Introduction

The waste generated in hospitals commonly comprises general waste, sharps, human tissues, pharmaceuticals, pathological, radioactive chemical materials, and other infectious materials. The hospital waste is largely divided into Infectious and Non-Infectious Waste. Approximately 75% to 90% of the total hospital waste is noninfectious and is comparable with domestic solid waste. However, poor segregation practices may lead to the mixing of infectious waste with noninfectious waste and lead to an increase in the total volume of infectious waste. In India, on an average, 0.5–0.99 kg/person/day general solid waste is produced which is higher (i.e. 0.1–0.49 kg per person per day) than solid waste generated in low-income nations and lower than in developed countries (1.5 kg per day). The Government of India has issued guidelines for the management of different kinds of hospital waste from time to time including Solid Waste Management (SWM) Rules in the year 2016 and is mandatorily applicable to all organizations including the hospitals.

Objective: We conducted this study to assess the knowledge and awareness among nursing professionals regarding various provisions of solid waste management rules, 2016. Methods: It was a cross-sectional study done on nursing professionals across all seniority and from various specialties and super specialty departments. A pretested questionnaire comprising 20 questions was used as a study tool. Results: There were a total of 550 participants. The mean knowledge count of the respondents was 9.487273 (1.00–14.00). The mean score was 59.3% of the overall achievable score. In the subgroup analysis, respondents above 60 years of age, married, females, urban residents, nursing sisters scored better than the middle-aged professionals, unmarried, males, rural residents, and staff nurses. Conclusions: This study has given insight into various domains of SWM rules, 2016 where nurses performed well and those where considerable gaps exist. The health care workers are more aware of biomedical waste (M&H) rules, and the solid waste management rules are new to them. It is recommended that the biomedical waste management training program must include training on general solid waste management rules.

Keywords: Health Care Worker (HCW), knowledge, nursing professionals, Solid Waste Management (SWM) Rules, 2016

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to time. Similarly, the Government has issued Solid Waste Management Rules in the year 2016 and are mandatorily applicable to all organizations including hospitals. These rules have replaced the old rules on Municipal Solid Waste Management. The hospital is a matrix organization and generates a huge quantity of general solid waste along with other types of wastes. Hence, solid waste management rules, 2016 are equally applicable to health care institutions, and any noncompliance will invite penal action from the Pollution Control Board.

The rationale for the study
A huge amount of waste is generated from hospitals by the patients, their attendants, staff, and the public in their day-to-day activities. In addition to biomedical waste, a large quantity of general solid waste is also generated. The Government of India has framed Solid Waste Management rules, 2016 for smooth management of solid waste. Hence, we are bound to follow these rules in our hospitals. Therefore, every medical institution needs to keep its health care workers updated about various provisions of these rules. Lack of awareness on this front may make the entire institution liable to be blamed for the implications of poor solid waste disposal. The awareness of the health care workers about various provisions of Solid Waste Management rules will help in improving solid waste management. The Department of Hospital Administration has an important role to play in a regular update of knowledge among the health care workers. In the literature review, it was found that large studies are available regarding awareness about biomedical waste management rules. However, much emphasis has not been put on this front and even operational research studies in a hospital setting from India are not available on this topic in the indexed literature. With this background in mind, we planned this study for nursing professionals posted in various specialty and super specialty departments for assessing their awareness about solid waste management rules, so that the future need for training (if any) may be assessed, and the solid waste generated in hospital is managed as per solid waste management rules, 2016.

Aim and objectives
a) To study the prevailing knowledge about SWM Rules, 2016 among Nursing Professionals.
b) To find out the association between the knowledge differential regarding Solid Waste Management rules vis a vis different variables.

Methodology

Study setting
This was a cross-sectional survey conducted at a leading 2050-bedded tertiary care hospital of northern India with an average of 7000 outdoor patients per day and around 330 new indoor admissions per day.

Sample and sampling
The study population consisted of nursing professionals working in various specialties and super specialties. In our study, 50% (i.e. n = 534 and a round of 550) of the nursing personnel on the role of the institute were included. The nursing professionals are posted in all hospital areas and are in direct touch with the patients and their attendants. The nursing professionals are also supervising the work of various housekeeping and other staff working in their areas. The sampling frame was prepared by obtaining their names from different departments. By following a convenient sampling technique, requisite numbers of participants were selected from each department.

Study tool
A self-administered questionnaire was prepared after an extensive literature review and used as a study tool. The questionnaire was pilot tested among 20 different experts for checking its validity. Thereafter, as per the inputs received during pilot testing, the questionnaire was modified. The questions in this tool included those on socio-demographic variables and knowledge about various provisions of solid waste management rules, 2016 like the meaning of solid waste, nodal ministry, collection, segregation, and disposal of solid waste, bulk waste generator, color coding, etc. The questionnaire consisted of a total of 20 questions, out of which 16 were closed-ended questions for assessing the knowledge regarding various aspects of solid waste management and 04 questions were open-ended on a five-point Likert scale format for eliciting the opinion of respondents regarding the implication of these rules on health care workers and institutions.

Data analysis
Sixteen close-ended questions were scored. Each correct response was given a score of one. The data were analyzed by using IBM SPSS 20 software. The overall mean score (95% CI) was calculated for all the nursing professionals. Various statistical tests, viz. Chi-square test, analysis of variance (ANOVA), t-test were used, and category-wise subgroup analysis was done to generate the hypothesis on whether knowledge differential exists among nursing professionals at different levels, viz. staff nurses, nursing sisters, etc., and whether their knowledge differential had any association with the selected variables.

Ethical clearance
Permission from the Institute Ethics Committee was obtained before conducting this study. Informed consent was obtained before administering the study tool, and the confidentiality and privacy of all respondents were maintained absolutely.
Results

There was a total of 550 respondents. Age, gender, marital status, place of residence, educational qualification, and designation-wise distribution of the respondents is given in Table 1. It was observed that 40% of the respondents were in the 31–40-year age group, 93% were females, 55% were General Nursing Midwifery diploma holders, 91% were married, 88% were from an urban background, and 76% were staff nurses.

The mean knowledge score of the respondents was 9.49 (range 1–14). The total achievable score in this study was 16, and hence the mean knowledge score was 59.3% of the total achievable scores [Table 2].

The statistics of groups having two different categories were analyzed by applying the independent sample t-test, and it was found that the mean knowledge score of males was higher than females ($P = 0.941542$), and the mean knowledge score of married respondents was higher than unmarried ($P = 0.323673$).

| Parameter               | Frequency | Percentage |
|-------------------------|-----------|------------|
| Age Group (In Years)    |           |            |
| 20-30                   | 184       | 33.5       |
| 31-40                   | 218       | 39.6       |
| 41-50                   | 52        | 9.5        |
| 51-60                   | 89        | 16.2       |
| >60                     | 7         | 1.3        |
| Gender                  |           |            |
| Male                    | 39        | 7.1        |
| Female                  | 511       | 92.9       |
| Marital Status          |           |            |
| Married                 | 501       | 91.1       |
| Unmarried               | 49        | 8.9        |
| Resident                |           |            |
| Urban                   | 485       | 88.2       |
| Rural                   | 65        | 11.8       |
| Education Qualification |           |            |
| GNM                     | 304       | 55.3       |
| B.Sc.                   | 172       | 31.3       |
| M.Sc.                   | 20        | 3.6        |
| Ph.D.                   | 1         | 0.2        |
| Others                  | 53        | 9.6        |
| Designation             |           |            |
| SN                      | 420       | 76.4       |
| NS                      | 120       | 21.8       |
| ANS                     | 1         | 0.2        |
| Others                  | 9         | 1.6        |
| Total                   | 550       | 100.0      |

Table 1: Distribution of sample size as per age group, gender, marital status, place of residence, educational qualification and designation

This difference in knowledge score was not statistically significant. However, the mean knowledge score of respondents with an urban background was found statistically higher than the respondents with a rural background ($P = 0.000858$) [Table 3].

The statistics of groups having more than two different categories were analyzed by applying one-way ANOVA test. It was found that for the age variable, the mean knowledge score was increasing with the age of the respondents and was highest in respondents falling in the age group of more than 60 years. This difference in knowledge score was statistically significant ($P = 0.027588$). Likewise, for the designation variable, it was revealed that the mean knowledge score increased with seniority among the respondents i.e., the senior nursing professionals had more knowledge about solid waste management rules than their junior counterparts, and this difference in knowledge was also found statistically significant ($P = 0.000447$). However, for the educational qualification variable, the mean knowledge score although showed an increasing trend with rising in qualification, but the difference was not found statistically significant ($P = 0.572951$) [Table 4].

The question-wise analysis was undertaken for assessing the knowledge about different provisions of solid waste management rules, 2016. It was revealed that knowledge of nursing professionals about various provisions like the year and act under which SWM Rules, 2016 were framed, the applicability of these rules on health care institutions, the definition of bulk waste generators, and correct segregation practice of solid waste was very good (score more than 70%). The knowledge was good about color coding of wet waste collection bins, provision of accidental reporting under SWM Rules, etc., (score between 60 and 70%). However, knowledge was fair (score between 50 and 60%) about the meaning of solid waste and different activities under these rules, color code of dry solid waste collection bin, etc. The knowledge was average (score between 40 and 50%) about the nodal ministry for implementation of solid waste management rules, various waste categories covered under these rules, government agency approving solid waste processing and treatment facilities, and annual report format.

The study tool also had four statements with a response format on a five-point Likert scale for receiving the opinion of respondents regarding various implications of SWM Rules, 2016. It was revealed that 85% of the respondents agreed or strongly agreed that knowledge about SWM Rules, 2016 is important for them. The Chi-Square test was applied to seek a relationship of this statement with various variables and it was found that this statement had a statistically significant association with the place of residence of the respondents ($P$ value = 0.001011). The majority of the respondents (64%) disagreed that safe management
of solid waste is an extra liability on them. This statement has significant association with age group ($P$-value = 0.021895), place of residence ($P$-value = 0.0000001), and designation of the respondents ($P$-value = 0.000841). Furthermore, 61% of the nursing professionals agreed or strongly agreed that waste management is teamwork, and no single class of people is answerable for it. This statement was found to have a statistically significant association with the place of residence of the respondents ($P$ value = 0.033268). About three-fourths of respondents (i.e. 75%), strongly disagreed or disagreed that safe solid waste disposal efforts by the hospital will lead to an increased financial burden on the institution, and this was found to have a significant association with gender ($P$-value = 0.0002702) and educational qualification ($P$-value = 0.041404) of the respondents [Table 5].

**Discussion**

All health care workers must fully understand the different provisions of solid waste management rules. A lot of studies are available regarding knowledge of health care professionals about biomedical waste management rules; however, no research work is available on the study topic in the indexed literature. This may be because biomedical waste being unique to hospital setup and infectious is an area of attention of the research scholars as compared to the general solid waste. However, the proper disposal of general solid waste is equally important, particularly in a hospital setup. Hence, this study was carried among nursing professionals of tertiary care, research, academic, and referral hospitals of northern India to map their awareness about various facets of solid waste management rules, 2016.

In the present study, it was revealed that the average knowledge score of nursing professionals was 59.3% of the overall achievable score. As discussed in the foregoing para that no previous study was found in the indexed literature regarding solid waste management rules; however, many studies are available regarding knowledge of biomedical waste management rules. In one such study,[15] it was found that the mean knowledge score of respondents in the pretest was 56% of the total achievable score. This finding reflects that the health care workers may have good practical knowledge about hospital waste management in general, do not have good knowledge about the different rules governing hospital waste management. This may be explained by the argument that broader practical aspects may be taught to the health care workers, and the same is also learned by them with their working experience. The understanding of rules in totality is a different domain, and the hospital management probably does not emphasize the same. Nevertheless, violation of any provision of waste management rules may invite strict legal action from the Government enforcing agencies, and hence health care workers must not only have practical orientation regarding solid waste management but should also have adequate knowledge about various provisions of these rules.

Our study has generated some significant differentials in the knowledge scores. Respondents beyond 60 years of age, married, females, urban residents, nursing sisters scored better than the middle-aged professionals, unmarried, males, rural residents, and staff nurses. The postgraduates also scored higher than the graduates. Better knowledge scores in some groups related to others could be because of better exposure to the matter in the former compared to the latter. This exposure can be due to superior drill or/and applied exposures.

On question-wise analysis in our study, it was found that the knowledge of nursing professionals regarding correct segregation practice of solid waste was very good (score more than 70%). On comparing our study finding with Delhi[14] study, it was found that their nurses had very good knowledge (89%) regarding solid waste disposal however their housekeeping staff had average knowledge (44%) on this font. Similarly, in our study, the knowledge was good about color coding of wet waste collection bins (score between 60 and 70%), which was lower than the knowledge of nurses (88%) and higher than the housekeeping staff (56%) of Delhi[14] study.
This study has given further insight into various domains of Solid Waste Management Rules, 2016 where nurses performed well, and those where a significant gap exists. We have also found out the perceptions of the nurses about the implications of these rules on health care workers and health institutions. It was revealed that most of the respondents believed that knowledge about SWM Rules, 2016 is important for them, and safe solid waste disposal efforts by the hospital will not lead to increased monetary liability on the institution. The views generated in the study reflect the positive attitude of the nursing staff towards training and implementation of these rules in their respective hospital areas.

Solid waste management is applicable in Primary Health Care also, it is very pertinent that primary care health workers should be made aware of these BWI rules and they practice this in letter and spirit.

| Parameter | Strongly Disagree | Disagree | Neither agree nor Disagree | Agree | Strongly Agree | Chi square | P         |
|-----------|------------------|----------|---------------------------|-------|---------------|------------|-----------|
| Resident  | Urban            | 6.8%     | 5.4%                      | 3.9%  | 59.0%         | 24.9%      | 18.442717 | 0.001011 |
|           | Rural            | 18.5%    | 4.6%                      | 4.6%  | 35.4%         | 36.9%      |           |

| Age       | 20-30            | 23.4%    | 40.8%                     | 4.9%  | 25.0%         | 6.0%       | 29.315300 | 0.021895 |
|           | 31-40            | 11.0%    | 35.3%                     | 7.3%  | 39.9%         | 6.4%       |           |
|           | 41-50            | 15.4%    | 30.8%                     | 9.6%  | 34.6%         | 9.6%       |           |
|           | 51-60            | 16.9%    | 34.8%                     | 3.4%  | 31.5%         | 13.5%      |           |
|           | >60              | 0.0%     | 57.1%                     | 0.0%  | 42.9%         | 0.0%       |           |

| Designation | Rural | 12.8% | 37.9% | 6.4% | 34.4% | 8.5% | 40.194870 | 0.0000001 |
| SN | 14.5% | 37.6% | 7.1% | 33.6% | 7.1% | 26.592384 | 0.008841 |
| NS | 19.2% | 37.5% | 2.5% | 30.8% | 10.0% | |
| ANS | 0.0% | 0.0% | 0.0% | 100.0% | 0.0% | |
| Others | 66.7% | 0.0% | 0.0% | 33.3% | 0.0% | |

| Sex | Resident | Urban | 30.9% | 11.3% | 2.9% | 28.9% | 26.0% | 10.466007 | 0.033268 |
|     | Rural    | 30.8% | 7.7% | 6.2% | 15.4% | 40.0% | |

| Education Qualification | Resident | Urban | 30.9% | 11.3% | 2.9% | 28.9% | 26.0% | 10.466007 | 0.033268 |
|                       | Rural    | 30.8% | 7.7% | 6.2% | 15.4% | 40.0% | |
rules in the hospital setting is available in the indexed literature. Secondly, our sample size was representative of nursing professionals across different levels of seniority and age group working in a tertiary care medical college hospital. Therefore, it will serve as an important yardstick for knowledge of solid waste management rules among nursing professionals.

**Limitation of this study**

There were some significant limitations with our study like it was a single center–based study and other multiple centers were not evaluated. Secondly, only one category of health care workers i.e., nursing professionals was included in the study; hence, the findings of this study cannot be generalized to all categories of health care workers.

**Take home message**

• This study has given insight into various facets of solid waste management rules, 2016 where nursing professionals performed well and those where considerable gaps exist.

• The knowledge about these rules is indispensable; hence, gap areas need to be addressed on a priority basis.

• Training at regular intervals on SWM Rules, 2016 should be held, so that nurses across all levels of seniority can learn about them.

• The health care workers are more aware of biomedical waste (M&H) rules, and the solid waste management rules are new to them.

• Therefore, it is recommended that all biomedical waste management training programs should also include general solid waste management rules.

**Declaration of patient consent**

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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**Conflicts of interest**

There are no conflicts of interest.

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