ENHANCING SUSTAINABILITY IN CONTRAST MEDIA USE: KNOWLEDGE, IMPLEMENTATION AND TRAINING FOR RADIOLOGIC TECHNOLOGISTS

Abinash Jha, Rajesh Prasad Yadav, Suraj Sah

Department of Radiology and Imaging, National Academy of Medical Sciences, Bir Hospital, Mahabouddha, Kathmandu, Nepal

ABSTRACT

Iodinated contrast media (ICM) are vital for computed tomography and other diagnostic imaging, but their use raises concerns about environmental contamination, dependence on limited iodine resources, rising costs, and supply-chain risks. Radiologic technologists are central to contrast preparation, administration, and protocol implementation. However, there is limited evidence on their knowledge and practices regarding sustainable contrast use in low- and middle-income countries. This study aims to assess knowledge, self-reported practices, training exposure, institutional support, and perceived barriers to sustainable contrast media use among radiologic technologists in Nepal. A cross-sectional online survey was administered to Nepal Health Professional Council–registered radiologic technologists employed in government, teaching, and private imaging facilities. The structured questionnaire evaluated knowledge and awareness, contrast-related practices, training exposure, institutional provisions, environmental considerations, and perceived barriers. Knowledge was defined as the correct identification of weight-based contrast dosing as a sustainable practice. A composite practice score (0–3) assessed renal function evaluation, use of weight-based dosing, and involvement in contrast selection. Data were analyzed using descriptive statistics and chi-square tests. Of 205 respondents, 92.2% demonstrated good knowledge and 82.9% reported good practice (11.2% moderate, 5.9% poor). Renal function assessment prior to contrast administration (97.6%) and weight-based dosing (94.6%) were commonly reported, and 84.4% were involved in selecting contrast type and dose. Awareness that contrast media can pollute water resources was 76.1%, and support for eco-friendly institutional policies was 92.2%. However, only 16.6% had received training on contrast sustainability and 29.3% reported an institutional disposal protocol, despite 91.7% expressing willingness to attend training. Previous training was associated with knowledge ($p = 0.046$) but not practice ($p = 0.259$). Radiologic technologists in Nepal show high knowledge and generally favorable self-reported practices in sustainable contrast media use, despite limited formal training and inconsistent institutional support. Targeted education, practical guidelines, and stronger organizational systems may support the adoption of more sustainable, environmentally responsible imaging services.

KEYWORDS

Computed tomography, environmental impact, Iodinated contrast media, radiologic technologists, sustainable healthcare

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CORRESPONDING AUTHOR

Abinash Jha,
Associate Professor
Department of Radiology and Imaging,
National Academy of Medical Sciences,
Bir Hospital, Mahabouddha, Kathmandu, Nepal
Email: jhaabinash90@gmail.com
Orcid No: https://orcid.org/0009-0001-0392-4845
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INTRODUCTION

Iodinated contrast media (ICM) are integral to contemporary CT and other imaging modalities, improving diagnostic accuracy and confidence. Global CT utilization and ICM consumption continue to rise, raising concerns about safety, supply security, and environmental impact.[1-5] Most ICMs are excreted largely unchanged and are only partially removed by conventional wastewater treatment, with residues detected in surface and drinking water.[1,6-9] Alongside these environmental concerns, increasing ICM use depends on a finite iodine supply and is vulnerable to supply-chain disruption.[1,2,4,5]

Professional bodies have proposed strategies to optimise ICM use, including patient-specific and weight-based dosing, protocol optimization, dose-saving technologies, vial sharing and, where feasible, recovery or recycling.[1-3,5,8-14] These recommendations have largely been developed in high-income settings and are often directed at radiologists and institutional leaders.[1-3] In routine practice, however, radiologic technologists prepare and administer ICM, implement protocols, adjust scan parameters and shape day-to-day practices around dose optimization, waste minimization and disposal.[1,6,8,10]

Despite this central role, little is known about technologists' knowledge, practices and training needs regarding sustainable contrast media use, particularly in low- and middle-income countries.[1,2,8,10] Nepal, a lower-middle-income country with expanding CT services but constrained budgets and limited formal training in contrast sustainability, exemplifies this gap.[1,2,5,9]

This study aimed to assess knowledge, self-reported practices, training exposure, institutional support and perceived barriers related to sustainable contrast media use among Nepal Health Professional Council (NHPC)–registered radiologic technologists in Nepal.

MATERIALS AND METHODS

Study design and setting: A cross-sectional observational study was conducted between July and September 2025 among radiologic technologists working in diagnostic imaging departments of government, teaching and private hospitals/centers in Nepal, where contrast media are routinely used.

Study population, eligibility and sampling: Participants were NHPC–registered radiologic technologists who: (i) held at least a bachelor's degree in radiologic technology; (ii) were currently working in clinical settings where contrast media are used; and (iii) were directly or indirectly involved in contrast administration and protocol implementation. Technologists not registered with NHPC, those working exclusively in non-contrast imaging, students and interns not independently involved in contrast procedures and questionnaires that were substantially incomplete or internally inconsistent were excluded.

The required sample size was calculated using Cochran's formula for a single proportion (95.0% confidence level, 5.0% margin of error, p = 0.5) and adjusted for a source population of approximately 700 NHPC-registered technologists, yielding a target sample of 249. A final sample of 205 respondents was obtained through convenience sampling via NHPC contact lists and professional networks, with email invitations.

Questionnaire development and content: A structured questionnaire was developed following a review of literature on iodinated contrast media use, sustainability, environmental impact and radiology practice, and consultation with radiology and public health experts to ensure content relevance. Draft items were reviewed for clarity and feasibility. The questionnaire was pilot-tested among a small group of eligible radiologic technologists who were not included in the final analysis; feedback was used to refine wording, length and response options. Formal psychometric validation (e.g., internal consistency and test–retest reliability) was not undertaken.

The final questionnaire comprised five sections:

1. Socio-demographic and professional characteristics (age, gender, education, work experience and workplace type);
2. Knowledge and sustainable contrast media use (familiarity with "sustainable contrast media use," guideline awareness and identification of a sustainable practice);
3. Current practices (renal function assessment, weight-based dosing, involvement in selecting contrast type/dose, multidisciplinary meetings and protocol review);
4. Training exposure and institutional support (previous/current training access, willingness to attend training, preferred training modalities and topics); and
5. Environmental aspects, attitudes and perceived barriers (environmental

awareness, disposal protocols, eco-friendly handling training, support for eco-friendly policies and barriers).

Response options and operational definitions: Attitudes and perceptions were measured using five-point Likert-scale items (strongly agree, agree, neutral, disagree, strongly disagree). For descriptive reporting, frequencies and percentages were presented; for selected analyses and tables, responses were collapsed into three groups (agree/strongly agree, neutral, disagree/strongly disagree). Likert responses were coded on a scale of 1 to 5 for data entry and analysis.

Practice indicators were collected using dichotomous yes/no responses. Multiple-response items (e.g., types of contrast media used, preferred training modalities, and perceived barriers) were summarized as counts and percentages, with N =205 as the denominator.

Knowledge classification: Knowledge was classified as good if the respondent correctly identified weight-based contrast dosing as a sustainable practice; all other responses were classified as poor.

Practice classification: Practice was assessed using three items: renal function assessment before contrast administration, use of weight-based dosing and involvement in selecting contrast type and dose. Yes responses were coded 1 and No responses 0, summed to create a composite practice score (0–3) and categorized as good (3), moderate (2) or poor (0–1).

Data collection procedures: The questionnaire was administered as a self-completed online survey using Google Forms. The survey link, participant information sheet and electronic consent statement were distributed via email and professional networks. Participants provided electronic consent before accessing survey questions. No personal identifiers were collected, and responses were submitted anonymously. Two reminder messages were disseminated during the data collection period to enhance participation.

Ethical considerations: Ethical approval was obtained from the Nepal Health Research Council (NHRC) (Ref. No. 2369; Protocol Registration No. 146-2025). The protocol was approved through an expedited review process and classified as minimal risk. Participation was voluntary and anonymous, and electronic informed consent was obtained prior to survey completion.

Data management and statistical analysis: Data were exported from Google Forms into Microsoft Excel and then imported into IBM SPSS-25 for analysis. Data were checked for completeness and internal consistency, and responses with substantial missing data or contradictory answers were excluded.

Continuous variables were summarized using means and standard deviations (and medians and ranges where appropriate). Categorical variables were summarized using frequencies and percentages. Associations between knowledge or practice category and selected variables (education level, workplace type and previous training exposure) were examined using chi-square tests, with $p < 0.05$ considered statistically significant.

RESULTS

A total of 205 radiologic technologists participated. Age was available for 192 respondents; the mean age was 29.7±7.0 years (range 20–55). Valid work-experience data were available for 189 respondents after conversion of month-based entries to years and exclusion of one implausible value; mean work experience was 6.7±5.8 years (median 5.0, IQR 2.0–9.0; range 0.1–32.0). Females constituted 116 (56.6 %) and most participants held a Bachelor's degree (173; 84.4 %). The majority were employed in government facilities 133 (64.9 %) (Table 1).

Regarding knowledge and awareness, 174 (84.9%) reported having heard the term "sustainable contrast media use" and 139

Table 1: Sociodemographic characteristics of respondents (n=205)

Characteristics	Category	n (%)
Age (years)	<30	124 (60.5)
	30–40	54 (26.3)
	>40	14 (6.8)
Sex	Male	88 (42.9)
	Female	116 (56.6)
	Other	1 (0.5)
Education	Bachelor	173 (84.4)
	Master	32 (15.6)
Workplace type	Government	133 (64.9)
	Teaching hospital	33 (16.1)
	Private	30 (14.6)
	Other	9 (4.4)
Work experience (years)	<2	30 (14.6)
	2–6	76 (37.1)
	>6	83 (40.5)

*Age (years): Missing 13 (6.3%), Work experience: Missing 16 (7.8%)

Table 2: Knowledge and awareness regarding sustainable contrast media use (n=205)		
Item	**Response**	**n (%)**
Heard the term "sustainable contrast media use"	Yes	174 (84.9)
Aware of any guideline on sustainable contrast media use	Yes	139 (67.8)
Example of sustainable practice	Weight-based contrast dosing	189 (92.2)
	Fixed volume for all patients	7 (3.4)
	Disposing contrast in open drains	6 (2.9)
	Ignoring renal function reports	3 (1.5)
Knowledge category	Good	189 (92.2)
	Poor	16 (7.8)

Table 3: Self-reported practices and contrast media used (n=205)		
Item	**Response**	**n (%)**
Evaluate renal function before contrast use	Yes	200 (97.6)
Use weight-based contrast dosing	Yes	194 (94.6)
Involved in selecting contrast type/dose	Yes	173 (84.4)
Need multidisciplinary meetings on contrast protocols	Yes	163 (79.5)
Contrast protocol compliance reviews	Regularly	36 (17.6)
	Occasionally	85 (41.5)
	Rarely	57 (27.8)
	Never	27 (13.2)
Practice category (3-item composite)	Good	170 (82.9)
	Moderate	23 (11.2)
	Poor	12 (5.9)
Contrast media used in facility*	Iodinated	187 (91.2)
	Gadolinium-based	161 (78.5)
	Barium sulphate	57 (27.8)
	Others	19 (9.3)

*Multiple responses permitted

(67.8%) reported awareness of any guideline on sustainable contrast media use. When asked to identify an example of sustainable contrast practice, 189 (92.2%) correctly selected weight-based contrast dosing. Using this criterion, 189 (92.2%) were classified as having good knowledge (Table 2).

With respect to reported practices, 200 (97.6%) evaluated renal function before contrast use, 194 (94.6%) used weight-based dosing and 173 (84.4%) were involved in contrast selection. Based on the 3-item composite practice score, 170 (82.9%) had good practice, 23 (11.2%) had moderate practice and 12 (5.9%) had poor practice. Contrast protocol compliance reviews were performed regularly in 36 (17.6%), occasionally in 85 (41.5%), rarely in 57 (27.8%) and never in 27 (13.2%) (Table 3).

Iodinated contrast was the most commonly reported contrast agent in facilities (187;91.2%), followed by gadolinium-based agents (161;78.5%) and barium sulphate (57;27.8%). (Multiple responses permitted) (Table 3).

Attitudes were generally favourable: 181 (88.3%) agreed that sustainable contrast use reduces environmental harm, 193 (94.1%) agreed that institutional policies are necessary and 197 (96.1%) agreed that training improves sustainability (Table 4). Environmental awareness was high, with 156 (76.1%) reporting that contrast media can pollute water resources,

Table 4: Attitudes, training and environmental/disposal aspects (n=205)

Domain	Item	n (%)
Attitude statements (Agree/Strongly agree)	Reduces environmental harm	181 (88.3)
Training	Institutional policies are necessary	193 (94.1)
	Training improves sustainability	197 (96.1)
	Department prioritizes sustainable practices	122 (59.5)
	Received training on contrast sustainability (Yes)	34 (16.6)
	Access to training (Yes)	33 (16.1)
	Would attend training if available (Yes)	188 (91.7)
Preferred training mode	Workshops	75 (36.6)
	In-service training	46 (22.4)
	Online sessions	45 (22.0)
	Seminars	39 (19.0)
Training topics*	Dose optimization	187 (91.2)
	Patient safety	170 (82.9)
	Environmental safety	163 (79.5)
	Cost-effectiveness	126 (61.5)
	Regulations	121 (59.0)
Environmental/ disposal	Aware contrast can pollute water resources (Yes)	156 (76.1)
	Institution has a disposal protocol (Yes)	60 (29.3)
	Trained on eco-friendly contrast handling (Yes)	54 (26.3)
	Improper disposal causes pollution (Agree/Strongly agree)	194 (94.6)
	Support eco-friendly institutional policies (Agree/ Strongly agree)	189 (92.2)

*Multiple responses permitted for training topics

Table 5: Barriers to sustainable contrast media use (n=205)

Barrier	n (%)
Lack of guidelines*	159 (77.6)
Lack of training*	157 (76.6)
Lack of awareness*	126 (61.5)
Time constraints*	85 (41.5)
Cost issues*	72 (35.1)
Institutional resistance (Yes)	121 (59.0)
Technology limitations (Yes)	110 (53.7)

*Multiple responses permitted.
"Other/unspecified responses were reported but are not shown."

and 194 (94.6) agreeing that improper disposal causes pollution. However, only 60 (29.3%) reported an institutional protocol for contrast disposal and 54 (26.3%) reported training on eco-friendly contrast handling (Table 4).

Training exposure was limited: 34 (16.6%) had received training on contrast sustainability and 33 (16.1%) reported access to training, while 188 (91.7%) indicated willingness to attend training if available (Table 4).

The most frequently reported barriers were lack of guidelines (159;77.6%) and lack of training (157;76.6%), followed by lack of awareness (126;61.5%), time constraints (85;41.5%) and cost issues (72;35.10%). Institutional resistance

Table 6: Factors associated with knowledge and practice (chi-square tests)

Association	Test statistic	p-value
Training × knowledge category	$\chi^2(1)=3.970$	0.046
Education × knowledge category	$\chi^2(1)=0.517$	0.472
Workplace type × practice category	$\chi^2(6)=4.743$	0.577
Training × practice category	$\chi^2(2)=2.702$	0.259

was reported by (121;59.0%) and technology limitations by (110;53.7%) (Table 5).

In bivariate analyses, previous training on contrast sustainability was associated with knowledge category ($\chi^2(1)=3.970$, $p = 0.046$). Education level was not associated with knowledge ($\chi^2(1)=0.517$, $p = 0.472$). Practice category was not associated with workplace type ($\chi^2(6)=4.743$, $p = 0.577$) or previous training ($\chi^2(2)=2.702$, $p = 0.259$) (Table 6).

DISCUSSION

This nationwide online cross-sectional survey suggests that radiologic technologists in Nepal reported high knowledge as operationally defined (92.2%) and generally favourable self-reported practices (82.9%) related to sustainable iodinated contrast media (ICM) use. Key behaviours relevant to patient safety and stewardship were common, including renal function assessment (97.6%) and weight-based dosing (94.6%) and most respondents reported involvement in selecting contrast type and dose (84.4%). However, structured training exposure was low (16.6%) and fewer than one-third reported the presence of an institutional protocol for contrast disposal (29.3%), despite high willingness to attend training (91.7%) and strong support for eco-friendly policies (92.2%). Reported barriers were predominantly organizational, particularly lack of guidelines and training, indicating a gap between individual readiness and system-level support.

These findings align with calls for improved contrast stewardship emphasizing patient-specific dosing, protocol optimization, and conservation amid increasing utilization, environmental concerns, and supply vulnerability.[1-3,8,10] Health system–level programs have demonstrated sustained reductions in intravenous contrast utilization, underscoring the role of institutional governance and workflow redesign in addition to individual competence.[3] Similarly, guidance developed during iodinated contrast shortages highlights the importance of coordinated practice-management strategies, multidisciplinary implementation, and monitoring to maintain service continuity.[2,4,5] The low reporting of disposal protocols in this study is consistent with evidence that hospital-level ICM waste management and environmentally responsible handling remain inconsistent and often require practical, standardized pathways.[6,8] Inventory and packaging decisions also influence waste and sustainability, with diversification strategies and delivery system choices demonstrating measurable environmental and cost implications.[9,11] Emerging CT technologies, including photon-counting and spectral approaches, may enable reduced contrast volumes in selected indications, although feasibility and cost-effectiveness may vary by setting.[12-14]

From an implementation perspective, the observed association between prior training and knowledge but not practice—may indicate that some practices are driven primarily by routine clinical protocols, workload constraints, or resource availability rather than formal education alone. Accordingly, strengthening sustainable ICM use in Nepal will likely require a combination of structured, practice-oriented training, locally adapted guidelines, and standardized procedures for contrast handling, waste minimization, and disposal embedded into routine workflows.[1,2,6,8,10] Department-level governance (e.g., multidisciplinary protocol review, procurement and workflow alignment, and routine monitoring of utilization and wastage) may improve consistency and resilience, particularly during supply disruptions.[2-5,11]

This study has limitations. The cross-sectional design precludes causal inference; convenience sampling and online participation may limit generalizability; and self-reported behaviors may overestimate desirable practices. Knowledge was operationalized using a single key item, and formal psychometric validation of the questionnaire was not performed. Future studies should incorporate objective audits of contrast consumption and waste, and evaluate the impact of training and protocol interventions on clinical, operational, and environmental outcomes.[3,6,8]

Radiologic technologists in Nepal demonstrated high knowledge as operationally defined and generally favorable self-reported practices related to sustainable iodinated contrast media use, particularly routine renal function assessment and weight-based dosing. However, formal training on contrast sustainability and eco-friendly handling, and the availability of institutional protocols for contrast disposal were limited. Organizational barriers especially lack of guidelines and training were frequently reported, indicating a gap between individual readiness and system-level support. Strengthening structured, practice-oriented education, developing locally feasible contrast stewardship guidelines, and implementing standardized procedures for contrast handling, waste minimization, and disposal may support the delivery of more sustainable and environmentally responsible imaging services in Nepal.

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