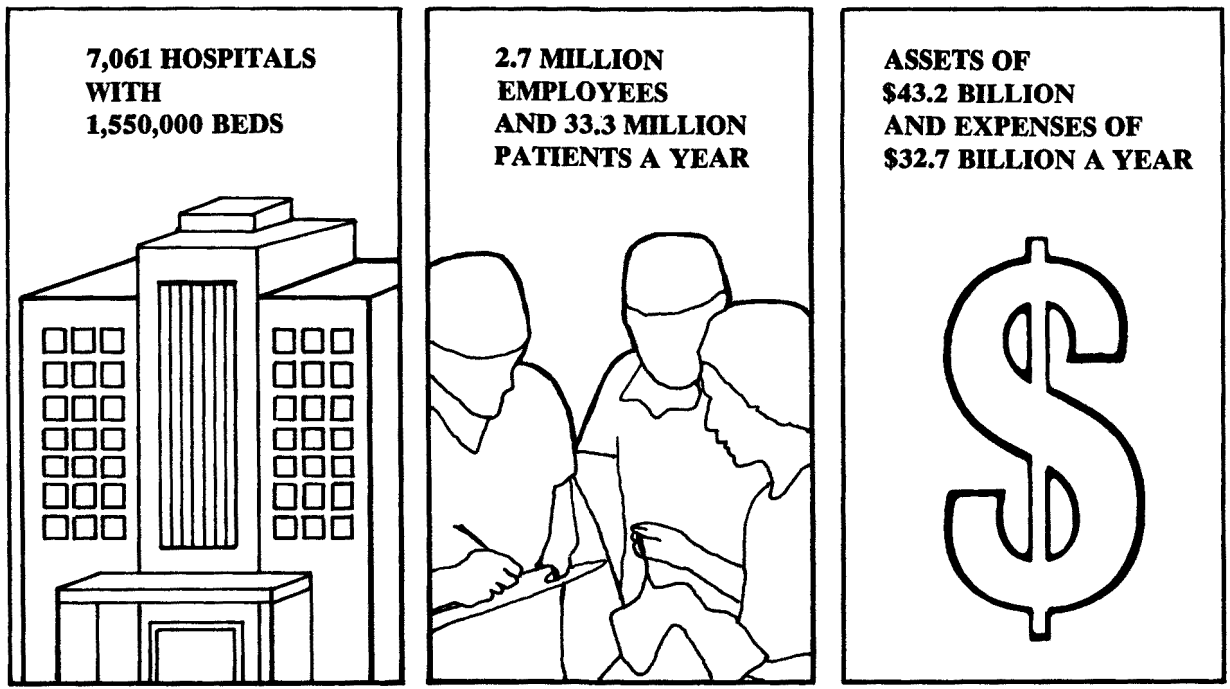
HOSPITAL WASTES

Phenomenal progress has been made in methods and equipment for the care of hospital patients. Hundreds of single-service items have been marketed to reduce the possibility of hospital-acquired infections. Yet hospitals generally have been slow to improve their techniques for handling and disposing of waste materials, which are increasing in quantity as a result of more patients and higher per-patient waste loads. Present disposal systems tend to be costly, outdated, and poorly designed and operated; they require large staffs and repeated handling of wastes.

What the effect has been on health and safety has not been measured, but without proper management, wastes containing contaminated materials, dangerous chemicals, or discarded needles are a potential hazard to millions of patients, employees, and visitors. Furthermore, the health of the entire community can be jeopardized if wastes are temporarily but inadequately stored outside the hospital, hauled through the streets without proper precautions, or thrown onto open dumps.

The potential hazards of hospital wastes, their growing volume and changing characteristics, and the generally in-

american hospitals are big business



Source: American Hospital Association, 1972 figures.

sanitary and expensive methods now used to handle them call for action from hospital designers and administrators, government agencies, and the community at large. Included in the body of information that can help guide that action are studies funded by the U.S. Environmental Protection Agency (EPA) and conducted by the University of Minnesota, West Virginia University, and the County of Los Angeles.

EPA studies

The University of Minnesota's School of Public Health surveyed 80 hospitals in 37 States to gather information on the kinds and amounts of wastes hospitals discard and how the wastes are handled and disposed of. Conducted from 1966 to 1970 by Albert F. Iglar and Richard G. Bond, the study covered nongovernmental, nonprofit general hospitals, which account for a large percentage of U.S. hospital admissions. The smallest hospital had 50 beds, the largest 1,226. Over 40 percent of the hospitals were originally constructed more than 50 years ago. However, 54 percent had undergone major alteration or expansion since 1965. Funding for the study came from EPA's Office of Solid Waste Management Programs.

The County of Los Angeles study, conducted by Esco-Greenleaf (a joint venture of Engineering Service Corporation, Los Angeles, and Greenleaf/Telesca, Engineers and Architects, Miami), focused on improved solid waste techniques adaptable to hospitals and other types of multistory buildings. This study covered only

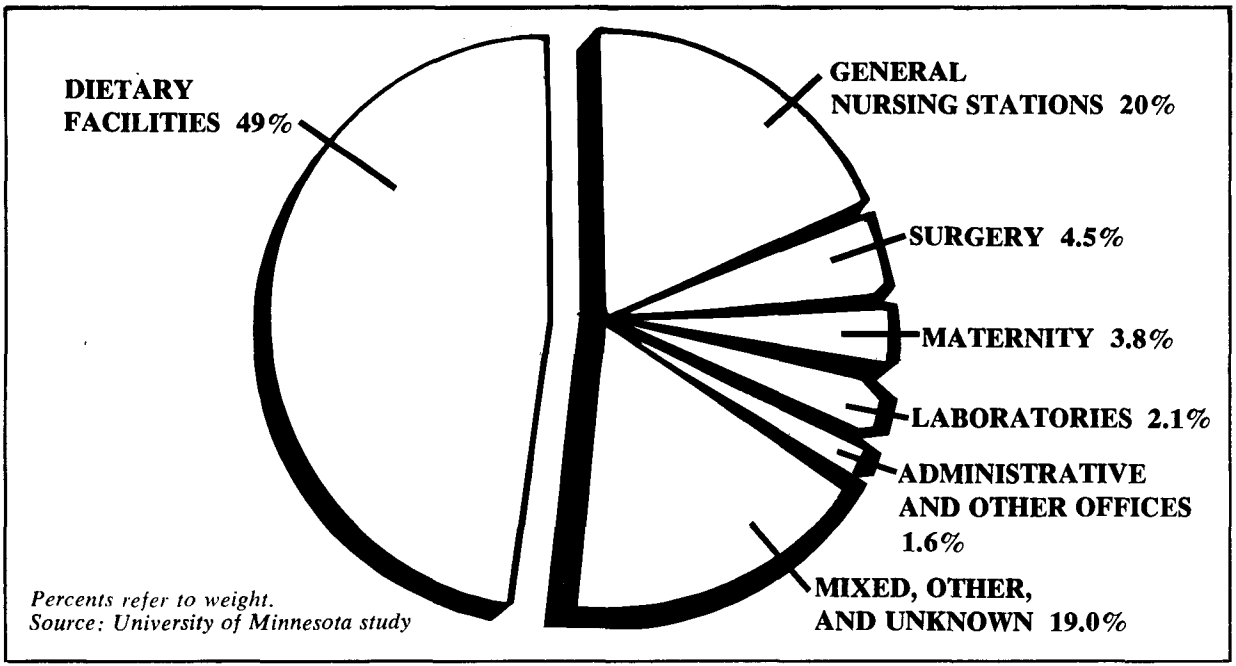
seven hospitals, but it covered them in more detail than was possible in the 1-day visits made in the University of Minnesota study. The seven Los Angeles hospitals ranged in size from the 2,300-bed Los Angeles County-University of Southern California Medical Center, one of the largest teaching hospitals in the country, to the 232-bed hospital of the Mira Loma Rehabilitation and Detention Facility. The Mira Loma Hospital specializes in providing medical care for tuberculosis patients but also offers generalized hospital care to nearby communities. Funds for the 1968–69 Los Angeles study were provided by the Office of Solid Waste Management Programs.

The 3-year study of the West Virginia University Medical Center, a 438-bed teaching hospital and research institution, examined in detail the kinds and amounts of wastes discarded. The study was conducted from 1968 to 1971 by Jerry C. Burchinal of West Virginia University with funds provided by EPA's Office of Research and Development.

waste sources & kinds

The sources of solid wastes in hospitals are many—nursing floors and stations; dietary facilities; laboratory, X-ray, and surgical departments; pharmacy; emergency room, offices, and service areas. In the hospitals surveyed by the University of Minnesota, dietary facilities account for about 50 percent of the total wastes, followed by general nursing stations with 20 percent; surgery and maternity, about 4 percent each; and offices and laboratories,

dietary facilities account for half of hospital wastes



Percents refer to weight.
Source: University of Minnesota study

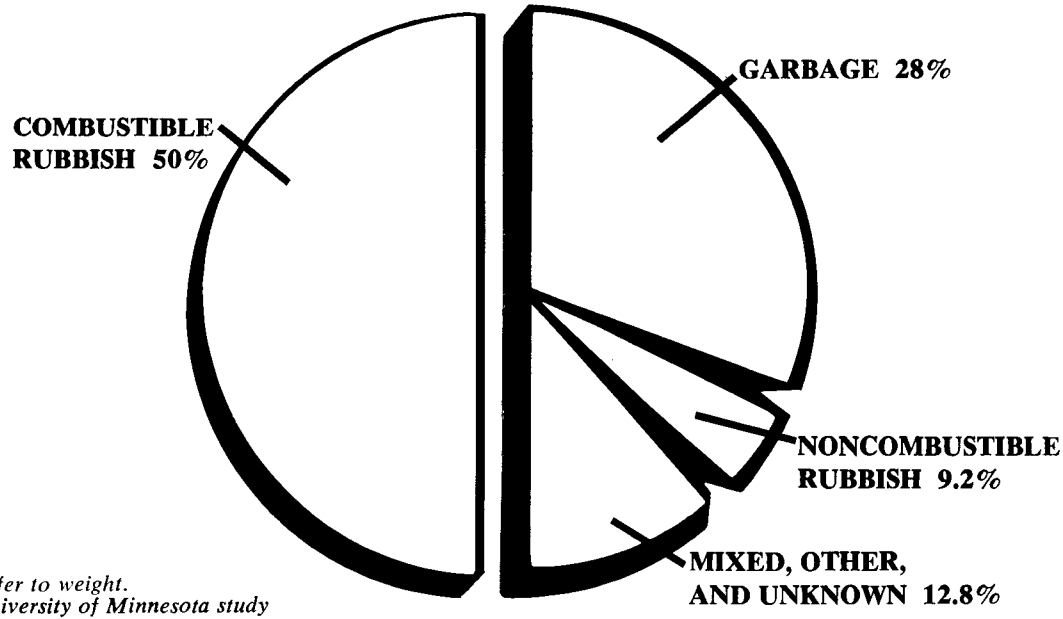
2 percent each. These figures generally agree with those for the West Virginia University Medical Center hospital, although the dietary facilities there account for only 40 percent of the wastes.

The composition of the wastes is typical of wastes produced by the community in general. Combustible rubbish accounts for about 50 percent of the total weight of wastes in the hospitals surveyed. Garbage (including estimates of the weight of food waste discharged via garbage grinders) accounts for approximately 28 percent, followed by noncombustible rubbish at about 9 percent.

At most hospitals, combustible rubbish is probably associated with at least small amounts of microbiological and chemical contamination. Food wastes, on the other hand, are not necessarily contaminated, although they can putrefy and attract insects and rodents. Both combustible rubbish and garbage can be handled easily by municipal-type disposal facilities.

Some hospital wastes result directly from diagnosing and treating patients. Although they constitute quite small fractions of the total, such wastes are frequently hazardous and require separate handling and treatment. Hazardous wastes include biological, radioactive, and chemical wastes, plus sharp items such as disposable needles. Hospital staffs try to keep hazardous wastes separate from other wastes, but these attempts often fail. Therefore, with few exceptions (for example, administration office wastes, which are physically separated from patients), all hospital wastes must be considered potentially contaminated. People with access to most areas of the hospital—in-

half of hospital waste is combustible



Percents refer to weight.
Source: University of Minnesota study

cluding patients, doctors, nurses, technicians, orderlies, aides, maids, janitors, laundry workers, volunteers, and visitors —may come in contact with these wastes.

Special bacteriological and virological studies were made in the West Virginia study. Results indicate that pathogenic organisms may be present in hospital solid waste in significantly high concentrations. Bacillus organisms made up 80 to 90 percent of all microbes observed, with staphylococci and streptococci each composing between 5 and 10 percent of the population. *Staphylococcus aureus* was by far the most common pathogen detected.

The number of airborne bacteria increases during handling of the solid wastes. Proper handling, including placing the wastes in bags, can markedly reduce the total number of airborne bacteria. The possibility exists that viable organisms may be transmitted to other parts of the hospital by way of the chutes or open carts. Virus-survival studies indicate that almost all materials found in hospital solid wastes can become vehicles for transmission of viruses.

amounts of wastes

The amounts of wastes generated by American hospitals vary widely, depending on their facilities and the kind of service they provide. In 1950, 7 pounds per patient per day was a commonly quoted figure; by 1970, the figure had risen to about 10 pounds per patient per day. The increases have been due in large measure to increasing popularity of single-use items, single-patient items, unit-dose and

unit-serving packages, and similar products. These "disposable" items are seen as a measure to minimize risk of the spread of infection, but their increasing use is an important cause of the increase in hospital operating costs in recent years. According to a National Sanitation Foundation conference on single-use items, the need for economy is being subordinated to such factors as increasing affluence and growing difficulty in staffing hospitals, as well as demands for safety, comfort, and convenience. The result can be higher hospital costs and grossly overloaded waste handling facilities.

The wastes generated in the 80 general hospitals surveyed by the University of Minnesota ranged from 4.7 to 16.2 pounds per patient per day. The mean figure is 8.7 pounds. The volumes generated range from 1.0 to 4.0 cubic feet per patient per day, with the mean being 2 cubic feet. While both weight and volume are primarily related to bed capacity, they are also significantly related to a number of other factors:

Community Characteristics. Hospitals in larger communities and those in Standard Metropolitan Statistical Areas tend to generate more wastes.

Presence of Specialized Facilities and Services. Pathology laboratories, cobalt therapy, radioisotope utilization, laboratory research, a hospital-controlled school of nursing, and a psychiatric inpatient clinic —all tend to increase wastes per patient per day.

Utilization of Hospital. Patient census on the day of the survey, as well as the number of surgical procedures, outpatient visits, and live births affect waste generation.

Employees and Trainees. The larger the staffs, the more waste is generated per patient per day, especially if housing is provided.

State License, and Accreditation by the Joint Commission on Accreditation of Hospitals. Both tend to correlate with increasing quantities of wastes.

The Minnesota study team developed an equation that includes the most important of these variables for use in estimating solid waste poundages for specified conditions. This equation provides better estimates of solid wastes per patient per day than is possible using bed capacity or patient census alone.

The quantities of wastes discarded by the seven Los Angeles hospitals are distributed in an even wider range than the hospitals in the Minnesota study. The Los

Angeles County-University of Southern California (LAC-USC) Medical Center discards 11.6 pounds per day per patient, and another hospital affiliated with a medical school discards 16.7. At the lower end is the Mira Loma Hospital (5.1) and a geriatrics center (3.6). The latter type of patient care requires limited bed space, supplies, staff, and support personnel, as opposed to the Medical Center, which provides a comprehensive range of medical care for all age groups.

This extremely wide range of waste generation indicates the unreliability of the traditional pounds-per-patient-per-day-figure for designing solid waste systems. A figure is needed that allows estimating waste generation rates for hospitals of different sizes and different types of medical care. Such a figure may be the "equivalent population"—that is, the average population present for each 8-hour shift over 24 hours a day and 7 days a week, counting outpatients at one-half value. The range of the seven Los Angeles hospitals reduces to 2.08–5.57 pounds per capita per day on this basis. The wastes generated by the West Virginia University hospital are in the same range—in three sets of measurements made over a 2-year period, the hospital was discarding 4.0 pounds per day per capita of equivalent population.

The equivalent population method thus appears to permit hospital designers to predict the amounts of wastes generated for various types of institutions. However, it cannot predict wastes for the individual units of the institution. Location of the units with regard to supply and disposal points markedly affects material handling costs and consequently is an important

consideration in design and operation of hospitals.

The West Virginia study derived a series of simple mathematical equations that predict wastes for units within hospitals. The main variable for most patient-care units proved to be the total paid staff for a 24-hour period, not including doctors. Doctors are excluded because the number varies considerably for the same unit on different days. Furthermore, doctors would be counted at more than one unit as they made their rounds. The paid staff of nurses, aides, clerks, orderlies, housekeepers, and maids of a unit remains constant and parallels the amount of wastes produced. Patient-care units group themselves into two main divisions. Units such as surgery, maternity and newborn, and intensive care have large staffs and produce large quantities of wastes. Units handling, for example, psychiatric, pediatric, and neurology patients have smaller staffs and produce smaller amounts.

Support activities dealing mostly with paperwork produce similar quantities of wastes, with the main variable being total number of paid staff, excluding supervisors or administrators. A number of special units producing considerably smaller quantities of waste depend on other variables.

The equations are empirical in origin and statistically reliable; they provide, however, only an estimate of mean daily quantities. Unusual circumstances in the hospital, community epidemics or disasters, peak loads, increased use of disposables, and similar variables can produce quantities of waste that exceed the average. During the study period, peak loads from units in the West Virginia University

estimating waste

Generated by Individual Units of West Virginia Medical Center

HOSPITAL FACILITY	EXPECTED POUNDS PER DAY ARE EQUAL TO:
HEAVY-CARE UNITS:	
General surgery, neurosurgery, cardiovascular, urology, eye, chest, burns, maternity-newborn, orthopedics, operating room, intensive care, recovery	**4.47 times** the total number of paid staff* for that unit, excluding doctors
LIGHT-CARE UNITS:	
Metabolic, psychiatric, general medicine, pediatrics, gynecology, neurology, ear-nose-throat	**2.77 times** the total number of paid staff* for that unit, excluding doctors
SUPPORT UNITS:	
Administrative offices, gift shop, dietary offices, laundry, pharmacy, receiving, regional medical program, Appalachian Respiratory Diseases Lab	**2.21 times** the total number of paid staff* for that unit, excluding supervisors or administrators
SPECIAL UNITS:	
X-ray, radiation therapy, emergency room, central supply	**0.48 times** the number of patients treated or orders filled
Clinical laboratories, outpatient clinic	**0.19 times** the number of tests run or patients treated
Kitchen, cafeteria	**1.5 times** the number of patient meals served

** Registered nurses, licensed practical nurses, practical nurses, nurses' aides, orderlies, laboratory assistants, technicians, graduate assistants, secretaries, station clerks, cashiers, office support personnel, janitors, maids, housekeepers, floor sweepers, maintenance men, laborers, etc. Source: West Virginia University study*

hospital ranged from 15 to 35 percent higher than mean daily quantities.

more disposables

Increased use of disposables could have a dramatic effect on the amounts of wastes discarded by hospitals. The West Virginia University hospital, for example, handles 4,700 pounds of disposable wastes a day and 10,140 pounds of reusable wastes (those processed in the laundry). Assuming that, on the average, disposable items will be one-third the weight of reusable items, an additional 3,300 pounds of disposable wastes could be generated by the hospital, and the existing solid waste management system would have to be almost doubled. With solid waste management costs at the hospital averaging $100 per ton, a significant new expense would be involved.

The West Virginia study points up the need for hospital administrators to look carefully at how each single-use item will affect the operations and costs of the hospital before they approve its use. Purchasing, receiving, storing, distributing, collecting, processing, and disposal should be considered, not just safety, acceptance, and convenience for the patient and staff.

waste storage

Hospital wastes are stored in many kinds of receptacles—wastepaper baskets, garbage cans, empty oil drums, laundry hampers, carts, buckets, and even on the

floor. Plastic containers are coming into widespread use. They are easier to lift and clean than metal containers, and the bases and sides are impermeable to insects, since they do not rust, bend, or dent.

Use of disposable liners for waste containers has substantially increased sanitation of solid waste handling in hospitals. The bulk of the solid waste is unbagged in only 16 percent of the hospitals in the Minnesota study. This usually means that wastes are stored loose in containers and have to be transferred to other receptacles, increasing the risk of spreading infectious agents. The study found that 79 percent of the hospitals visited use plastic bags for most of their solid waste. Paper bags are used as the primary means of enclosure in only a few of the hospitals. Paper bags, especially waterproof ones, are frequently used to enclose relatively small amounts of wet or contaminated material. Because a hospital uses bags does not guarantee, however, that the bags would be used effectively or at all times. The surveyors noted numerous instances of bags leaking because they were torn or not tightly closed, endangering the persons handling the wastes, as well as others in the hospital.

Central storage of solid wastes is usually outdoors, even though such areas are accessible to children and other unauthorized individuals. In addition, the storage areas at many of the hospitals are unsightly, highly soiled, and accessible to insects and rodents. Various types of containers are used: bulk receptacles (57 percent of the hospitals visited) and small cans or improvised receptacles (53 percent), and even storage without recep-

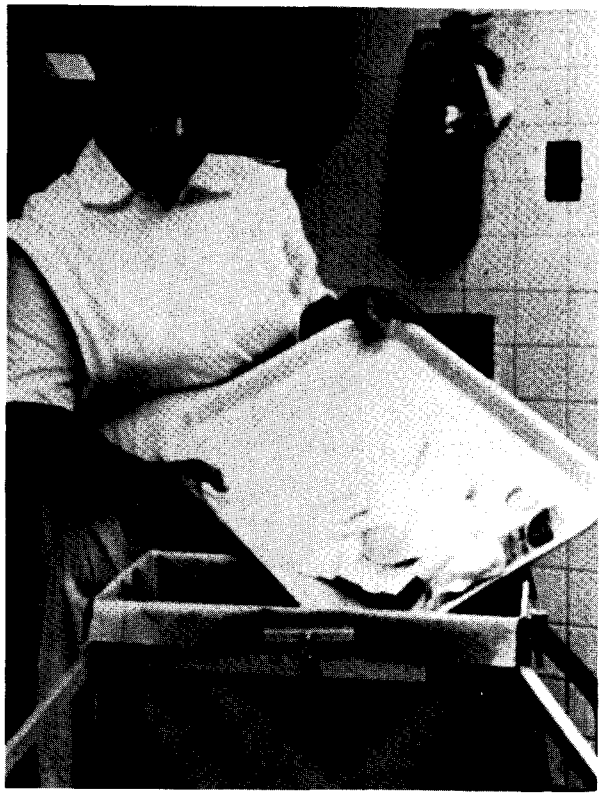
tacles (6 percent). A majority of the hospitals visited have more than one central storage location.

waste handling

An unusual feature of hospital waste management is that wastes are generated continuously around the clock, but they are collected sporadically at fixed intervals during the day shift. The housekeeping department usually has primary responsibility for collection within the hospitals surveyed, although a number of other departments have regular responsibility for other facets of waste collection. Generally, only minimal qualifications are required for persons collecting wastes.

Most of the hospitals surveyed use manually propelled carts of some variety to collect waste materials. The most frequently used carts (40 percent of the hospitals) have rigid walls made from wood, metal, or other materials. Flat carts are used as the primary means in 26 percent of the hospitals. Carrying waste by hand is the primary means in only 8 percent of the hospitals, but it is used to at least a small extent at nearly every hospital. More sophisticated mechanical systems are found at only a few hospitals.

Hospital carts are frequently constructed in such a way that sanitizing them is impossible, thus providing surfaces where bacteria can multiply. The routing of carts into and through areas where freedom from contamination is critical and near clean equipment and supplies increases the probability of contamination from wastes. In addition, per-



sons collecting wastes are repeatedly exposed to chemical and microbiological contamination and other hazards, but have minimal knowledge, skill, or equipment to protect themselves.

Gravity chutes are a simple and inexpensive means of transferring wastes vertically and are an important method at 32 percent of the institutions visited by the University of Minnesota study team. Chutes are found more frequently and in larger numbers at hospitals with higher bed capacities. However, the chutes are seldom constructed with mechanical exhausts, interlocking charging doors, or other systems for preventing the spread of microbiological contamination. In several instances, linen chutes are reserved for conveying solid wastes during certain times of the day—another potential way of spreading contamination.

Chute usage has additional drawbacks: fire hazards, spilling of wastes during loading, blockages, difficulties in cleaning, and odors. Proper design and construction can help to prevent some of these, especially the fire hazard and cleaning problems. Others can be avoided by excluding certain wastes, especially grossly contaminated articles, and by exercising more care in use of chutes.

The problems associated with gravity chutes are well illustrated in the West Virginia University hospital. The chute there receives combustible wastes from all 10 floors and terminates in a room adjacent to the incinerator room. The wastes include "floor refuse" such as paper, trash, and food wastes from the wards; pathologic wastes, including dressings, syringes, and other disposable equipment; and some kitchen wastes. Air temperatures in the chute closet average in the low 80's and the relative humidity is in the 55-to-65-percent range. In practice, wastes can remain in the chute for several hours and occasionally back up as far as the third floor of the hospital. The first door immediately above the chute closet is the door to the kitchen. The waste packs against this door and could become a source of food contamination.

The West Virginia study establishes the possibility of viable bacteria being transmitted to other parts of the hospital via the chute. The doors do not fit tightly, thus air constantly leaks into the hallway. The air in the chute tends to flow upward and outward into the hallways. If two or more chute doors are open at the same time, the air flows through the highest open door at a rate several times the flow when only one door is open.

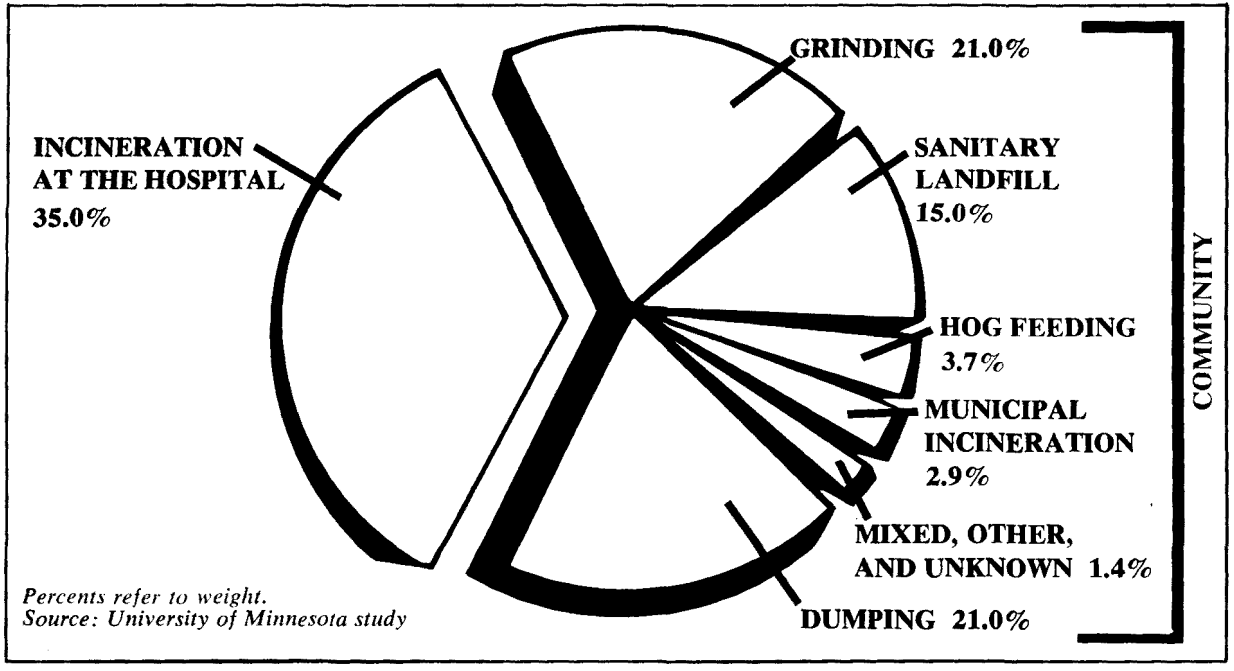
processing & disposal

Hospital wastes are disposed of in a number of ways, usually by the hospital's maintenance or engineering department. Eventually, almost two-thirds of the wastes leave the hospitals and go out into the community for disposal. About 35 percent by weight, principally combustible rubbish and biological materials, are disposed of in hospital incinerators. Noncombustibles are usually separated and—along with the incinerator residue—leave the hospital to be disposed of on the land.

Of the 80 hospitals surveyed in the Minnesota study, 70 use incinerators to dispose of some wastes. Usually, the incinerators are operated by persons lacking the necessary skills and knowledge. At only 39 percent of the hospitals using incinerators is operation limited to a specific operator or group of operators. A more common practice is for the persons collecting the waste to load it into the incinerator. The operators lack—or fail to use—even the most simple personal protective equipment such as face shields. About half of the institutions have a separate room for incinerators, but the rooms are occasionally uncomfortable and even hazardous because of heat, smoke, dust, and danger from exploding aerosol or ether containers.

In addition to a lack of skilled personnel, the hospital incinerators have numerous operating problems. Since they usually operate intermittently, maintaining adequate combustion temperature is difficult. Since very pronounced peaks occur in collection, there are brief periods when in-

most hospital wastes go outside the hospital



cinerators operate at above their rated capacity. Both situations can lead to poor incineration, air pollution, and even to the escape of infectious agents.

Grinding of garbage and discharging to public sewers is practiced at 84 percent of the hospitals, while 27 percent use grinders to dispose of biological materials into the sewage system. On the average, 21 percent of hospital wastes is disposed of by grinding. The method has several advantages. It reduces opportunities for insect and rodent infestation and so reduces problems both of environmental sanitation and odor. It reduces labor costs, since collection need not be so frequent when food wastes are removed. It also reduces the quantities of difficult-to-burn food wastes sent to incinerators.

Another major method of disposal is on the land—21 percent of the wastes go to dumps and 15 percent to sanitary landfills. Hog feeding is a minor method, accounting for only about 4 percent. The Minnesota study team considered it incongruous that institutions established for the care of the sick should permit hog feeding at all.

special problems of hazardous wastes

The various kinds of potentially hazardous wastes produced in hospitals pose special problems. Biological wastes such as human and animal remains, blood, afterbirths, bacteriological cultures, and bandages contaminated with bacteria require spe-

cial procedures, with a minimum of handling, to avoid spreading disease. The ease with which disease can spread is illustrated by the case of one general hospital where morgue employees had 10 times the incidence of tuberculosis as other hospital employees.

Incineration is the most frequently used disposal technique for such wastes among the hospitals studied by the University of Minnesota. Some biological wastes are also ground, buried, hauled away with other wastes, and—in the case of placentas—sent to drug firms.

More than half of the hospitals visited in the Minnesota study use radioisotopes for medical purposes. At 76 percent of the hospitals, radioactive wastes are first allowed to decay to a satisfactory level, then disposed of routinely with other wastes. At 17 percent of the hospitals using radioisotopes, contaminated waste is incinerated at the hospital without long-term storage to reduce radioactivity levels. At one hospital, radioactive waste is mixed with other waste and hauled away without benefit of decay, although the amounts disposed of without prior decay appear to be small.

Chemical wastes are generally intimately mixed with other wastes or present as a contaminant. A common example might be an organic solvent absorbed in paper toweling. In the course of their visits, the Minnesota study team observed several incidents in which large quantities of a chemical waste caused problems. At one institution, for example, about 3 cubic feet of hypochlorite bleaching powder had been dumped into a bulk waste receptacle, causing considerable discomfort to hospital personnel nearby. Since many chemical wastes are organic materials, they can

usually be incinerated, although explosive or toxic materials may require special precautions.

Disposable needles and syringes constitute a significant safety hazard to personnel handling wastes in 69 percent of the hospitals surveyed. The hospitals generally have policies providing for the safe disposal of sharp wastes. In a typical case, the policy calls for replacing the sheath on the needle, bending the needle or breaking it, and sealing it in a disposable container. Policies are often disregarded, however, and disposable needles are found mixed with other wastes and even protruding from bags of waste. The possibility of danger beyond the hospital should also be considered, since sharp wastes are hauled away without incineration at 45 percent of the hospitals surveyed.

hauling & disposal away from hospital

More than 40 percent of a hospital's solid wastes end up being transported on public streets and disposed of within the surrounding communities. Wastes are hauled away from every hospital visited by the Minnesota study team, with more than one-third of the hospitals being served by two or more haulers. Private haulers serve the largest number of hospitals, followed by municipal agencies, the hospital itself, hog farmers, and haulers under contract to the hospital. As hospital wastes move through the streets and to the disposal site, they lose their

identity as hazardous wastes that might require special precautions. (The same is true of the medical wastes generated in doctor's offices, nursing homes, and veterinary clinics.)

When wastes are removed from the hospitals, in 73 percent of the cases they go to a municipal disposal facility—which is sometimes an incinerator or a sanitary landfill, but frequently an open dump. A dump is a source of air and water pollution and a breeding place for insects and rats; when it receives hazardous wastes it adds a new threat to employees, to any scavengers, and to the entire community. A well designed and operated disposal site should provide for proper disposal of the relatively small amounts of hazardous wastes received from hospitals or other sources in the community.

evaluation of total system

The large amounts of potentially contaminated wastes generated by hospitals raise the possibility that they are a concentrated source of environmental health problems. The Minnesota study found that at many hospitals solid wastes are indeed contributing to occupational injuries, air pollution, and insect and rodent infestation, and pointed out some remedial steps that could be taken immediately.

The Los Angeles study also examined the total solid waste management systems in hospitals. A rating method was developed for evaluating the systems with regard to four basic environmental factors

steps to improve the systems

- *Seal as many wastes* as possible in disposable bags at the point of generation, or enclose them in such a way as to prevent or minimize contamination of the hospital environment.
- *Construct carts and other equipment* used to handle wastes so they are easy to keep in sanitary condition.
- *Construct and operate chutes* in such a way as to prevent or minimize microbiological contamination of air, linen, and various areas of the hospital.
- *Reduce the danger* to personnel handling wastes. Provide preventive health services such as immunizations as well as protective equipment such as gloves and uniforms. In the future, introduce equipment and systems that require less manpower.
- *Require higher qualifications* for those handling wastes. Provide them with training on the hazards associated with hospital wastes and the means of protecting not only themselves but others in the hospital and the community.
- *Improve operation of incinerators* by training operators to keep loads within incinerator capacity and to maintain temperatures high enough for good combustion.
- *Provide for safe management of hazardous wastes within the hospital* so that they cannot pose a danger to the community.

Source: University of Minnesota study

—*Hospitals*, Journal of the American Hospital Association

or conditions that affect the health and welfare of the hospital's occupants and the general public:

Sanitation: control of all conditions that contribute to contamination and may permit spread of disease or infection.

Safety: control of all conditions relating to prevention of accidents.

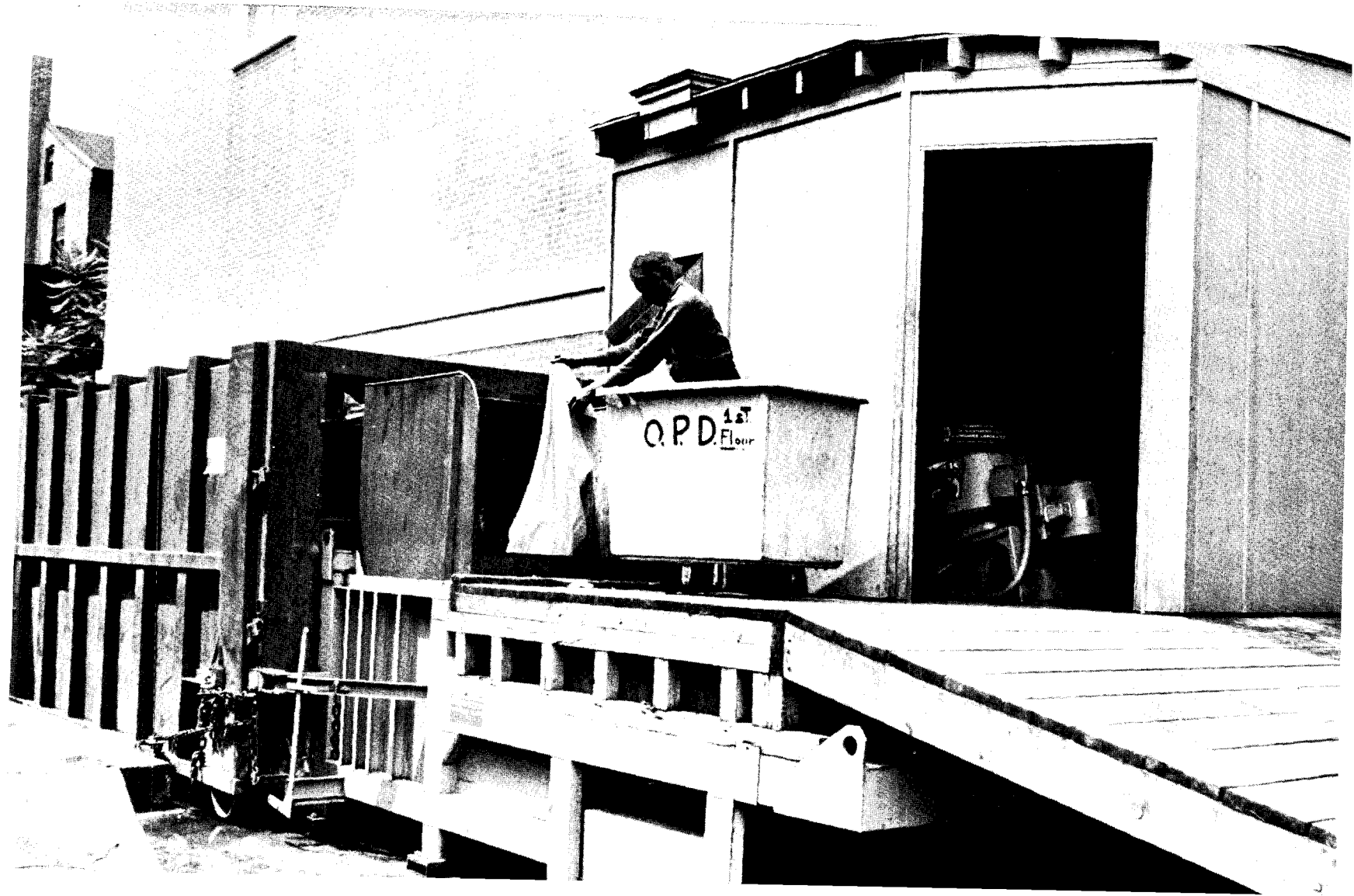
Security: prevention of unauthorized access to waste handling and disposal areas.

Esthetics: acceptability in terms of factors such as appearance, noise, odors, convenience, and workability of the system.

Considering both the capability of the system or equipment as designed and how it was operated in practice, the solid waste management system of each of the seven hospitals was given a deficiency rating from 0 percent—completely acceptable as is—to 100 percent—not acceptable for present use. The ratings ranged from 20 to 58 percent, indicating that even the best of the seven hospitals needs to improve substantially the quality of its system.

Efficiency and costs of the systems could also be improved. These systems rely heavily on manual methods, pushing labor costs up to over 90 percent of total operating costs. Unit costs vary and depend largely on physical complexities of layout and equipment, as well as on the skill and inclination of labor.

Most of the hospitals surveyed have comprehensive and sound policies on solid waste management, including specific directives on segregation and special handling of hazardous materials. But in practice, the policies break down. Employees fail to make the right judgments consistent-


O.P.D. 1st Floor

ly, and stricter supervision is needed to ensure that employees:

- Maintain proper handling and disposal of pathologic and sharp wastes.
- Separate disposable wastes from reusable wastes such as dinnerware and linens.
- Bag materials properly.
- Deposit chute materials promptly.
- Supervise storage, processing, and disposal areas closely; maintain security so that unauthorized personnel cannot gain access.

It would be relatively expensive to provide adequate supervision in the conventional waste systems of larger hospitals, which rely so heavily on people rather than mechanized systems. Such supervision is necessary, however, if the solid waste management systems are to be upgraded quickly.

new concepts

Long-range solutions to hospital waste management problems involve devising methods for conveying wastes from their source to storage or ultimate disposal areas with minimum handling and exposure to occupants of the building and the community. The Los Angeles study examined new concepts and equipment preparatory to designing an integrated system for possible installation in the LAC-USC Medical Center.

The problem is essentially one of materials handling and is adaptable to mechanization, although it is now managed

predominantly by manual methods largely built in by the design of the building. It is common to find, even in the newest hospitals, numerous interim storage points where wastes are temporarily deposited, thereby breaking the cycle of movement and requiring rehandling of the same material a number of times. These conditions continue to exist for several reasons. The hospital administrator, attuned to "doing it by hand," ignores the problem, the planner is unaware of it, and the materials-handling industry is not sufficiently alert to a new market. The materials-handling industry's apparent reluctance is understandable, for it is accustomed to working with objects or substances that are generally similar if not identical in size, weight, etc. Hospital wastes, on the other hand, almost defy description. Not only do they lack uniformity of size and shape but they may well be hazardous in various ways.

Despite the advanced state of development of general materials-handling equipment, tried and proven mechanical units designed exclusively for handling solid wastes are almost nonexistent, with the exception of chutes and pneumatic tubes. The mechanized and automated handling systems currently being tested and improved are relatively high in capital costs. However, they will likely provide overall economy in annual operating costs for many small and large institutions.

A pneumatic tube system for handling both soiled linens and disposable wastes has the greatest potential for use in existing buildings. For buildings still in the planning stage, conveyor systems for transferring sealed containers also merit con-

sideration. The conveyor system has the added advantage of being able to distribute clean supplies and would probably be economical only if designed to handle them as well as disposable and nondisposable wastes. Both pneumatic tubes and conveyors for sealed containers would improve operating standards since materials move in a closed system that minimizes exposure within the hospital and also reduces interim storage.

In addition to various types of temporary storage receptacles, hospitals must have areas where collected wastes and handling equipment can be stored. Although indispensable, such areas are seldom given adequate consideration by builders and designers. Storage areas that are too small and badly located create fire and health hazards. Carefully planned as part of the total solid waste management system, storage

facilities will require less space and eliminate unnecessary and expensive handling operations.

The space required for waste storage can be reduced even more by processing wastes to reduce their volume. Probably the simplest form of processing is to bag or encapsulate wastes. Compacting, grinding, shredding, pulverizing, and similar

techniques can be used alone or in combination. Another alternative is to discharge pulped materials into the sewers, an already contaminated channel. The chief concern with this method is the ultimate effect on the cost and operation of sewage treatment plants and on potential reuse of water from the plants.

The greatest investment and advances in equipment for hospital solid waste systems are occurring in handling, storage, and processing. But perhaps the greatest need is in processing and final disposal. Incineration is a widely used method of on-site processing. It is not a final disposal method, since it leaves a residue that requires disposal.

Both incinerator design and operation are highly complex. The importance of design is generally recognized, but the importance of proper operation—especially the need for qualified operators—is frequently overlooked. Industry is capable of designing incinerators to meet strict new air pollution control standards. In areas where air pollution is severe, the most sophisticated control devices will probably be required. However, they may prove too expensive for smaller incinerators.

Certain indirect benefits with monetary value can accrue as a result of environmental improvements. People in the hospital—especially those associated with direct handling of waste materials—are likely to have fewer accidents and illnesses. Similarly, the community at large would have less exposure to wastes in transport and off-site disposal. The cost of building maintenance and losses due to fires should be reduced. Congestion in building corridors would be reduced, allowing other hospital operations to be more efficient.

integrated plan for medical center

The new concepts of hospital waste management identified in the California study were used in designing a single, closed, integrated system for possible installation in the LAC-USC Medical Center. The need for a closed system rests on the premise that hospital wastes should be treated as if they are all contaminated. With closed transport, surveillance could be limited to initial handling at the ward level and final handling at the processing and disposal systems. The final step of the proposed system calls for on-site disposal, or processing to produce a sterile homogeneous material that can be safely hauled and disposed of off site.

Since installation of a system of automated carts or mechanical conveyors was impractical, the only alternative handling system with the required capabilities appeared to be pneumatic tube conveyors. Although twin-tube systems are preferable for separate handling of linens and wastes, a single-tube system was selected for the plan because it takes less space and is less expensive. A piping network would connect the existing chutes to the laundry and the disposal plant. Accumulated materials would be evacuated as needed. Linens would be in one type of color-coded bag, wastes in another. An interval sensor in the system would direct each bag to its proper location without cross-contamination. The vertical chutes would be placed under a slight negative pressure to minimize aerosol contamination. This closed

system eliminates interim storage and rehandling of wastes and meets environmental standards.

A number of alternatives for processing and disposal were considered. On-site incineration or pyrolysis and hauling the residue to a landfill was considered a safe method that would not contaminate the community. However, this method has drawbacks for Los Angeles, where stringent measures must be followed to avoid air pollution.

A method involving grinding and sterilizing wastes and transporting them to a landfill was considered. Methods that discharge ground wastes into the sewers could also meet the basic criteria, but the nature and quantity of hospital solid wastes may be a burden to conventional sewage treatment processes. A possible answer is the use of a method such as wet oxidation to reduce the quantities of solids. This method permits handling of the wastes at a much faster rate than is possible with conventional processes.

From this analysis, four largely automated systems were identified:

- Pneumatic conveyor system, pulping or wet grinding, wet oxidation, discharging to sewers.
- Pneumatic conveyor system, incineration, transport of residue to landfill.
- Pneumatic conveyor system, pulping or wet grinding, wet oxidation, dewatering, transport to landfill.
- Pneumatic conveyor system, pulping, discharging to sewers.

These systems were then evaluated according to the same four environmental

criteria—sanitation, safety, security, and esthetics—used on the solid waste management systems in the seven Los Angeles hospitals. The costs and the economic benefits, if any, were estimated for each system.

On the basis of investment requirements and annual operating costs, the system involving pneumatic conveyors, pulping of disposable wastes at a central pulping station, and discharging to the sewers appeared to have merit. There are still so many unknowns about the effects of solids in sewer systems, however, that the proposal that was recommended includes an experimental sewage treatment plant and a wet oxidation unit. The solids would be dewatered, without addition of chemical coagulants, to a moist solid which would be nonputrefying, biologically stable, free of obnoxious odors, and safe for trucking to a landfill.

future systems

Until recently, the solid waste management systems of hospitals have been ignored. The hospital administrator was not aware of his system's cost or how effectively it was operating. The solution to the most critical problems will ultimately be in the design of buildings. The solid waste system must come to receive the same consideration in preliminary stages that plumbing, air conditioning, heating, and other functions now receive.

Until modern systems are widely used, hospitals will continue to struggle with mounting waste tonnages, and they will be forced to use stopgap and piecemeal measures that are expensive and fail to fully protect the hospital's occupants and the surrounding communities.

This summary is based on three reports:

Hospital Solid Waste Disposal in Community Facilities, by Albert F. Iglar and Richard G. Bond. 1973. 350 pages. Available as publication No. PB-222 018 from the Department of Commerce, National Technical Information Service, Springfield, Virginia 22151, at $9 per copy.

Solid Waste Handling and Disposal in Multistory Buildings and Hospitals, by Esco/Greenleaf. 1972. Volume I, *Summary, Conclusions, and Recommendations,* is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, at $2 per copy. Volume III, *Research on Systems Development,* is also available from GPO, at $1.75 per copy, Volume II, *Observations of Local Practices,* and Volume IV, *Selection and Design of Solid Waste Systems,* are available as publication Nos. PB-213 133 and PB-213 135, respectively, from the Department of Commerce, National Technical Information Service, Springfield, Virginia 22151, at $3 per copy of either volume.

A Study of Institutional Solid Wastes, by Jerry C. Burchinal and Lynn P. Wallace. 1973. 234 pages. Available as publication No. PB-223 345 from the Department of Commerce, National Technical Information Service, Springfield, Virginia 22151, at $5.75 per copy.

SEE ALSO:

Hospital Solid Waste, An Annotated Bibliography, by Rexford D. Singer, Alain G. DuChene, and Nichole J. Vick. 1973. Available as publication No. PB-227 708/AS from the Department of Commerce, National Technical Information Service, Springfield, Virginia 22151, for $5.75 per copy.

μσ772α