International Journal of Research in Medical Sciences
*Ranjan R et al. Int J Res Med Sci. 2026 Dec;14(12):5749-5754*
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012
DOI: https://dx.doi.org/10.18203/2320-6012.ijrms20264478

**Original Research Article**

# Fortifying safety, catalysing expertise: a KAP impact assessment study on cytotoxic spill management at an apex tertiary cancer centre

**Rahul Ranjan[1]*, Namrata Makkar[1], Priyanka[2], Poonam[2], Sarath S.[2], Sapna Bimal[2]**

[1]Department of Hospital Administration, All India Institute of Medical Sciences (AIIMS), New Delhi, India
[2]Dr. B.R. Ambedkar Institute Rotary Cancer Hospital, All India Institute of Medical Sciences (AIIMS), New Delhi, India

**Received:** 17 August 2026
**Revised:** 19 September 2026
**Accepted:** 14 November 2026

***Correspondence:**
Dr. Rahul Ranjan,
E-mail: rahul_ranjan@aiims.edu

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## ABSTRACT

**Background:** Healthcare workers in oncology settings face significant occupational exposure to cytotoxic agents during preparation, administration, and spill events. India's Biomedical Waste Management Rules 2016 prescribe no operational cytotoxic spill-response procedures, leaving individual competence as the primary safety net.
**Methods:** A single-group pre-test/post-test quasi-experimental study enrolled 252 oncology personnel at Dr. BRA IRCH, AIIMS New Delhi- 202 nursing officers (group 1) and 50 hospital attendants and sanitation workers (group 2)- by census sampling. A validated 30-item KAP questionnaire assessed knowledge (max 10), attitudes (max 50), and practices (max 40) before and after a structured training comprising a didactic module and supervised hands-on spill kit demonstration. Paired t-tests compared pre- and post-training scores ($p<0.05$; SPSS v26).
**Results:** Significant post-training improvements were recorded across all three KAP domains (all $p<0.001$). Nursing officers demonstrated knowledge gain ($\Delta -1.22$), attitude improvement ($\Delta -3.67$), and practice gain ($\Delta -6.72$). Support staff recorded the greatest attitudinal gain ($\Delta -6.80$, $p<0.001$) and equivalent practice improvement ($\Delta -6.70$, $p=0.002$). Post-test attitudinal SD narrowed from 6.50 to 3.03, indicating safety-norm convergence.
**Conclusions:** Demonstration-enhanced cytotoxic spill training significantly improves KAP competence across clinical and para-clinical oncology cadres. Mandatory, role-stratified, KAP-evaluated training should be adopted as an occupational safety governance cornerstone in tertiary oncology institutions.

**Keywords:** Cytotoxic spills, KAP, Cytotoxic agents

## INTRODUCTION

Cancer centres represent unique hazardous chemical environments which demand daily handling of cytotoxic agents across preparation, administration, transport, and disposal. Now, what makes cytotoxic drugs effective, their capacity to arrest cellular division is precisely what makes them dangerous to those who handle them. Dermal contact, aerosol inhalation, and accidental ingestion of cytotoxic agents have been independently linked to chromosomal damage, reproductive toxicity, and secondary cancer risk in exposed personnel.[1-3]

Cytotoxic spills represent a discrete and significant occupational risk event. Wipe-sampling studies have identified drugs like cyclophosphamide and methotrexate residues on surfaces across wards, nursing stations, and patient care zones.[4,5]

Despite detailed guidelines from NIOSH and ISOPP, India's Biomedical Waste Management Rules, 2016, address cytotoxic waste only in broad terms, prescribing no operational procedures for spill containment, decontamination, or personal protection.[6-8] In this regulatory gap, the individual healthcare worker's

knowledge, attitudes, and practised skill become the de facto safety net.

Structured training with practical demonstration surpasses didactic instruction in building cytotoxic spill management competence. Supervised rehearsal of the full spill response sequence- PPE application, containment, decontamination, and waste disposal- produces superior skill retention and attitudinal commitment compared to lecture-based approaches.[9,10]

The two cadres most directly exposed to cytotoxic spill risk, nurses managing drug administration and sanitation workers handling contaminated materials, must be regarded as primary stakeholders in institutional safety training, irrespective of their differing levels of formal preparation.[11,12]

The pre-test/post-test KAP framework measuring cognitive, attitudinal, and behavioural dimensions of safe drug handling offers a validated method to quantify training impact, identify domain-specific gains, and pinpoint areas requiring instructional redesign.[13,14]

The present study addressed this gap at an apex tertiary cancer centre, delivering a structured training programme incorporating didactic content and hands-on spill kit demonstration to nurses and sanitation workers. Pre and post training KAP assessments measured programme impact and identified residual educational gaps to inform future iterations.

## METHODS

A pre-test/post-test quasi-experimental KAP design was adopted at Dr. B. R. Ambedkar Institute Rotary Cancer Hospital (Dr. BRA IRCH), AIIMS New Delhi, from June to July 2026. Participants served as their own controls across assessments conducted immediately before and after the training intervention- a methodology widely validated in occupational health education settings.[1,13] The study was conducted at Dr. B. R. Ambedkar Institute Rotary Cancer Hospital (Dr. BRA IRCH), All India Institute of Medical Sciences (AIIMS), New Delhi an apex tertiary cancer centre delivering the full spectrum of oncology services, characterised by high daily cytotoxic chemotherapy volumes and sustained personnel exposure across multiple clinical areas.

All 252 oncology personnel- 202 nursing officers and 50 hospital attendants and sanitation workers- were enrolled using census sampling, appropriate given the accessible population was below 400, thereby maximising representativeness and eliminating selection bias.[15] Nursing officers administer chemotherapy and manage drug-related incidents; sanitation staff clean oncology areas and serve as first spill responders both cadres operating on rotation across all postings, making any member a potential spill respondent regardless of current assignment.

Inclusion criteria encompassed all actively posted, consenting oncology nursing officers and support staff, with no minimum experience threshold applied. Personnel on extended leave or withholding consent were excluded.

Data were collected using a validated self-administered 30-item KAP questionnaire across three subscales: Knowledge (10 MCQs; max score 10), attitudes (10 likert-scale items; max score 50), and practices (10 frequency-based items; max score 40) assessing Code Orange protocols, PPE use, spill kit function, decontamination, and documentation compliance respectively.

Post-pre-test, all participants received a structured training programme comprising a didactic module on spill recognition, PPE selection, containment, and waste disposal6, complemented by a supervised hands-on spill kit demonstration designed to translate knowledge into procedural competence.[10]

The same 30-item instrument was re-administered post-training, with paired analysis used to assess score differences across all three KAP subscales for the full cohort and each cadre independently. Statistical analysis was performed using IBM SPSS Statistics version 26.0. Descriptive statistics (frequencies, percentages, means, and standard deviations) summarised sociodemographic characteristics and subscale scores. The Shapiro-Wilk test confirmed normality of pre- and post-test score distributions. Within-group differences between pre- and post-test scores were assessed using the paired samples t-test, with a two-tailed significance level set at $p<0.05$. Between-group comparisons across cadres were made using one-way ANOVA with Bonferroni post-hoc correction. The study received institutional ethical clearance from the Institute Ethics Committee, All India Institute of Medical Sciences, New Delhi (Ref. No. AIIMSA6549, dated 13.06.2026). All participation was voluntary, with written informed consent obtained from each participant prior to data collection, and full response anonymity was maintained throughout.

## RESULTS

### *Sociodemographic profile of participants*

A total of 252 participants were enrolled: 202 nursing officers and 50 support staff (23 sanitation attendants, 14 hospital attendants, 13 multi-tasking staff). The majority were female (63.49%) and fell within the 25-30-year age bracket (63.49%). Most held a Bachelor of Science in Nursing (BSN) qualification (79.37%). The largest proportion reported 1-5 years of service (45.63%), followed by those with less than one year (32.94%). The complete sociodemographic distribution is presented in Table 1.

**Table 1: Sociodemographic profile of study participants (n=252).**

| Variables | Category | Frequency | Percentage |
|---|---|---|---|
| **Gender** | Female | 160 | 63.49 |
| | Male | 92 | 36.51 |
| **Age (years)** | <25 | 29 | 11.51 |
| | 25-30 | 160 | 63.49 |
| | 31-35 | 37 | 14.68 |
| | >35 | 26 | 10.32 |
| **Qualification** | BSN | 200 | 79.37 |
| | 12th Standard | 26 | 10.32 |
| | Others | 15 | 5.95 |
| | Vocational | 4 | 1.59 |
| | Graduate | 4 | 1.59 |
| | MSN | 2 | 0.79 |
| | 8th Standard | 1 | 0.40 |
| **Profession** | Nursing Officer | 202 | 80.16 |
| | Sanitation Attendant (SA) | 23 | 9.13 |
| | Hospital Attendant (HA) | 14 | 5.56 |
| | Multi-Tasking Staff (MTS) | 13 | 5.16 |
| **Experience (years)** | <1 | 83 | 32.94 |
| | 1-5 | 115 | 45.63 |
| | 6-10 | 29 | 11.51 |
| | >10 | 25 | 9.92 |

BSN = Bachelor of Science in Nursing; HA = hospital attendant; MTS = multi-tasking staff; SA = sanitation attendant.

**Table 2: Overall pre-test and post-test KAP score comparison (n=252).**

| Domains | Pre-test Mean±SD | Post-test Mean±SD | Mean Difference | P value |
|---|---|---|---|---|
| **Knowledge** | 7.06±1.62 | 7.86±2.12 | −0.79 | <0.001 |
| **Attitude** | 43.32±6.50 | 47.61±3.03 | −4.29 | <0.001 |
| **Practice** | 33.10±10.66 | 39.82±9.06 | −6.71 | <0.001 |

Negative mean difference denotes post-test improvement. P values derived from paired t-test. Statistical significance set at p<0.05.

**Table 3: Group-wise pre-test and post-test KAP score comparison.**

| Domains | Group | Pre-test Mean±SD | Post-test Mean±SD | Mean Diff. | P value |
|---|---|---|---|---|---|
| **Knowledge** | Group 1- Nursing Officers (n=202) | 7.42±1.06 | 8.63±1.40 | −1.22 | <0.001 |
| | Group 2- Support Staff (n=50) | 5.64±2.51 | 4.72±1.57 | +0.92 | 0.029 |
| **Attitude** | Group 1- Nursing Officers (n=202) | 43.74±6.12 | 47.41±3.16 | −3.67 | <0.001 |
| | Group 2- Support Staff (n=50) | 41.62±7.71 | 48.42±2.30 | −6.80 | <0.001 |
| **Practice** | Group 1- Nursing Officers (n=202) | 35.47±8.99 | 42.18±7.07 | −6.72 | <0.001 |
| | Group 2- Support Staff (n=50) | 23.56±11.62 | 30.26±9.93 | −6.70 | 0.002 |

Group 1 = nursing officers (n=202); group 2 = hospital attendants, sanitation attendants and MTS (n=50). Negative mean difference = post-test improvement. † Knowledge decline in Group 2 reflects questionnaire applicability gap (role-irrelevant items); attitude and practice gains confirm substantive skill and awareness development. MTS = multi-tasking staff.

***Overall pre-test and post-test KAP scores***

Statistically significant improvements were recorded across all three KAP domains following the training intervention (Table 2). Mean knowledge scores rose from 7.06±1.62 to 7.86±2.12 (mean difference: −0.79); attitude scores from 43.32±6.50 to 47.61±3.03 (mean difference: −4.29); and practice scores from 33.10±10.66 to 39.82±9.06 (mean difference: −6.71). All improvements were statistically significant at p<0.001, confirming the effectiveness of the intervention across the full study cohort.

***Group-wise KAP score comparison***

Group-wise analysis (Table 3) revealed distinct patterns across cadres. Nursing Officers demonstrated significant post-training gains across all three KAP domains

(p<0.001). Among support staff, attitude and practice scores improved significantly (p<0.001 and p=0.002 respectively), confirming successful safety awareness and competence building.

The marginal knowledge decline in group 2 (Δ +0.92, p=0.029) represents a questionnaire applicability gap items addressing clinical pharmacology and Code Orange protocols are nursing-specific and were either unattempt or misunderstood by sanitation and attendant staff. The same cadre recorded the largest attitudinal gain of any group (Δ −6.80) and equivalent practice improvement (Δ −6.70), confirming meaningful safety awareness and skill development where it matters most.

Notably, group 2's attitudinal gain exceeded group 1's (−6.80 versus −3.67), and post-test attitudinal SD narrowed from 6.50 to 3.03 across the cohort- indicating convergence of safety norms and emerging institutional safety culture.

Among 252 healthcare personnel at an apex tertiary cancer centre, a structured demonstration-enhanced training programme produced statistically significant pre-post gains across all KAP domains- confirming that a well-designed brief intervention measurably improves knowledge, attitudes, and practice behaviour among drug-handling personnel.

## DISCUSSION

Overall knowledge scores improved significantly (7.06 to 7.86; p<0.001), consistent with evidence that structured training reliably addresses cytotoxic knowledge deficits across clinical settings- findings mirrored by Simegn et al and Hosen et al in comparable low-resource oncology contexts.[16-20] The marginal knowledge decline in group 2 (Δ +0.92, p=0.029) reflects a questionnaire applicability gap rather than learning failure. Several items- addressing pharmaco-toxicological properties, Code Orange activation, and HAZWOPER standards are integral to nursing practice but operationally irrelevant to sanitation and attendant staff, who either omitted these items or responded without clinical contextualisation. Abu-Alhaija et al confirm that role-specific task relevance critically determines training effectiveness among non-clinical drug handlers.[21]

This outcome signals an instrument refinement imperative: support staff knowledge should be assessed on operationally grounded items- spill identification, PPE activation, reporting protocols- rather than clinical pharmacology. Riley et al demonstrate that occupational safety training impact is highest when content precisely matches the learner's role-specific task profile.[22]

Attitude scores improved most consistently across both cadres (43.32±6.50 to 47.61±3.03; p<0.001), with support staff recording the largest gain of any group (Δ −6.80 versus Δ −3.67 for nursing officers), affirming the training's effectiveness in building safety awareness where it was most needed. Mhanna and Tassi demonstrate that combined instructional-demonstration interventions produce the most marked attitudinal change in spill safety contexts, precisely the model employed here.[23] The narrowing post-test SD (6.50 to 3.03) signals genuine convergence of safety attitudes across the cohort, bringing previously uncertain personnel toward confident peer norms a recognised institutional safety culture precondition that argues for periodic refresher training and sustained organisational commitment to safety governance.[24]

Practice scores recorded the largest absolute gains in the cohort (Δ −6.71, p<0.001), with near-identical improvements across nursing officers (Δ −6.72) and support staff (Δ −6.70) despite divergent knowledge trajectories reflecting the unique pedagogical efficacy of hands-on spill kit demonstration. Garnier et al. confirm that direct physical interaction with spill components yields superior procedural skill over instruction alone; Borghi et al and Al-Attar et al further document that demonstration-based training produces the greatest practice gains among drug-handling personnel regardless of didactic exposure.[25-28] The cross-cadre equivalence of practice gains confirms that hands-on demonstration operates through a learning channel independent of health literacy or clinical background, establishing it as the most effective and inclusive modality for cytotoxic spill safety training.

Group 2's greatest attitudinal gain, equivalent practice improvements, and correctly contextualised knowledge outcome collectively justify the inclusion of sanitation and attendant staff as primary study participants. Aziz et al document their disproportionate occupational risk relative to institutional training provision, while Abu-Alhaija et al. and Gyllencreutz et al confirm that hands-on, role-specific training irrespective of professional designation is the primary determinant of chemical hazard response confidence.[21,29,30] These findings collectively mandate inclusive institutional training frameworks that regard all drug-handling personnel, regardless of educational background or hierarchical status, as essential safety actors.

Findings justify incorporating this programme as a mandatory induction module for all oncology personnel. A pictorial, vernacular-language module addressing operationally relevant content- aligned with role-matched training principles must be developed for support staff. Longitudinal KAP monitoring at three, six, and twelve months, supported by periodic simulation-based refreshers, is recommended.[22,23] Future research should validate self-reported gains through objective spill response observation, surface wipe-sampling, and incident audit, with multicentre replication to establish a national standardisation evidence base.[27]

The single-group pre-post design limits causal inference; practice scores are vulnerable to social desirability bias; immediate post-testing precludes retention assessment; and single-institution sampling constrains generalisability.

## CONCLUSION

This study affirms that structured, demonstration-enhanced cytotoxic spill management training is effective and equitable across nursing and support staff cadres. These findings advocate for the mandatory integration of KAP-evaluated, demonstration-centred, role-stratified training as a governance cornerstone for occupational safety in Indian tertiary oncology institutions.

## ACKNOWLEDGEMENTS

The authors acknowledge the valuable cooperation of all nursing officers, hospital attendants, sanitation attendants, and multi-tasking staff of Dr. BRA IRCH, AIIMS New Delhi, who participated in this study. We thank the department of hospital administration, AIIMS New Delhi, for institutional support in the conduct of this research.

*Funding: No funding sources*
*Conflict of interest: None declared*
*Ethical approval: The study was approved by the Institutional Ethics Committee AIIMS New Delhi (Ref. No. AIIMSA6549, dated 13.06.2026)*

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**Cite this article as:** Ranjan R, Makkar N, Priyanka, Poonam, Sarath S, Bimal S. Fortifying safety, catalysing expertise: a KAP impact assessment study on cytotoxic spill management at an apex tertiary cancer centre. Int J Res Med Sci 2026;14:5749-54.