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Knowledge and Practice of Biomedical Waste Management Among Healthcare Workers in a District Hospital

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ABSTRACT

Hospitals produce a stream of infectious, sharp, chemical and pharmaceutical waste that must be kept apart from ordinary rubbish, and the task of doing so falls largely to the doctors, nurses, laboratory staff and cleaners on the wards. This narrative review examines what the published literature says about healthcare workers' knowledge and practice of biomedical waste management and how far survey evidence can be trusted to describe what people actually do. It draws on reviews, surveys and methodological papers on the hazards of healthcare waste, sharps injuries and bloodborne infection, treatment and disposal options, workplace safety behaviour, and the design of knowledge–attitude–practice surveys, and it reports no new data and no observations from any hospital. Awareness that biomedical waste is hazardous appears widespread, but knowledge of categories, containers and post-exposure steps is uneven across professional groups, and practice commonly lags behind knowledge. Most surveys are cross-sectional, rely on self-report, use convenience samples and unvalidated instruments, and seldom observe practice or measure supplies, so they are better at showing that gaps exist than at showing how large they are. Cleaners, porters and treatment operators carry much of the physical risk yet are the groups most often omitted. The review concludes that studies pairing self-report with observation and audit, and that include every staff group, would add most, and it outlines what a local assessment should contain.

Keywords: Biomedical waste; Healthcare workers; Knowledge and practice; Sharps injuries; Waste segregation; Infection prevention; Narrative review

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Article Class: Narrative Review

1. Introduction

Every hospital produces waste that no ordinary dustbin should receive. Swabs and dressings soaked in blood, discarded

needles and scalpel blades, cultures and specimens, expired medicines, and the packaging that surrounds all of these leave the clinical area every day. Most of what a



health facility discards is no more hazardous than household waste, and a smaller part is infectious, sharp, chemical or pharmacological in character (1, 2). The practical task of biomedical waste management is to keep those two streams apart, so that the hazardous part is treated properly and the harmless part is not made hazardous by mixing.

That task falls mostly to the people who work on the wards. Doctors, nurses, laboratory staff and cleaners decide, many times a shift, which container receives which item. Their knowledge, attitudes and practice therefore matter, and surveys of exactly these three things have been run in hospitals in many countries, including India (3, 4). India has had national rules on the subject since the late 1990s, revised substantially in 2016, and reviews of how those rules have worked in practice describe progress alongside persistent gaps (5, 6).

The title of this article refers to a single district hospital. This review does not report data from any hospital. It collects and weighs what has been published about knowledge and practice of biomedical waste management among healthcare workers in general, so that a reader can judge what a local study of this kind could add and what it could not. We report no local observations, and any statement about a particular hospital should be read as outside the scope of this paper. The aim is a fair account of what is known, and of what is only repeated.

The review is organised around one uncomfortable pattern. Surveys repeatedly record that staff know more than they do, and the distance between the two is rarely measured well (3, 7). Throughout, the emphasis is on what such surveys can and cannot establish, because that decides how a local study of the same question should be designed and what it can fairly claim.

2. Literature Review

2.1 What Counts as Biomedical Waste

Definitions differ between countries but share a core. Infectious waste, sharps, pathological and anatomical waste, pharmaceutical and cytotoxic waste, chemical waste and a small amount of radioactive material are routinely singled out as needing special handling, while the paper, packaging and food waste of a hospital belong with ordinary municipal waste (1, 8). Table 1 summarises the main categories and the principal reason each is treated as hazardous.

Table 1. Main categories of healthcare waste and why each is handled separately.

Category	Typical items	Main concern
Infectious	Soiled dressings, swabs, cultures (1)	Transmission of infection
Sharps	Needles, blades, broken glass (9)	Injury and bloodborne viruses
Pathological	Tissue, body parts, placentas	Infection; ethical handling
Medicines	Expired or unused products	Toxicity; environmental release
Chemical	Disinfectants, laboratory reagents (8)	Toxic or corrosive effects
General	Paper, packaging, food waste	Hazard only if mixed with the above

Note: Qualitative summary of categories described in the cited reviews; national definitions differ.

2.2 Sharps Injuries and Bloodborne Infection

Of all the hazards in healthcare waste, sharps have drawn the most attention, because they injure the people who handle them. Needles, lancets, blades and broken glass can carry blood from one person into another, and a person who is injured at work may be exposed to hepatitis B virus,



hepatitis C virus or HIV. Global estimates have attributed a measurable share of occupational infections with these viruses to sharps injuries, and others to contaminated injections more broadly (9, 10). A later analysis suggested that the burden from unsafe injections changed over the first decade of this century, although it did not disappear (11).

The risk from a single injury depends on the virus, the depth of the wound and the amount of blood involved. Reviews of occupational bloodborne infection describe the risk after a needlestick as highest for hepatitis B, lower for hepatitis C and lowest for HIV, and a classic case-control study of HIV seroconversion after percutaneous exposure found that deep injuries and visible blood on the device raised the risk (12, 13). Vaccination against hepatitis B protects health workers who are immunised, and post-exposure prophylaxis guidance exists for HIV (14, 15). Neither measure removes the need to prevent the injury in the first place.

Injuries cost money and distress as well as infections: reviews describe expenses for testing and follow-up, lost working time, and anxiety while results are awaited (16, 17). A survey in a German university hospital is a reminder that the problem is not confined to resource-limited settings (18).

2.3 Treatment, Disposal and the Wider Environment

Once segregated, waste must be treated. Steam sterilisation, chemical disinfection, incineration, shredding and deep burial are the options most often described, and their suitability depends on the waste category, the cost of equipment and the capacity to operate it (2, 19). Reviews of practice in lower-income settings emphasise that the best technology on paper may be the wrong choice where fuel, trained operators or maintenance are scarce (2, 20). Plastic

makes up a substantial part of healthcare waste, and analyses of recycling potential show how much depends on keeping plastics uncontaminated and separate (21).

The environmental footprint of health care itself has also come into view. Estimates for the United States and for health systems worldwide attribute a non-trivial share of national emissions and pollution to the sector (22, 23). Every ward contributes to the waste part of that footprint directly, and non-hazardous items put in the wrong bin raise treatment costs for no clinical gain.

Treatment choices also carry trade-offs that a ward worker never sees. Incineration reduces volume and destroys pathogens, but it can release pollutants if it is poorly operated, which is why reviews of the options keep returning to operator training and maintenance rather than to the technology alone (1, 2). Steam sterilisation avoids combustion, yet it leaves the waste physically intact and still in need of a disposal route (19). Whatever the method, treatment can only work on what reaches it, and a bag that was mixed at the bedside arrives at the plant as the most expensive kind of waste.

2.4 Practice in Hospitals Across Regions

Studies of hospitals in different parts of the world describe a similar spread of practice. Reviews of healthcare waste management in Asia and in India describe national rules that exist in many countries but are applied unevenly between facilities (5, 6, 24). A survey of government health centres in Addis Ababa documented gaps in segregation and handling (25) and a study of hospitals in southern Portugal examined how staff perceived the risk as well as what they did (7). Research output in this field has grown quickly but is concentrated in particular topics and places (26).



2.5 Waste During the COVID-19 Pandemic

The pandemic that began in 2019 put healthcare waste in the news. Hospitals reported sharp rises in infectious waste, much of it masks, gowns and gloves, and some had to change collection and treatment routines quickly (27, 28). Commentators warned that used protective equipment might itself spread infection or become an environmental problem, and recommended safe handling and, where possible, reusable or recyclable alternatives (29, 30). Disinfection technologies for pandemic waste were reviewed (31), and laboratory work on how long coronaviruses persist on surfaces and in aerosols gave a basis for the precautions that were adopted (32, 33).

3. Materials and Methods

3.1 Scope and Question

The review asks one question in two parts. What does the published literature show about healthcare workers' knowledge, attitudes and practice in biomedical waste management, and how far can the survey evidence be trusted to describe what people actually do? None of these steps is difficult, but each is easy to skip on a busy ward.

3.2 Literature Assembly

This is a narrative synthesis. We drew on peer-reviewed reviews, surveys and methodological papers that bear on the hazards of healthcare waste, the performance of waste systems in hospitals, sharps injuries and their prevention, the behavioural science of workplace safety, and the design of knowledge–attitude–practice surveys. Sources were chosen for relevance, citation in the field and clarity of method, and we cite only work published up to the date of this issue. The narrative form has defenders as well as critics (34, 35).

We did not run a formal systematic search, did not screen records against pre-set criteria, and did not extract data. The consequence is that this paper is a better guide to the shape of the evidence than to the size of any effect, and it avoids quoting percentages from individual surveys that could not be checked against the primary papers for this article.

3.3 Appraisal Framework

To judge how far a survey result can be trusted, we used a short list of questions adapted from guidance on narrative review quality and on knowledge–attitude–practice research (36, 37). They are set out in Table 2. The questions on self-report and on social desirability carry particular weight in this field, because staff asked about their own conduct tend to describe the conduct they believe is expected (38).

Table 2. Appraisal questions applied to knowledge and practice surveys.

Question	Why it matters	Weak answer looks like
Who was surveyed?	Staff groups differ in exposure	Doctors and nurses only (37)
Was the tool tested?	Items may not measure the intended idea	Unvalidated questionnaire
Self-report or observation?	Reported conduct flatters respondents (38)	No audit or observation
How was good knowledge defined?	Thresholds change conclusions	Cut-off not justified
Was supply checked?	Practice needs containers and bags	No mention of supplies
Can the finding travel?	Settings differ	One hospital, one day

Note: Adapted by the authors from the cited guidance; questions are prompts for judgement, not a scoring scale.



4. Results

4.1 What Knowledge and Practice Surveys Show

Surveys among hospital staff, including those in India, report awareness that is real but uneven. Respondents commonly recognise the idea of colour-coded segregation and the risk from needles, and their answers differ between professional groups, between departments and between those who have and have not been trained (3, 4). Studies in Portugal and Ethiopia describe a similarly mixed picture of awareness and practice in very different health systems (7, 25). Figure 1 shows the pathway along which these everyday decisions are made.



Schematic, not data

Figure 1. Biomedical waste pathway inside a hospital and the points where practice commonly fails (schematic, not data).

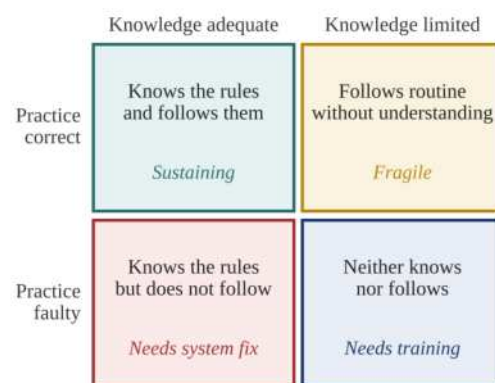
4.2 From Knowing to Doing

The most consistent message of the literature is that knowledge is necessary and insufficient. Social-psychological models of behaviour hold that action follows from intention, which in turn is shaped by attitudes, social expectations and perceived control (39). A nurse may

know that a used needle belongs in a puncture-proof container and still drop it on a tray if the container is full, out of reach or missing. Behaviour-change frameworks treat capability, opportunity and motivation as separate requirements, and a lack in any one can stall the others (40).

Workplace research on safety adds the social setting. Where supervisors visibly treat safety as a priority, workers in many industries report and behave more safely, and the same logic is plausible on a ward where senior staff model correct segregation (41). That finding comes from manufacturing, not from hospital waste studies, so it is a hypothesis here. A hospital can have every poster on the wall and still lack a working bin in the right corridor.

Figure 2 sketches the four combinations of knowing and doing. The cell that worries safety managers is the one in which staff know the rules and do not follow them, because training cannot repair it. The cell in which staff follow the rules without understanding them is fragile in another way, since practice collapses when the routine is disturbed. Absence of a reported difference in a small survey is not evidence that no difference exists.



Conceptual matrix, not data

Figure 2. Four combinations of knowing and doing (conceptual matrix, not data).



4.3 Where Practice Breaks Down

The pathway in [Figure 1](#) has several points at which things commonly go wrong. Segregation at the point of generation is the first and most important, because an error made there cannot be undone downstream without handling the waste again. Mixed bags and sharps found in general waste are described in hospitals in several regions ([1](#), [25](#)). Those who carry bags to the storage area are often the lowest-paid and least-trained staff, even though they face high exposure ([6](#), [24](#)).

Sharps handling deserves separate comment. Preventive measures that remove the hazard are consistently favoured over measures that ask for care. A review of safety-engineered devices found that their introduction was generally followed by fewer percutaneous injuries, although the studies were mostly uncontrolled before-and-after comparisons ([42](#)). A Cochrane review concluded that blunt suture needles reduce needlestick injuries in surgical staff ([43](#)). Recapping of used needles, once taught as routine, is discouraged in modern guidance because it is a common route of injury.

Training is the commonest response to a problem and the least well evaluated. Many papers recommend more of it, and few describe a trial of one training programme against another or follow staff long enough to see whether benefits last. Staff turnover can wear away the effect of a training programme. The weakness is not unique to waste management, but it limits confidence in the standard advice. Short refresher sessions are also far easier to arrange than changes to supplies or staffing, which may help explain why they dominate the recommendations. [Table 3](#) sets the determinants of practice that the literature identifies beside the levers that could change them.

Table 3. Determinants of waste-handling practice and levers that could address them.

Factor	Example	Possible lever
Capability	Unsure which bin suits an item (40)	Clear charts; short refreshers
Opportunity	Container full or out of reach	Supplies; bin placement
Motivation	Rule seen as optional (39)	Visible supervisor example (41)
Device design	Needle exposed after use (42)	Safety-engineered devices
Injury readiness	Unclear steps after exposure (15)	Vaccination; reporting route

Note: Qualitative synthesis; the cited frameworks describe general behaviour, not waste handling specifically.

4.4 Quality of the Evidence

[Figure 3](#) arranges the same determinants in layers from the individual outward. What the layered view makes plain is how little of the survey literature measures anything beyond the first layer. Questions about the individual are cheap to ask; questions about supplies, staffing and supervision need audits or observation, which are costlier and therefore less common.

Across the surveys, the same limitations recur. They are cross-sectional, so cause and effect cannot be separated. They rely on self-report, which tends to flatter the respondent ([38](#)). Samples are often convenience samples from one or two hospitals, and the instruments are seldom validated. Observation of practice, the most direct measure, is rare, and when it is done it can itself alter behaviour. For these reasons the literature is better at showing that gaps exist than at showing how large they are, which is exactly the question a local study would want answered. The point is not that these surveys are poor, only that their results travel less far than their abstracts suggest.

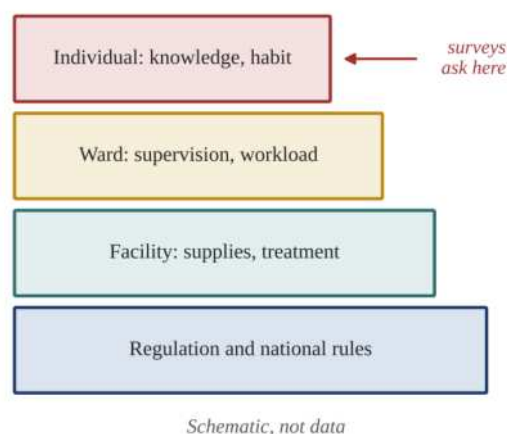


Figure 3. Layers of influence on waste-handling practice, from the individual outward (schematic, not data).

One further difficulty is that surveys are rarely comparable. Questionnaires differ in what they ask, in how they define adequate knowledge and in which staff they include, so two studies that report similar headlines may be describing different things (26, 37). Pooling their results would be misleading, and we have not tried to. What can be said is that the same weak points, namely categories, containers and the steps after an injury, appear again and again in settings that otherwise have little in common (3, 15, 25).

5. Discussion

5.1 Interpretation

A study of knowledge and practice in one district hospital would add most if it were designed with these gaps in mind. Asking staff what they know is useful, but asking what they did yesterday, and checking that against a look at the bins, tells a hospital far more about where to put effort. A survey may find a training need where an audit would find a missing container. Nothing here argues against training; it argues for measuring what the training changes.

The literature also suggests that responsibility should not rest on clinicians

alone. Cleaners, porters and the staff who operate treatment equipment carry much of the practical risk, and they are the groups most often left out of surveys and training (6, 24). Any local assessment that skips them will understate both the hazard and the opportunity.

It follows that the choice of measure is itself a decision about what the hospital wants to learn. A knowledge score is easy to collect and easy to report, but it describes the classroom rather than the corridor. Observation, bin audits and records of injuries and near-misses describe the corridor, and they are the sources a manager can act on (41, 42). Combining the two lets a hospital see whether a gap lies in what people know, in what they have to work with, or in the habits of a particular unit.

5.2 Limitations

This review is narrative and carries the limitations of that form. The selection of sources reflects our judgement, no formal search or quality scoring was done, and some regions and languages are probably under-represented. Several older sources describe a different regulatory and technological context, and the pandemic literature is itself a fast-moving body of work. We have deliberately not quoted figures from individual surveys because we could not verify them against the primary reports for this article. A reader who needs those numbers should consult the original studies and apply the appraisal questions above. Reviews of this kind are more useful when they say where the evidence stops than when they smooth it over.

5.3 Directions for Future Work

Three needs stand out. First, a formal systematic review with a transparent search and a quality appraisal, which would replace our judgement with explicit



criteria. Second, studies that pair self-reported practice with observation and audit, and that include all staff groups and not only clinicians. Third, trials, even small ones, that compare training with and without changes to supplies, device design or supervision, and that follow staff long enough to see whether any improvement lasts. Reading the literature this way keeps attention on what people actually do.

6. Conclusion

The published literature shows that healthcare workers generally understand that biomedical waste is hazardous, that their understanding of details is uneven, and that practice often falls short of knowledge. It does not show how large the shortfall is in any particular hospital, and survey designs that rely on self-report cannot tell us. Studies that observe practice and measure supplies will say more than those that only ask about it.

For a hospital, the practical message is modest. Provide the right containers where they are needed, include every staff group, protect staff through vaccination and clear post-exposure routes, and check what people do as well as what they say. For researchers, the opportunity is to turn a familiar descriptive literature into evidence about what works, which will take someone deciding that the everyday routines of the ward deserve to be measured. A question that sounds simple can hide several different behaviours.

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9. Conflict of Interest

The authors declare no conflict of interest.

10. Author Contributions

E.G. conceived the review and wrote the sections on hazards and sharps injuries. R.M. wrote the sections on treatment, disposal and the pandemic. S.M. wrote the sections on staff practice and the appraisal framework. All authors revised the manuscript and approved the final version.

11. Ethics Statement

This is a review of published literature. No human participants or patient data were involved and no ethical approval was required.

12. Data Availability

No new data were generated. All sources are cited in the reference list.

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