

Radiation therapists' knowledge and training needs regarding pelvic organ preparation in endometrial cancer radiotherapy: a multicenter cross-sectional survey of the radiotherapy health workforce

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Abstract

Background

For endometrial cancer (EC) patients receiving radiotherapy, optimal pelvic organ (bladder and rectum) preparation is essential for treatment accuracy, target coverage, and organ-at-risk sparing. Radiation therapists (RTs) are the frontline staff responsible for verifying patient preparation and image-guided radiotherapy (IGRT) setup prior to each fraction; however, the magnitude of the subjective-objective knowledge gap and the training needs regarding pelvic organ preparation in this workforce have not been quantified at a national scale. This represents a modifiable health-system and workforce-competence gap with direct implications for quality of care.

Methods

A cross-sectional, mixed-methods online survey was conducted from 1 May to 30 June 2025 among 375 radiation therapists across 23 centers nationwide; quantitative and qualitative responses were analyzed. A 10-point Likert scale categorized qualitative responses.

Results

242 therapists from 20 centers completed the survey (response rate, 64.5%). Although therapists reported high subjective confidence, objective questions revealed low correct rates (range: 10.4%–61.8%). Therapists showed high awareness of image-guided radiotherapy (IGRT) (mean, 8.95) but limited use of IGRT and monitoring devices. Only 68.6% (166/242) reported prior training. In a post-hoc subgroup analysis, prior training was not associated with significantly higher objective accuracy on the specialised questions, although trained therapists reported higher subjective confidence. Lack of training opportunities and time constraints were the greatest barriers. Respondents endorsed enhanced training (mean, 8.90), preferring hands-on short intensive sessions. The most required topic was the detailed extent of bladder filling and rectal emptying (96.3%).

Conclusions

A gap between subjective confidence and objective pelvic-organ-preparation knowledge was identified among Chinese radiation therapists. Future training with hands-on practice through short, intensive sessions on the topic of detailed extent of bladder filling and rectal emptying is most desired. Notably, in a post-hoc subgroup analysis, prior training was linked to higher self-rated confidence but not to greater objective accuracy, indicating that training quality—rather than mere exposure—is what matters and pointing to a curriculum blind spot. Findings generalize to countries where therapist training overlaps with diagnostic imaging rather than radiation oncology.

Background

The accuracy of pelvic organ preparation is not merely a clinical detail but a determinant of radiotherapy delivery quality, directly influencing the reproducibility of patient positioning, the validity of IGRT image registration, and ultimately target dose coverage. For patients with endometrial cancer (EC), surgery is the primary radical treatment. For those with postoperative risk factors, adjuvant radiotherapy may provide clinical benefit (1–3). Radiation therapy (RT) can be delivered using external beam radiotherapy (EBRT) or vaginal cuff brachytherapy (VBT) to areas at high risk of recurrence. In both EBRT and VBT, the vaginal cuff is a critical treatment site. Located between the bladder and rectum, changes in bladder filling and rectal emptying may alter the position of the vaginal cuff, potentially compromising treatment accuracy(4). Even with adequate patient compliance, suboptimal bladder filling or rectal distension may result in a larger portion of bladder or rectal tissue being exposed to radiation, thereby increasing the risk of cystitis and proctitis(5–7). Moreover, insufficient bladder filling fails to displace the bowel bag that descends into the pelvic cavity, resulting in larger radiation exposure volumes of the bowel and consequently more severe intestinal toxicity. As demonstrated in the EMBRACE study(8), the bladder filling protocol should shift from the conventional "high-volume filling" approach to an "individualized bladder volume" strategy, emphasizing reproducibility rather than absolute volume. Regarding rectal emptying, multiple studies and guidelines have established specific requirements(8, 9). The protocol recommended maintaining a rectal diameter ≤ 2 cm through low-residue diet and other measures. Auxiliary assessments such as image-guided verification, ultrasound and digital rectal examination were advised to evaluate pelvic organ preparation status.

Radiation therapy is prepared and delivered by a multidisciplinary team consisting of radiation oncologists, radiotherapy physicists, and radiation therapists (10). Radiation therapists physically deliver the treatment plans developed by radiation oncologists and medical physicists. They serve as frontline personnel who directly assess patients' pelvic organ preparation adherence prior to each treatment and determine treatment feasibility. It should be noted that in China, radiation therapists are typically graduates of diagnostic radiography, medical imaging technology, or nuclear medicine programs(11). These programs contain virtually no dedicated theoretical instruction specific to radiotherapy clinical practice. Before entering clinical practice, most therapists have not received systematic education and training in radiation therapy. To date, no studies have investigated whether they possess adequate knowledge of pelvic organ preparation protocols, the training required to improve their clinical skills, or how such training programs should be structured.

To address this gap, the present study was conducted as part of a nationwide multicenter clinical trial on molecular-subtype-guided adjuvant radiotherapy for postoperative EC patients. Based upon this research, we evaluated radiation therapists' knowledge of patients' pelvic organ preparation adherence prior to radiotherapy among multiple national radiotherapy centers. Additionally, we assessed their educational requirements and optimal training content in this domain

Methods

Study design and setting

A cross-sectional, mixed-methods study was conducted using an anonymous, self-administered online questionnaire distributed to 375 radiation therapists across 23 centers nationwide. These centers are all participating centers in a prospective, multicenter clinical trial (ClinicalTrials.gov, NCT05524389, registered Feb. 5, 2024). Respondents completed the survey on electronic devices. The survey remained open from 1 May to 30 June 2025, with weekly reminders issued during the final three weeks of June. Each participant was able to answer the survey only once.

Participants and Questionnaire

Inclusion criteria were: currently employed as a radiation therapist; prior experience operating equipment for pelvic EBRT or VBT; and willingness and ability to complete the 15-minute questionnaire.

There was no consensus on the appropriate methodology to assess therapists' knowledge of patients' pelvic organ preparation adherence. Therefore, we designed a 42-item self-produced questionnaire (Suppl. 1). During the questionnaire development phase, we engaged in focused discussions with five senior radiation therapists (minimum 10 years of clinical experience) to evaluate: (a) subjective assessment of therapists' knowledge of patients' pelvic organ preparation adherence, (b) objective assessment of therapists' knowledge of patients' pelvic organ preparation adherence, (c) awareness of IGRT, (d) specific training requirements. The questionnaire was subsequently evaluated by 30 medical researchers active in the multicenter study. For the objective assessment, five specialized medical questions covering clinical radiation therapy, radiation physics, and pelvic anatomy were developed. Content validity was established through review by 10 medical experts, with an accuracy rate exceeding 90% among 20 clinical professionals. Test-retest reliability was assessed by 15 experienced radiation therapists from different participating centers. The questionnaire was reviewed using a think-aloud method (12). It consisted of 42 questions divided into six sections, including multiple-choice, single-choice, and qualitative items. For multiple-choice questions, all answers had to be correct to be considered a correct response. A 10-point Likert scale was used to categorize qualitative answers.

Data collection and statistical analysis

All research data was collected and processed into identifiable electronic data. A completeness check was conducted after the questionnaires were submitted, and only responses where the first section was completed were analyzed. For continuous variables, the Shapiro-Wilk test was performed to distinguish between normally distributed and non-normally distributed data. For normally distributed data, the t-test was used. For non-normally distributed data, the Kruskal-Wallis test was used for inter-group comparison. Statistical analysis was performed using the chi-square test for categorical variables. Qualitative data from open-ended questions were analyzed using thematic analysis based on Braun and Clarke's six-phase framework(13), involving familiarization with data, generating initial codes, searching

for themes, reviewing themes, defining and naming themes, and producing the report. All analyses were performed using SPSS software (version 22.0; SPSS Inc., Chicago, IL).

Results

A total of 242 participants from 20 centers completed the survey (response rate, 64.5%). Refer to Fig. 1 for the research process flowchart.

Section 1: Demographic characteristics

The mean age of participating therapists was 34.2 years (range 18–59 years). Of all the respondents, 66.1% (160/242) were male. The mean years of working experience were 10.1 years (range 0–39 years). The majority (81.0%, 196/242) held bachelor's degrees as their highest academic qualification. The specialties were relatively balanced, with the top three being: medical imaging technology (35.5%, 86/242), medical imaging diagnostics (29.3%, 71/242), and clinical medicine (18.6%, 45/242). As to professional titles, the highest proportion was junior therapist (38.8%, 94/242), followed by supervisor therapist (32.2%, 78/242). Additionally, 30 therapists (12.4%) from 12 medical institutions were assigned to disease-specific professional groups.

Section 2: Subjective assessment of therapists' knowledge on patients' pelvic organ preparation adherence

Regarding assessment of therapists' self-initiatives in guiding patients on pelvic organ preparation adherence prior to treatment, we found that 92.6% (224/242) of therapists reported frequently providing active guidance for patients. Only 7.4% (18/242) occasionally provided guidance, with no therapists reporting never providing guidance.

In terms of therapists' subjective knowledge on assessment of patients' pelvic organ preparation status on a scale of 1–10, the mean score for bladder filling was 8.60 and for rectal emptying was 8.32. The average score for subjective knowledge on how to guide patients on bladder filling was 8.94, while for rectal emptying, it was 8.29. This indicated that most therapists subjectively thought they had good understanding of patients' pelvic preparation status and patient guidance. Interestingly, therapists generally demonstrated better knowledge of bladder preparation compared to rectal preparation (Table 1).

Table 1

Overview of the questionnaire on radiation therapists' knowledge regarding EC patients' pelvic organ preparation adherence and training needs.

Contents / Respondents	Assessment
Subjective assessment of therapists' knowledge (n = 242)	Score (on a 1–10 scale)
Knowledge regarding the optimal extent of bladder filling	8.60
Knowledge regarding the optimal extent of rectum emptying	8.32
Knowledge regarding guiding patients on bladder preparation	8.94
Knowledge regarding guiding patients on rectum emptying	8.29
Objective assessment of therapists' knowledge	Accuracy rate
- EBRT (n = 222)	
Q1, key point: clinical radiation therapy	45.5%
Q2, key point: pelvic anatomy	10.4%
Q3, key point: radiation physics	29.7%
- VBT (n = 102)	
Q1, key point: clinical radiation therapy and radiation physics	16.7%
Q2, key point: clinical radiation therapy and radiation physics	61.8%
Attitude on IGRT (n = 222)	Score (on a 1–10 scale)
Necessity regarding IGRT prior to each treatment	8.95
Training investigation (n = 242)	
- Willingness	Score (on a 1–10 scale)
Willing to participate in relevant training.	8.90
- Desired contents (multi-choice)	Ratio (n)
Bladder filling and rectal emptying protocols across various disease categories	96.3% (233)
How to instruct patients on bladder filling preparation	80.6% (195)
How to instruct patients on rectum emptying preparation	80.2% (194)
Knowledge of pelvic anatomical structures	75.2% (182)
Areas of target volumes	80.6% (195)
Abbreviations: EC, endometrial carcinoma; EBRT, external beam radiation; VBT, vaginal brachytherapy; IGRT, image guidance radiotherapy.	

Contents / Respondents	Assessment
Subjective assessment of therapists' knowledge (n = 242)	Score (on a 1–10 scale)
Patient-physician communication skills	72.3% (175)
- Barriers to participate in training (multi-choice)	Ratio (n)
Excessive workload/ time constraints	69.0% (167)
Lack of training opportunities	70.2% (170)
Content with the status quo	12.8% (31)
Adequate professional level renders training redundant	13.2% (32)
- Desired methods (multi-choice)	Ratio (n)
Hands-on practice	90.5% (219)
Online teaching	41.3% (100)
Theoretical instruction	59.1% (143)
Case-based discussions	59.1% (143)
- Desired duration of each training session (single choice)	Ratio (n)
1 hour	54.5% (132)
2–3 hours	28.1% (68)
Half a day	9.1% (22)
≥ 1 day	8.3% (20)
- Desired frequency (single choice)	Ratio (n)
Once a month	37.6% (91)
Once every three months	23.6% (57)
Once every six months	21.5% (52)
Once a year	17.4% (42)
Abbreviations: EC, endometrial carcinoma; EBRT, external beam radiation; VBT, vaginal brachytherapy; IGRT, image guidance radiotherapy.	

Section 3: Objective assessment on therapists' knowledge on patients' pelvic organ preparation adherence for EBRT and VBT

A total of 91.7% (222/242) of participants reported they had performed postoperative EBRT for EC patients. Objective assessment through three specialized questions (clinical radiation therapy, radiation physics, and pelvic anatomy) revealed low correct answer rates. For Q1 (reasons for bladder filling and

rectal emptying), while 98.2% selected "reducing dose to organs at risk" and 97.3% selected "ensuring treatment accuracy," 50.9% incorrectly chose "promoting postoperative recovery." For Q2 (affected target volumes), only 88.3% selected the vaginal cuff as the most affected area, and many incorrectly selected lymphatic drainage regions that are not affected by bladder/rectal filling. For Q3 (radiation physics advantages of rectal emptying), the accuracy rate was 29.7%.

Among all respondents, only 42.1% (102/242) reported they had performed postoperative VBT for EC patients. We objectively assessed therapists' knowledge on clinical radiation therapy and radiation physics for VBT. Q1, "What effects could insufficient bladder filling have on radiation dosage distribution and clinical treatment outcomes?" The treatment area surrounded the applicator and was virtually unaffected by bladder volume. However, 56.9% (58/102) of therapists incorrectly selected "inadequate target coverage," revealing insufficient understanding of the precise target volume boundaries. Q2, "What effects could insufficient rectal emptying have on radiation dosage distribution or clinical treatment outcomes?" Rectal distension caused approximation of the bowel wall to the target volume, consequently increasing radiation dose to the rectum. Neither target coverage nor bladder max dose were affected by rectal filling status. However, 33.3% (34/102) of therapists selected "target miss," and 5.9% (6/102) chose "excessive bladder dose." These responses demonstrated limited comprehension of therapists' clinical radiation therapy and radiation physics.

Overall, the accuracy rates of the three EBRT related questions were 45.5%, 10.4%, and 29.7%. And the accuracy rates of the above two VBT related questions were 16.7% and 61.8%, respectively. There was a substantial gap between subjective and objective knowledge of pelvic organ preparation adherence, suggesting that there is still considerable professional knowledge for therapists to acquire.

Section 4: Therapists' attitudes towards IGRT and its current application status

Therapists rated the necessity of pre-treatment image guidance at an average score of 8.95 (on a 1–10 scale). However, in clinical practice, the most common IGRT frequency was weekly (1–2 times per week, 61.7%), with only 22.1% performing image guidance before every treatment. When IGRT was not performed (n = 173), only 14.5% utilized objective bladder/rectum volume monitoring devices. Among those without auxiliary devices, patient self-report was the primary source (95.9%), followed by family member feedback (64.9%) and physical palpation (29.1%).

Regarding objective assessment of pelvic organ preparation adherence prior to brachytherapy, pre-treatment auxiliary monitoring devices usage only accounted for 36.3% (37/102). Among the remaining cohort (n = 65), therapists' primary sources for assessing bladder / rectum preparation status were patient self-report (95.4%, 62/65), followed by family member feedback (76.9%, 50/65).

Section 5: Supplemental questions

For cervical patients, there were significantly more therapists having performed EBRT (93.8%,227/242) than brachytherapy (43.8%,106/242) in terms of treatment methods. Therapists demonstrated marginally better subjective understanding of patients' pelvic organ preparation adherence for EBRT than brachytherapy (mean score: 8.75 vs. 8.52).

Section 6: Training status and needs

Among surveyed RTs, 68.6% (166/242) reported having received standardized training on bladder/rectal preparation for patients with pelvic tumors. The most common training format was hands-on practice (83.6%), followed by theoretical lectures (70.9%), case-based discussions (59.4%), and online courses (46.1%). Regarding barriers, 70.2% cited lack of training opportunities and 69.0% reported excessive workload/time constraints. Willingness for training was high (mean score, 8.90). The most desired training topic was bladder filling and rectal emptying protocols (96.3%), followed by guidance for patients on urine retention (80.6%) and defecation (80.2%). Hands-on practice was selected as the most effective training method (90.5%). For duration, 54.5% preferred one-hour sessions, and 37.6% chose monthly frequency.

Section 7. Analysis of factors influencing therapists' knowledge and training needs regarding patients' pelvic organ preparation adherence

Subgroup analyses were performed to identify factors associated with RT knowledge and training needs. All subgroup comparisons—working experience, geographical region, gender, and prior training (Tables 2–5)—were post-hoc, exploratory analyses rather than pre-specified hypotheses. (i) Working experience. Three groups were compared: 0–5 years ($n = 90$), 6–10 years ($n = 49$), and ≥ 10 years ($n = 103$). No significant differences in subjective or objective scores were observed (all $P > 0.05$). (ii) Geographical region. Eastern ($n = 91$), Northeastern ($n = 53$), Central ($n = 21$), and Western ($n = 77$) regions showed no significant differences in subjective knowledge levels. However, Eastern regions performed better on objective assessments, particularly in EBRT. (iii) Gender. No significant gender-based differences were observed in any aspect ($P > 0.05$). (iv) Prior training. Therapists who had received prior training ($n = 166$) reported significantly higher subjective confidence in pelvic organ preparation compared with those who had not ($n = 76$) across all four self-rated items (all $P < 0.001$; Table 5). In contrast, objective accuracy on the five specialised questions showed no significant between-group difference. Prior training was also associated with higher endorsement of every targeted training topic (all $P < 0.05$) and with different barrier profiles: trained therapists more often cited excessive workload (77.7% vs 50.0%, $P < 0.001$), whereas untrained therapists more often cited lack of training opportunities (84.2% vs 63.9%, $P = 0.002$). This divergence between subjective and objective performance in the trained group underscores the need for competency-based, objective assessment when evaluating radiation therapist education. As this was a cross-sectional, self-reported exposure without baseline measurement, the finding is associational and cannot establish causality. The trained group's higher self-rated confidence coupled with unchanged objective performance points to a mismatch between what was taught and what was assessed, not to the ineffectiveness of education.

Table 2

Influence of working experiences on knowledge, practice, and training needs regarding patients' pelvic organ preparation adherence

Years of working experiences	0–5 year(n = 90)	6–10 years(n = 49)	≥ 11years(n = 103)	P value
Subjective assessment of therapists' knowledge: score (on a 1–10 scale)				
Knowledge regarding the optimal extent of bladder filling	8.24	9.08	8.69	0.204
Knowledge regarding the optimal extent of rectum emptying	8.02	8.67	8.41	0.622
Knowledge regarding guiding patients on bladder preparation	8.63	9.35	9.01	0.166
Knowledge regarding guiding patients on rectum emptying	8.06	8.65	8.33	0.267
Objective assessment of therapists' knowledge: accuracy rate				
- EBRT				
Q1, key point: clinical radiation therapy	42.7%	41.7%	49.5%	0.559
Q2, key point: pelvic anatomy	8.0%	6.3%	12.1%	0.449
Q3, key point: radiation physics	25.3%	31.3%	31.3%	0.653
- VBT				
Q1, key point: clinical radiation therapy and radiation physics	13.3%	20.0%	23.4%	0.539
Q2, key point: clinical radiation therapy and radiation physics	46.7%	56.0%	72.3%	0.068
Attitude on IGRT : score (on a 1–10 scale)				
Necessity regarding IGRT prior to each treatment (n = 222)	8.76	8.92	9.10	0.570
Training investigation				
- Willingness: score (on a 1–10 scale)				
Willing to participate in relevant training (n = 242)	8.93	8.90	8.88	0.317
- Desired contents (multi-choice): ratio (n)				
Abbreviations: EC, endometrial carcinoma; EBRT, external beam radiation; VBT, vaginal brachytherapy; IGRT, image guidance radiotherapy.				

Years of working experiences	0–5 year(n = 90)	6–10 years(n = 49)	≥ 11years(n = 103)	P value
Subjective assessment of therapists' knowledge: score (on a 1–10 scale)				
Bladder filling and rectal emptying protocols across various disease categories	95.6%(86)	98.0%(48)	96.1%(99)	0.744
How to instruct patients on bladder filling preparation	76.7%(69)	79.6%(39)	84.5%(87)	0.386
How to instruct patients on rectum emptying preparation	73.3%(66)	81.6%(40)	85.4%(88)	0.105
Knowledge of pelvic anatomical structures	75.6%(68)	81.6%(40)	71.8%(74)	0.424
Areas of target volumes	80.0%(72)	91.8%(45)	75.7%(78)	0.063
Patient-physician communication skills	76.7%(69)	67.3%(33)	70.9%(73)	0.458
- Barriers to participate in training (multi-choice) : ratio (n)				
Excessive workload/ time constraints	66.7%(60)	71.4%(35)	69.9%(72)	0.817
Lack of training opportunities	60.0%(54)	83.7%(41)	72.8%(75)	0.011
Content with the status quo	16.7%(15)	14.3%(7)	8.7%(9)	0.244
Adequate professional level renders training redundant	8.9%(8)	24.5%(12)	11.7%(12)	0.028
- Desired methods (multi-choice) : ratio (n)				
Hands-on practice	91.1%(82)	87.8%(43)	91.3%(94)	0.776
Online teaching	37.8%(34)	44.9%(22)	42.7%(44)	0.668
Theoretical instruction	54.4%(49)	63.3%(31)	61.2(63)	0.512
Case-based discussions	61.1%(55)	59.2%(29)	57.3%(59)	0.864
- Desired duration of each training session (single choice) : ratio (n)				0.673
1 hour	51.1%(46)	63.3%(31)	53.4%(55)	
2–3 hours	32.2%(29)	22.4%(11)	27.2%(28)	
Half a day	6.7%(6)	8.2%(4)	11.7%(12)	
Abbreviations: EC, endometrial carcinoma; EBRT, external beam radiation; VBT, vaginal brachytherapy; IGRT, image guidance radiotherapy.				

Years of working experiences	0–5 year(n = 90)	6–10 years(n = 49)	≥ 11years(n = 103)	<i>P</i> value
Subjective assessment of therapists' knowledge: score (on a 1–10 scale)				
≥ 1 day	10.0%(9)	6.1%(3)	7.8%(8)	
- Desired frequency (single choice) : ratio (n)				0.000
Once a month	58.9%(53)	28.6%(14)	23.3%(24)	
Once every three months	26.7%(24)	18.4%(9)	23.3%(24)	
Once every six months	8.9%(8)	36.7%(18)	25.2%(26)	
Once a year	5.6%(5)	16.3%(8)	28.2%(29)	
Abbreviations: EC, endometrial carcinoma; EBRT, external beam radiation; VBT, vaginal brachytherapy; IGRT, image guidance radiotherapy.				

Table 3

Influence of geographical regions on knowledge, practice, and training needs regarding patients' pelvic organ preparation adherence

Geographical regions	Eastern(n = 91)	Northeastern(n = 53)	Central(n = 21)	Western(n = 77)	P value
Subjective assessment of therapists' knowledge: score (on a 1–10 scale)					
Knowledge regarding the optimal extent of bladder filling	8.71	8.89	8.48	8.31	0.364
Knowledge regarding the optimal extent of rectum emptying	8.63	8.32	8.00	8.04	0.183
Knowledge regarding guiding patients on bladder preparation	9.01	8.94	8.90	8.86	0.783
Knowledge regarding guiding patients on rectum emptying	8.62	7.92	8.29	8.17	0.498
Objective assessment of therapists' knowledge: accuracy rate					
- EBRT					
Q1, key point: clinical radiation therapy	63.3%	38.8%	50.0%	29.7%	0.000
Q2, key point: pelvic anatomy	13.9%	6.1%	15.0%	5.4%	0.202
Q3, key point: radiation physics	44.3%	26.5%	35.0%	13.5%	0.000
- VBT					
Q1, key point: clinical radiation therapy and radiation physics	35.5%	10.3%	16.7%	12.5%	0.071
Q2, key point: clinical radiation therapy and radiation physics	58.1%	62.1%	55.6%	66.7%	0.880
Attitude on IGRT: score (on a 1–10 scale)					
Abbreviations: EC, endometrial carcinoma; EBRT, external beam radiation; VBT, vaginal brachytherapy; IGRT, image guidance radiotherapy.					

Geographical regions	Eastern(n = 91)	Northeastern(n = 53)	Central(n = 21)	Western(n = 77)	P value
Subjective assessment of therapists' knowledge: score (on a 1–10 scale)					
Necessity regarding IGRT prior to each treatment (n = 222)	8.87	9.27	8.35	8.97	0.046
Training investigation					
- Willingness: score (on a 1–10 scale)					
Willing to participate in relevant training (n = 242)	8.89	9.02	9.29	8.74	0.584
- Desired contents (multi-choice) : ratio (n)					
Bladder filling and rectal emptying protocols across various disease categories	93.4%(85)	96.2%(51)	100.0%(21)	98.7%(76)	0.173
How to instruct patients on bladder filling preparation	72.5%(66)	90.6%(48)	57.1%(12)	89.6%(69)	0.000
How to instruct patients on rectum emptying preparation	71.4%(65)	88.7%(47)	61.9%(13)	89.6%(69)	0.001
Knowledge of pelvic anatomical structures	76.9%(70)	77.4%(41)	61.9%(13)	75.3%(58)	0.519
Areas of target volumes	87.9%(80)	69.8%(37)	61.9%(13)	84.4%(65)	0.009
Patient-physician communication skills	71.4%(65)	69.8%(37)	76.2%(16)	74.0%(57)	0.925
- Barriers to participate in training (multi-choice) : ratio (n)					
Excessive workload/ time constraints	61.5%(56)	75.5%(40)	76.2%(16)	71.4%(55)	0.248
Lack of training opportunities	63.7%(58)	69.8%(37)	90.5%(19)	72.7%(56)	0.103
Content with the status quo	11.0%(10)	11.3%(6)	33.3%(7)	10.4%(8)	0.082
Abbreviations: EC, endometrial carcinoma; EBRT, external beam radiation; VBT, vaginal brachytherapy; IGRT, image guidance radiotherapy.					

Geographical regions	Eastern(n = 91)	Northeastern(n = 53)	Central(n = 21)	Western(n = 77)	P value
Subjective assessment of therapists' knowledge: score (on a 1–10 scale)					
Adequate professional level renders training redundant	14.3%(13)	9.4%(5)	14.3%(3)	14.3%(11)	0.823
- Desired methods (multi-choice) : ratio (n)					
Hands-on practice	90.1%(82)	90.6%(48)	85.7%(18)	92.2%(71)	0.853
Online teaching	38.5%(35)	50.9%(27)	28.6%(6)	41.6%(32)	0.291
Theoretical instruction	61.5%(56)	52.8%(28)	28.6%(6)	68.8%(53)	0.007
Case-based discussions	63.7%(58)	52.8%(28)	19.0%(4)	68.8%(53)	0.000
- Desired duration of each training session (single choice) : ratio (n)					0.616
1 hour	62.6%(57)	52.8%(28)	52.4%(11)	46.8%(36)	
2–3 hours	24.2%(22)	32.1%(17)	28.6%(6)	29.9%(23)	
Half a day	6.6%(6)	9.4%(5)	4.8%(1)	13.0%(10)	
≥ 1 day	6.6%(6)	5.7%(3)	14.3%(3)	10.4%(8)	
- Desired frequency (single choice) : ratio (n)					0.007
Once a month	48.4%(44)	32.1%(17)	38.1%(8)	28.6%(22)	
Once every three months	27.5%(25)	28.3%(15)	9.5%(2)	19.5%(15)	
Once every six months	13.2%(12)	15.1%(8)	38.1%(8)	31.2%(24)	
Once a year	11.0%(10)	24.5%(13)	14.3%(3)	20.8%(16)	
Abbreviations: EC, endometrial carcinoma; EBRT, external beam radiation; VBT, vaginal brachytherapy; IGRT, image guidance radiotherapy.					

Table 4
Influence of gender on knowledge, practice, and training needs regarding patients' pelvic organ preparation adherence

Assessment	Male(n = 160)	Female(n = 82)	P value
Subjective assessment of therapists' knowledge: score (on a 1–10 scale)			
Knowledge regarding the optimal extent of bladder filling	8.55	8.71	0.660
Knowledge regarding the optimal extent of rectum emptying	8.21	8.52	0.379
Knowledge regarding guiding patients on bladder preparation	8.94	8.93	0.769
Knowledge regarding guiding patients on rectum emptying	8.12	8.63	0.138
Objective assessment of therapists' knowledge: accuracy rate			
- EBRT			
Q1, key point: clinical radiation therapy	48.0%	40.3%	0.279
Q2, key point: pelvic anatomy	9.3%	9.7%	0.926
Q3, key point: radiation physics	29.3%	29.2%	0.980
- VBT			
Q1, key point: clinical radiation therapy and radiation physics	21.7%	16.7%	0.531
Q2, key point: clinical radiation therapy and radiation physics	58.3%	64.3%	0.545
Attitude on IGRT: score (on a 1–10 scale)			
Necessity regarding IGRT prior to each treatment (n = 222)	8.91	9.01	0.842
Training investigation			
- Willingness: score (on a 1–10 scale)			
Willing to participate in relevant training (n = 242)	8.86	8.99	0.372
- Desired contents (multi-choice) : ratio (n)			
Bladder filling and rectal emptying protocols across various disease categories	96.3%(154)	96.3%(79)	1.000
Abbreviations: EC, endometrial carcinoma; EBRT, external beam radiation; VBT, vaginal brachytherapy; IGRT, image guidance radiotherapy.			

Assessment	Male(n = 160)	Female(n = 82)	P value
Subjective assessment of therapists' knowledge: score (on a 1–10 scale)			
How to instruct patients on bladder filling preparation	81.3%(130)	79.3%(65)	0.712
How to instruct patients on rectum emptying preparation	79.4%(127)	81.7%(67)	0.667
Knowledge of pelvic anatomical structures	74.4%(119)	76.8%(63)	0.676
Areas of target volumes	78.8%(126)	84.1%(69)	0.315
Patient-physician communication skills	70.0%(112)	76.8%(63)	0.261
- Barriers to participate in training (multi-choice) : ratio (n)			
Excessive workload/ time constraints	70.6%(113)	65.9%(54)	0.447
Lack of training opportunities	70.6%(113)	69.5%(57)	0.858
Content with the status quo	12.5%(20)	13.4%(11)	0.840
Adequate professional level renders training redundant	15.0%(24)	9.8%(8)	0.254
- Desired methods (multi-choice) : ratio (n)			
Hands-on practice	92.5%(148)	86.6%(71)	0.138
Online teaching	41.9%(67)	40.2%(31)	0.807
Theoretical instruction	61.3%(98)	54.9%(45)	0.340
Case-based discussions	59.4%(95)	58.5%(48)	0.900
- Desired duration of each training session (single choice): ratio (n)			0.059
1 hour	50.6%(82)	62.2%(51)	
2–3 hours	28.7%(46)	26.8%(22)	
Half a day	12.5%(20)	2.4%(2)	
≥ 1 day	8.1%(13)	8.5%(7)	
- Desired frequency (single choice): ratio (n)			0.148
Once a month	33.8%(54)	45.1%(37)	
Once every three months	25.0%(40)	20.7%(17)	
Abbreviations: EC, endometrial carcinoma; EBRT, external beam radiation; VBT, vaginal brachytherapy; IGRT, image guidance radiotherapy.			

Assessment	Male(n = 160)	Female(n = 82)	<i>P</i> value
Subjective assessment of therapists' knowledge: score (on a 1–10 scale)			
Once every six months	20.6%(33)	23.2%(19)	
Once a year	20.6%(33)	11.0%(9)	
Abbreviations: EC, endometrial carcinoma; EBRT, external beam radiation; VBT, vaginal brachytherapy; IGRT, image guidance radiotherapy.			

Table 5

Influence of prior training on knowledge, practice, and training needs regarding patients' pelvic organ preparation adherence

Assessment	Trained (n = 166)	Untrained (n = 76)	P value
Subjective assessment of therapists' knowledge (score, 1–10 scale)			
Knowledge regarding optimal extent of bladder filling	9.34	8.05	< 0.001
Knowledge regarding optimal extent of rectum emptying	8.85	7.08	< 0.001
Knowledge regarding guiding patients on bladder preparation	9.07	7.59	< 0.001
Knowledge regarding guiding patients on rectum emptying	8.84	7.18	< 0.001
Attitude on IGRT: score (on a 1–10 scale)			
Necessity regarding IGRT prior to each treatment (n = 222)	8.95	8.93	0.752
Objective assessment of therapists' knowledge: accuracy rate			
- EBRT			
Q1, key point: clinical radiation therapy	43.5%	50.0%	0.454
Q2, key point: pelvic anatomy	7.1%	14.7%	0.127
Q3, key point: radiation physics	28.6%	30.9%	0.850
- VBT			
Q1, key point: clinical radiation therapy and radiation physics	19.2%	20.7%	1.000
Q2, key point: clinical radiation therapy and radiation physics	58.9%	65.5%	0.695
Training investigation			
- Willingness: score (on a 1–10 scale)			
Willing to participate in relevant training (n = 242)	9.08	8.53	0.060
- Desired training contents (multi-choice, %)			
Abbreviations: EC, endometrial carcinoma; EBRT, external beam radiation; VBT, vaginal brachytherapy; IGRT, image guidance radiotherapy.			

Assessment	Trained (n = 166)	Untrained (n = 76)	P value
Subjective assessment of therapists' knowledge (score, 1–10 scale)			
Bladder filling and rectal emptying protocols across various disease categories	98.2%	92.1%	0.050
How to instruct patients on bladder filling preparation	83.1%	75.0%	0.190
How to instruct patients on rectum emptying preparation	84.3%	71.1%	0.026
Knowledge of pelvic anatomical structures	79.5%	65.8%	0.033
Areas of target volumes	86.7%	67.1%	0.001
Patient-physician communication skills	77.7%	60.5%	0.009
Barriers to participate in training (multi-choice) : ratio (n)			
Excessive workload/ time constraints	77.7%	50.0%	< 0.001
Lack of training opportunities	63.9%	84.2%	0.002
Content with the status quo	13.3%	11.8%	0.922
Adequate professional level renders training redundant	17.5%	3.9%	0.007
Desired methods (multi-choice) : ratio (n)			
Hands-on practice	92.8%	85.5%	0.122
Online teaching	39.8%	44.7%	0.556
Theoretical instruction	58.4%	60.5%	0.868
Case-based discussions	59.6%	57.9%	0.908
Desired duration of each training session (single choice): ratio (n)			0.271
1 hour	58.4%	46.1%	
2–3 hours	24.7%	35.5%	
Half a day	8.4%	10.5%	
≥ 1 day	8.4%	7.9%	
Desired frequency (single choice): ratio (n)			0.556
Abbreviations: EC, endometrial carcinoma; EBRT, external beam radiation; VBT, vaginal brachytherapy; IGRT, image guidance radiotherapy.			

Assessment	Trained (n = 166)	Untrained (n = 76)	P value
Subjective assessment of therapists' knowledge (score, 1–10 scale)			
Once a month	40.4%	31.6%	
Once every three months	22.9%	25.0%	
Once every six months	21.1%	22.4%	
Once a year	15.7%	21.1%	
Abbreviations: EC, endometrial carcinoma; EBRT, external beam radiation; VBT, vaginal brachytherapy; IGRT, image guidance radiotherapy.			

Discussion

This multi-institutional survey of radiation therapists across 20 centers identified a substantial gap between subjective confidence and objective knowledge of pelvic organ preparation adherence for postoperative EC patients. Key findings include: (1) therapists' high subjective confidence was not matched by objective performance; (2) utilization of IGRT and auxiliary monitoring devices was low; and (3) there is strong demand for hands-on, practical training.

Therapists subjectively believed they had sufficient understanding of patients' pelvic organ preparation adherence. However, objective assessment revealed suboptimal performance, indicating insufficient knowledge of pelvic anatomy and target volume delineation. This gap may be attributed to several factors. First, in China, most radiation therapists graduate with majors in medical imaging technology or diagnostic radiography, programs that contain virtually no dedicated radiotherapy-specific coursework. Second, specialization remains inadequate: only 30 therapists across 12 institutions had disease-specific assignments. Third, the high national demand for therapists, coupled with workforce shortages(14), leaves insufficient time for in-depth learning. These findings are consistent with the training needs assessment, which revealed strong willingness among therapists for enhanced education (mean score, 8.90).

Why prior training did not translate into higher objective accuracy warrants interpretation, not a conclusion that training is ineffective. Several non-mutually-exclusive explanations are plausible. First, selection and reverse causality: therapists who had sought training may have done so precisely because they perceived knowledge gaps, implying a lower baseline in the trained group; training may have narrowed rather than eliminated the gap, so a cross-sectional comparison reveals no net advantage. Second, the reported trainings were heterogeneous in content, format, and duration; most were brief, hands-on or lecture-based sessions (83.6% hands-on, 70.9% lectures) without standardised, competency-based assessment of the fine-grained pelvic-anatomy and radiation-physics knowledge probed by the objective items. Third, routine training may raise self-rated confidence without

correspondingly improving verified competence—consistent with the trained group’s higher subjective confidence but unchanged objective performance. Fourth, and most directly relevant to the objective questions, the content of the training therapists had previously received may have been misaligned with the specific competencies assessed. Existing programmes predominantly emphasised operational, hands-on aspects of machine setup and image acquisition, whereas the objective items probed fine-grained pelvic anatomy, target-volume boundaries, and the radiation-physics rationale underpinning bladder and rectal preparation. A course that does not explicitly teach the pathophysiological basis of preparation protocols would not be expected to raise scores on such knowledge items, regardless of trainees’ motivation or effort. Thus, the absence of an association should be interpreted as a curriculum-content and assessment gap, not as evidence that well-designed education cannot improve therapists’ cognition. These considerations suggest that training quantity per se is less important than training quality that embeds objective assessment, and that the present finding highlights a curriculum blind spot rather than evidence that education is futile.

In the Chinese clinical workflow, IGRT images are reviewed by the radiation therapist for initial positioning verification, with the treating radiation oncologist responsible for final approval. This division of labor reflects the reality that radiation oncologists cannot be present for every fraction; therapists serve as the first-line quality checkpoint. While therapists demonstrated high awareness of IGRT, clinical implementation remained limited. When IGRT was not utilized, only 14.5% of treatments incorporated objective pelvic organ volume monitoring devices, and patient self-report served as the primary information source. This reliance on subjective reporting highlights a potential vulnerability in treatment accuracy.

The professional requirements for RTs have evolved substantially with the implementation of IMRT, image-guided and adaptive radiotherapy. Whereas RTs were previously expected to master machine operation and patient positioning, precision radiotherapy now demands competence in anatomical structure identification, target volume understanding, and image guidance interpretation. The cancer burden was great worldwide. According to Global Cancer Observatory data(14), there would be 21.2 million new patients needing radiotherapy in 2050. It predicted China had the highest estimated patient radiotherapy demand (4, 675, 652) in 2050 and the radiation unit demand gaps were noteworthy. They estimated that the global radiotherapy workforce would need 141, 077 radiation therapists in 2050 worldwide. However, only a few countries provided radiotherapy-specific content of education programs(10, 11). Education and training were central components in ensuring accurate and safe treatment delivery. The failure to provide standards of training for radiation therapists resulted in a disparity of education across world(15, 16). In China, radiation therapists primarily graduate from diagnostic radiography, medical imaging technology, or nuclear medicine programs, which contain virtually no dedicated radiotherapy content. McNair et al.(17) and Li et al.(18) reported similar challenges in therapist training for pelvic organ management. The present findings are generalizable to countries where therapist training overlaps with diagnostic imaging rather than radiation oncology specifically.

Survey findings indicated that excessive workload and limited learning opportunities are the primary constraints on RT participation in training. This underscores the need for hospitals to optimize staffing and workflows. Respondents overwhelmingly identified hands-on practice as the most effective training method, with particularly high demand for instruction on bladder filling and rectal emptying requirements, suggesting future programs should emphasize practical skills training tailored to specific disease characteristics.

This study has several limitations. First, the sample size ($n = 242$), although drawn from 20 centers, may have limited statistical power for some subgroup analyses, particularly in the Central region ($n = 21$). Second, the selected hospitals may not fully represent national conditions. Third, non-response bias may exist: therapists who chose to participate may be more engaged with continuing education than non-responders, potentially overestimating knowledge levels. Fourth, the survey collected self-reported data on what therapists say they do, rather than quantifying what they actually do in clinical practice; this may or may not affect the validity of the findings. Fifth, these results are specific to the Chinese training context and are generalizable primarily to countries where therapist education overlaps with diagnostic imaging rather than radiation oncology specifically. Sixth, all subgroup analyses were post-hoc and exploratory rather than pre-specified; the prior-training comparison in particular relied on self-reported exposure of heterogeneous content and duration, and the higher workload reported by trained therapists raises reverse-causality concerns, so these associations should be interpreted cautiously. Despite these limitations, this is the first multi-institutional investigation specifically assessing radiation therapists' knowledge and training needs regarding patients' pelvic organ preparation adherence.

Conclusions

In summary, this multi-institutional survey identified a substantial gap between subjective confidence and objective knowledge of pelvic organ preparation adherence among Chinese radiation therapists, with prior standardized training elevating self-rated confidence but not translating into — a pattern that most plausibly reflects inadequate training content and the lack of competency-based assessment rather than any inability of education to improve therapists' cognition — higher objective accuracy. These findings carry direct implications for radiotherapy quality assurance: structured, hands-on, workflow-embedded continuing education—integrated with IGRT protocols, departmental checklists, and pre-treatment image review routines—should be prioritized over didactic, theory-only formats. Post-hoc subgroup signals (by training history, experience, geography, and gender) should be interpreted exploratory and inform hypothesis generation for future prospective, competency-based training studies in radiotherapy workforce development.

Abbreviations

EC
endometrial carcinoma
IGRT

image guidance radiotherapy
EBRT
external beam radiation
VBT
vaginal brachytherapy
CT
computed tomography
IMRT
intensity-modulated radiotherapy.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the principles of the Declaration of Helsinki. Participants are from centers participating in a prospective, multicenter clinical trial (ClinicalTrials.gov, NCT05524389, registered Feb. 5, 2024). It was approved by the Institutional Review Board of Peking Union Medical College Hospital (N0. I-22PJ664) at Nov. 8, 2022. Informed consent to participate was obtained from all individual participants included in the study.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

WW participated in the data curation and writing the original draft. GZ and XJ contributed to resources collection, data curation and validation of the manuscript. YZ, ZL, XL, ZC, TW, JM, WZ, XL, LZ, XS, SL, HZ,

LS, FH, HG and FZ participated in resources collection and data curation. XH participated in conceptualization, project administration, supervision while reviewed and edited the manuscript. XW and LW performed the methodology and formal analysis. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

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Figures

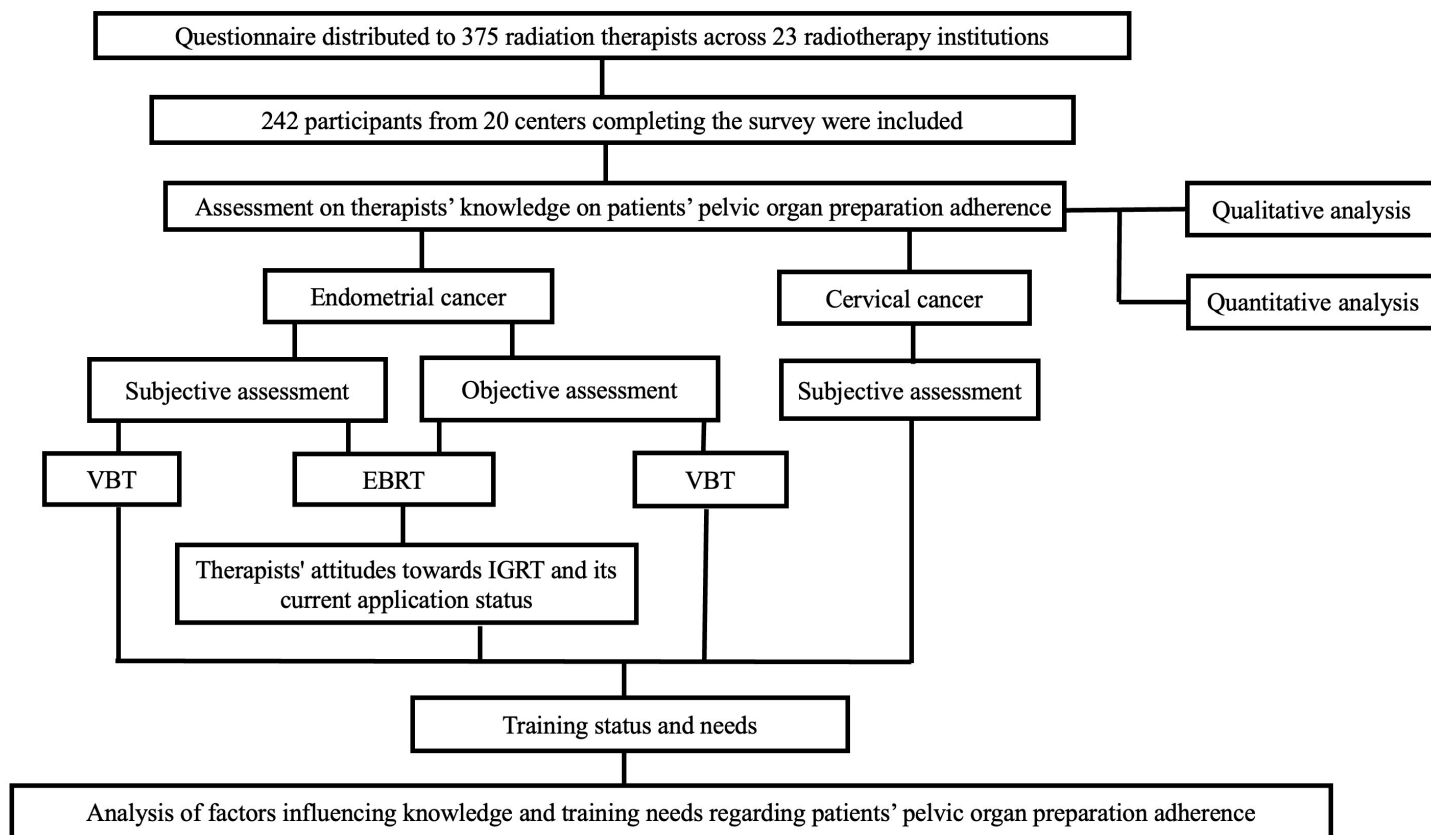


Figure 1

Research overview flowchart.

Abbreviation: EBRT, External Beam Radiation; VBT, Vaginal Brachytherapy; IGRT, image guidance radiotherapy.

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