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Knowledge and attitudes toward [^{18}F] fluorodeoxyglucose (^{18}F-FDG) positron emission tomography/computed tomography among non-radiologist medical staff

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Abstract

Background To investigate the current knowledge and attitudes towards [^{18}F]fluorodeoxyglucose (^{18}F-FDG) positron emission tomography (PET)/computed tomography (CT) among non-radiologist medical staff in China.

Methods This cross-sectional study was conducted between November 18, 2022, and December 6, 2022, at the First Affiliated Hospital (Southwest Hospital) of the Army Medical University (Third Military Medical University) among non-radiologist staff (medical, nursing, and others). The questionnaire survey (Cronbach's α = 0.887) included 28 items: 10 on demographics, 11 on knowledge (maximum score of 22), and seven on attitudes (maximum score of 35). The factors influencing knowledge and attitudes were identified using multivariable logistic regression analysis.

Results This study analyzed 631 valid questionnaires. The mean knowledge score was 7.16 ± 6.48 (32.55%), indicating poor knowledge. The mean attitude score was 22.859 ± 2.36 (65.29%), indicating positive attitudes. Nursing (OR = 0.301, 95%CI: 0.159–0.571), other occupations (OR = 0.426, 95%CI: 0.200-0.905), departments with high volumes of PET/CT prescriptions (OR = 0.419, 95%CI: 0.269–0.652), radioprotection training (OR = 2.520, 95%CI: 1.576–4.030), underwent (or a relative) a PET/CT (OR = 1.713, 95%CI: 1.063–2.761), and contact with 1–10 (OR = 2.429, 95%CI: 1.627–3.627) or > 10 (OR = 3.575, 95%CI: 1.762–7.252) patients per month were independently associated with higher knowledge scores. Only the knowledge scores (OR = 1.063, 95%CI: 1.032–1.094) were independently associated with higher attitude scores.

Conclusion Non-radiologist medical staff members in China have poor knowledge but positive attitudes toward PET/CT. This study identified knowledge areas worth improving in future training interventions. Radioprotection training appears particularly useful in improving the knowledge of PET/CT, which should translate into more favorable attitudes.

Trial registration Not applicable.

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Keywords Knowledge, attitude, and practice, Fluorodeoxyglucose F18, Positron emission tomography-computed tomography, Medical staff, Cross-sectional study

Background

Positron emission tomography (PET)/computed tomography (CT) is a functional imaging method that uses radiotracers to visualize and measure changes in metabolic processes and physiological activities, including blood flow, regional chemical composition, and absorption [1–3]. The PET images are combined with the CT images from the same machine to produce high-resolution images of areas with abnormal signals [1–3]. PET/CT is an examination that can be used for the diagnosis, staging, prognosis assessment, efficacy evaluation, recurrence, and metastasis of solid and hematological tumors [4–8]. For tumors, [^{18}F]fluorodeoxyglucose (^{18}F-FDG) is the most commonly used radiotracer since it accumulates within tissues with high metabolic activity, such as cancer cells [9].

With the continuous development of medical level and nuclear medicine technology in China, more and more hospitals are introducing ^{18}F-FDG PET/CT examination in ever larger numbers of patients. ^{18}F-FDG PET/CT examinations require the injection of radioactive ^{18}F-FDG into the patient, and a certain amount of ^{18}F-FDG remains in the patient's body after the end of the examination [10–12]. Although the patients who have undergone ^{18}F-FDG PET/CT examinations do not pose a real radiation hazard to the outside environment [10–12], some non-radiologist medical staff may be reluctant to come into contact with the patients because of concerns about potential radiation exposure. In addition, the levels of knowledge of non-radiologist medical staff about ^{18}F-FDG PET/CT examinations can influence the patients' knowledge and attitudes toward ^{18}F-FDG PET/CT.

Knowledge, attitude, and practice (KAP) surveys provide quantitative and qualitative data about the misconceptions and misunderstandings that can be obstacles to a specific subject or activity. Identifying these misconceptions and misunderstandings can lead to interventions against the barriers to the optimal implementation of the subject or activity [13, 14]. Only two previous studies examined the KAP toward PET/CT [15, 16]. The first was performed among oral physicians in India, and additional training regarding PET/CT was suggested [15]. The second examined the KAP of radiation oncologists toward imaging strategies for prostate cancer, including PET/CT, and reported several remaining controversies [16]. A study not specific to PET/CT revealed poor KAP toward radioprotection among nurses working in nuclear medicine departments in Kuwait [17]. The current knowledge and attitude levels of non-radiologist clinical staff toward ^{18}F-FDG PET/CT in China are unclear.

Therefore, this study aimed to investigate the current knowledge and attitudes toward ^{18}F-FDG PET/CT among non-radiologist medical staff in China. The results could help design training and teaching interventions to correct the KAP of the non-radiologist medical staff regarding ^{18}F-FDG PET/CT.

Materials and methods

Study design and participants

This cross-sectional study was conducted between November 18, 2022, and December 6, 2022, at the First Affiliated Hospital (Southwest Hospital) of Army Medical University (Third Military Medical University). The participants were non-radiologist medical staff, including physicians, nurses, technicians, and other staff, excluding interns, medical students, and residents. The study was exempted from the Ethics Committee of the First Affiliated Hospital of Army Medical University, PLA. Informed consent was obtained from the participants before completing the survey.

The inclusion criteria were (1) medical staff of clinical departments working in the First Affiliated Hospital of Army Medical University, (2) qualified to work in the corresponding positions, (3) clinical departments that prescribe PET/CT examinations, and (4) willing to participate in this study and signed the informed consent. The exclusion criteria were (1) medical staff working or with experience in the imaging department, (2) staff from non-clinical functional departments such as the management department or logistics support department, (3) refusing to participate in the study, (4) took a too short time (< 30 s), (5) filled the questionnaire with an obvious pattern, or(6) incomplete data.

Questionnaire

The questionnaire was designed with reference to the literature [18–20] and modified according to the comments made by two experts. The questionnaire was preliminary tested in 48 participants and had a Cronbach's α of 0.887, indicating good internal consistency.

The final questionnaire (Supplementary File) was in Chinese and included 28 questions in three dimensions. The basic information section included 10 items (gender, age, education, position, professional title, and years of work experience). The knowledge dimension included 11 items answered using the options "Don't understand", "Fairly well understand", and "Fully understand", respectively assigned scores of 2, 1, and 0, respectively; the total score ranged 0–22 points. The attitude dimension included seven items answered using a 5-point Likert

scale: "Strongly agree", "Agree", "Neutra", "Disagree", and "Strongly disagree", which were assigned scores of 5, 4, 3, 2, and 1, respectively; the total scores ranged 7–35 points.

A web-based survey was distributed through the Wenjuanxing platform. A QR code was generated and sent to the department communication group by the director of the relevant department. The medical staff of the department filled in the questionnaire online after reading the QR code with their phones. A given IP address could be used only once to complete the questionnaire.

Statistical analysis

SPSS 26.0 (IBM, Armonk, NY, USA) was used for statistical analysis. The continuous variables were presented as means ± standard deviations and analyzed using ANOVA. The categorical variables were presented as n (%) and analyzed using the chi-square test. Multivariable logistic regression analysis was used to analyze the factors influencing good knowledge and positive attitude. Modified Bloom criteria [21] were applied to determine poor/good knowledge and negative/positive attitudes: scores < 60% were considered poor, while scores ≥ 60% were considered good. For the multivariable analyses, because the knowledge scores were low, lower/higher knowledge and attitude scores were based on the highest tertile. A pathway analysis was performed to analyze the relationship between occupation, years of experience, knowledge, and attitude. A multivariable analysis was selected because it allows the identification of the factors independently associated with the KAP dimension scores [22]. Pathway analysis was selected because this study was cross-sectional, which does not allow for causality analysis. On the other hand, pathway analysis is a type of structural equation modeling analysis that allows the statistical inference of causality among KAP dimensions and other possibly involved factors [23–25]. Multivariable analyses identify associations but cannot infer causality [22]. Two-sided P-values < 0.05 were considered statistically significant.

Results

Characteristics of the participants

A total of 642 participants returned questionnaires, of which two were not filled out completely, two were filled out in less than 30 s, and, in seven cases, reported age minus the work experience was < 17. After exclusions, 631 valid questionnaires were analyzed.

Table 1 presents the characteristics of the participants. Most participants were female (72.27%), 30–39 years old (48.97%), had a bachelor's degree or below (66.09%), were nurses (51.98%), had a primary title or below (42.95%), was working in departments with a high volume of PET/CT prescriptions (67.99%), had ≥ 10 years of experience (53.25%), had no training in radioprotection (80.82%), never underwent (or a relative never underwent) a PET/CT scan (83.68%), and had no direct contact with patients who underwent a PET/CT (58.32%).

Knowledge dimension

The mean knowledge score was 7.16 ± 6.48 (32.55%), indicating poor knowledge. Higher knowledge scores were observed in males ($P < 0.001$), older participants ($P = 0.043$), a higher education level ($P < 0.001$), physicians ($P < 0.001$), higher professional titles ($P < 0.001$), departments with high volumes of PET/CT prescriptions ($P < 0.001$), with radioprotection training ($P < 0.001$), those (or a relative) who underwent a PET/CT ($P = 0.004$), and with contact with patients who underwent PET/CT ($P < 0.001$) (Table 1). All knowledge areas had poor scores, except "^{18}F-FDG PET/CT can be used for diagnosis, staging, curative effect evaluation, monitoring recurrence, finding primary focus, guiding puncture biopsy and radiotherapy" (37.24%) (Supplementary Table S1). The physicians showed higher knowledge than the nurses for all knowledge areas (all $P < 0.05$), except for "Lactating women can continue to breastfeed their babies after ^{18}F-FDG PET/CT examination." ($P = 0.772$) (Table 2 and Supplementary Tables S1-S4).

Attitude dimension

The mean attitude score was 22.859 ± 2.36 (65.29%), indicating positive attitudes. Higher attitude scores were observed in males ($P < 0.001$), higher education levels ($P < 0.001$), physicians ($P < 0.001$), < 5 years of experience ($P = 0.006$), and with contact with patients who underwent PET/CT ($P < 0.001$) (Table 3). Supplementary Table S5 presents the attitude items. The physicians had higher scores than the nurses for all attitude items (all $P < 0.05$), except for "On the day after the patient underwent an ^{18}F-FDG PET/CT examination, although there is no requirement in relevant regulations, you think it is necessary to restrict the patient's activities and ask them to avoid close contact with medical staff and other patients as much as possible." ($P = 0.557$), and "You think that ^{18}F-FDG PET/CT examination is expensive and not included in medical insurance, which will cause great economic pressure on patients.", for which the nurses had higher scores ($P = 0.009$) (Table 2 and Supplementary Tables S5-S8).

Factors associated with higher knowledge and attitude scores

Table 4 shows that nursing (OR = 0.301, 95%CI: 0.159–0.571, $P < 0.001$), other occupations (OR = 0.426, 95%CI: 0.200-0.905, $P = 0.027$), departments with high volumes of PET/CT prescriptions (OR = 0.419, 95%CI: 0.269–0.652, $P < 0.001$), radioprotection training (OR = 2.520, 95%CI: 1.576–4.030, $P < 0.001$), underwent (or a relative) a PET/CT (OR = 1.713, 95%CI: 1.063–2.761, $P = 0.027$),

Table 1 Comparison of knowledge across baseline characteristics

	n	%	Knowledge score	
			Mean ± SD	*P*
Total	631	100.00	7.16 ± 6.479	
Gender				< 0.001
Male	175	27.73	9.11 ± 6.175	
Female	456	72.27	6.41 ± 6.443	
Age				0.043
< 30 years old	162	25.67	6.75 ± 6.140	
30–39 years old	309	48.97	6.80 ± 6.467	
≥ 40 years old	160	25.36	8.27 ± 6.744	
Education				< 0.001
Bachelor's degree and below	417	66.09	6.31 ± 6.479	
Master's degree	127	20.13	8.22 ± 6.186	
Ph.D. degree	87	13.79	9.68 ± 6.068	
Occupation type				< 0.001
Medical	243	38.51	9.37 ± 6.310	
Nursing	328	51.98	5.88 ± 6.228	
Other	60	9.51	5.23 ± 6.077	
Professional title				< 0.001
Primary title and below	271	42.95	6.59 ± 6.373	
Middle title	266	42.16	6.65 ± 6.501	
Vice-senior title and above	94	14.90	10.24 ± 5.895	
Departmental situation				< 0.001
The department with a high number of PET/CT scan requests	429	67.99	8.02 ± 6.531	
The department with a low number of PET/CT scan requests	202	32.01	5.34 ± 5.986	
Years of work experience				0.193
< 5 years	155	24.56	7.52 ± 6.256	
5–10 years	140	22.19	6.29 ± 6.196	
≥ 10 years	336	53.25	7.35 ± 6.679	
Trained in radiation hygiene	121	19.18	10.46 ± 7.108	< 0.001
Had a PET/CT scan of you or your relatives	103	16.32	8.85 ± 6.330	0.004
Frequency of contact with patients who undergo ^{18}F-FDG PET/CT imaging examination				< 0.001
No contact with patients	368	58.32	5.08 ± 5.742	
1–10 cases per month	220	34.87	9.92 ± 6.242	
> 10 cases per month	43	6.81	10.84 ± 6.845	

and contact with 1–10 (OR = 2.429, 95%CI: 1.627–3.627, $P < 0.001$) or > 10 (OR = 3.575, 95%CI: 1.762–7.252, $P < 0.001$) patients per month were independently associated with higher knowledge scores.

Table 5 shows that only the knowledge scores (OR = 1.063, 95%CI: 1.032–1.094, $P < 0.001$) were independently associated with higher attitude scores.

Pathway analysis

As shown in Fig. 1; Table 6, the occupation type significantly influenced knowledge (β=-3.543, $P < 0.001$) and attitude (β=-0.775, $P < 0.001$), while years of experience significantly influenced attitudes (β=-0.035, $P < 0.001$), and knowledge influenced attitudes (β=-0.081, $P < 0.001$).

Discussion

The results indicate that non-radiologist medical staff had poor knowledge but positive attitudes toward PET/CT. Logistic regression indicated that good knowledge was independently associated with several factors: nursing, other occupations, departments with high volumes of PET/CT prescriptions, radioprotection training, underwent (or know someone) a PET/CT, and contact with 1–10 or > 10 patients per month. Logistic regression also showed that only the knowledge scores were independently associated with higher attitude scores. The logistic regression analyses are supported by the pathway analysis that showed that the occupation type influenced knowledge and attitude, while years of experience significantly influenced attitudes, and knowledge influenced attitudes. This study identified knowledge areas worth including in future training interventions.

Table 2 Comparison of scores for various items of knowledge and attitude among physicians and nurses

	Physicians	Nurse	*P*
Knowledge			
^{18}F-FDG is an analog of glucose, and ^{18}F-FDG PET/CT imaging responds to the level of glucose metabolism in cells	1.02 ± 0.85	0.32 ± 0.62	< 0.001
^{18}F-FDG PET/CT can be used for diagnosis, staging, curative effect evaluation, monitoring recurrence, finding primary focus, guiding puncture biopsy, and radiotherapy.	1.45 ± 0.71	0.78 ± 0.81	< 0.001
^{18}F-FDG PET/CT can also be used for differential diagnosis of unexplained fever, localization of epileptic foci, and assessment of myocardial activity	0.74 ± 0.84	0.45 ± 0.7	< 0.001
Twenty-four hours before ^{18}F-FDG PET/CT examination, patients should avoid strenuous exercise.	0.79 ± 0.84	0.58 ± 0.77	0.002
4–6 h before the ^{18}F-FDG PET/CT examination, patients should abstain from food and beverages (except water) and stop intravenous injections containing glucose or parenteral administration.	0.97 ± 0.86	0.69 ± 0.82	< 0.001
Diabetic patients who plan to undergo ^{18}F-FDG PET/CT examination need to manage their blood glucose, and it is best to communicate with nuclear medicine physicians in advance about the choice and use of oral hypoglycemic drugs and insulin.	0.83 ± 0.87	0.54 ± 0.78	< 0.001
If the patient who intends to undergo ^{18}F-FDG PET/CT has undergone surgery, radiotherapy, and chemotherapy in the past month, it is necessary to communicate with the nuclear medicine physician in advance about the purpose and timing of the examination.	0.85 ± 0.86	0.55 ± 0.78	< 0.001
Patients with renal failure and liver failure can be examined by ^{18}F-FDG PET/CT.	0.72 ± 0.84	0.39 ± 0.66	< 0.001
If necessary, children and pregnant women can also undergo an ^{18}F-FDG PET/CT examination.	0.56 ± 0.77	0.44 ± 0.72	0.037
Lactating women can continue to breastfeed their babies after ^{18}F-FDG PET/CT examination	0.42 ± 0.71	0.39 ± 0.66	0.772
After ^{18}F-FDG PET/CT examination, a small amount of radionuclides will remain in the patient's body, but the radiation level is very low and decays rapidly, which will not cause harm to close contacts. However, it is recommended that the patient avoid close contact with infants, children, and pregnant women on the day after the examination if it is not necessary.	1.01 ± 0.85	0.77 ± 0.85	0.001
Attitude			
^{18}F-FDG PET/CT examination plays an important role in the diagnosis and treatment of tumors.	4.54 ± 0.57	4.19 ± 0.7	< 0.001
You think that ^{18}F-FDG PET/CT examination is a reliable imaging technique.	4.41 ± 0.57	4.19 ± 0.72	< 0.001
You think that ^{18}F-FDG PET/CT examination is expensive and not included in medical insurance, which will cause great economic pressure on patients.	1.81 ± 0.71	1.97 ± 0.75	0.009
You think it is necessary to cooperate with the nuclear medicine department to educate and prepare patients before the ^{18}F-FDG PET/CT examination.	4.59 ± 0.57	4.41 ± 0.7	0.002
On the day after the patient underwent ^{18}F-FDG PET/CT examination, although the external radiation level is very low and decays rapidly, you are still worried that the patient will cause radiation harm to the contacts or the surrounding environment.	2.31 ± 0.97	2 ± 0.81	< 0.001
On the day after the patient undergoes ^{18}F-FDG PET/CT examination, you are willing to get in close contact with the patient if they need diagnosis, treatment, or nursing.	3.8 ± 0.93	3.68 ± 0.87	0.040
On the day after the patient underwent an ^{18}F-FDG PET/CT examination, although there is no requirement in relevant regulations, you think it is necessary to restrict the patient's activities and ask them to avoid close contact with medical staff and other patients as much as possible.	2.14 ± 0.95	2.06 ± 0.83	0.557

Several imaging modalities involve ionizing radiations (e.g., plain X-ray, CT, angiography, and fluoroscopy), but the source of these radiations is external, and there are no radiations when the device is turned off. On the other hand, scintigraphy techniques (e.g., PET, bone scan, and isotopic ventriculography) involve the injection of radiotracers that stay within the human body for some time after the examination is complete, but the remaining radiotracer does not represent a radiation hazard to other people and the environment [10–12]. Still, PET/CT can indeed represent an occupational hazard to the imaging department personnel because of their constant work with the radiotracer itself, with such patients, and when the radiotracer has been freshly injected, while the risk for non-radiologist medical staff is negligible [26–29]. Nevertheless, non-radiologist medical staff can develop anxiety toward radiation exposure [30].

The present study reported poor knowledge but positive attitudes of non-radiologist medical staff toward PET/CT. It is supported by a study that inadequate knowledge about radiation hazards among healthcare workers in Iran [31] and physicians and interns [32–36]. Two studies suggest that the KAP of healthcare providers toward PET/CT is suboptimal [15, 16], supporting the present study. Still, it is in contrast to a study that reported vastly improved knowledge of radiation hazards in the past decade [37]. A study in Ghana reported good knowledge and positive perceptions of radiation in non-radiology healthcare workers [38]. Of course, older medical staff with more experience, higher education, training in radioprotection, and a higher volume of direct contact

Table 3 Comparison of attitudes across baseline characteristics

	n	%	Attitude score	
			Mean ± SD	*P*
Total	631	100.00	22.89 ± 2.360	
Gender				< 0.001
Male	175	27.73	23.51 ± 2.671	
Female	456	72.27	22.65 ± 2.185	
Age				0.789
< 30 years old	162	25.67	22.93 ± 2.173	
30–39 years old	309	48.97	22.93 ± 2.392	
≥ 40 years old	160	25.36	22.78 ± 2.487	
Education				< 0.001
Bachelor's degree and below	417	66.09	22.52 ± 2.065	
Master's degree	127	20.13	23.68 ± 2.648	
Ph.D. degree	87	13.79	23.54 ± 2.807	
Occupation type				< 0.001
Medical	243	38.51	23.60 ± 2.637	
Nursing	328	51.98	22.49 ± 2.087	
Other	60	9.51	22.22 ± 1.851	
Professional title				0.137
Primary title and below	271	42.95	22.89 ± 2.218	
Middle title	266	42.16	22.72 ± 2.255	
Vice-senior title and above	94	14.90	23.38 ± 2.937	
Departmental situation				0.855
The department with a high number of PET/CT scan requests	429	67.99	22.90 ± 2.281	
The department with a low number of PET/CT scan requests	202	32.01	22.87 ± 2.525	
Years of work experience				0.006
< 5 years	155	24.56	23.41 ± 2.256	
5–10 years	140	22.19	22.82 ± 2.370	
≥ 10 years	336	53.25	22.68 ± 2.373	
Trained in radiation hygiene	121	19.18	22.99 ± 2.663	0.606
Had a PET/CT scan of you or your relatives	103	16.32	22.61 ± 2.541	0.187
Frequency of contact with patients who undergo ^{18}F-FDG PET/CT imaging examination				< 0.001
No contact with patients	368	58.32	22.60 ± 2.128	
1–10 cases per month	220	34.87	23.41 ± 2.583	
> 10 cases per month	43	6.81	22.77 ± 2.635	

with patients who underwent PET/CT are factors that should increase the knowledge about radiation hazards, as observed in the present study. Of note, physicians generally had higher knowledge and attitude scores than nurses, which probably reflects higher education and training in radioprotection [39]. A multi-country study even reported a suboptimal understanding of radiation and radioprotection among interventional radiology and cardiology catheter laboratory workers [40]. Such results were also observed by Shafiee et al. [41] among medical professionals regarding radiation protection in interventional radiology. Studies also observed that nurses had a higher rate of radiophobia than physicians, possibly driven, at least in part, by poorer knowledge of radiation [41–43].

The pathway analysis also supported the idea that being a physician and having more experience led to higher scores. Still, the study identified several critical knowledge gaps among non-radiologist medical staff that need to be addressed through targeted education, indicating that knowledge about PET/CT and its radiation hazards should be enforced in training sessions and continuous education. Since knowledge was the only factor independently associated with the attitude scores (as supported by the pathway analysis), improving knowledge is paramount. Indeed, based on the KAP theory, knowledge is the basis of attitude and practice [13, 14]. The recent incorporation of PET/CT or molecular imaging in the diagnostic guidelines of various oncology and non-oncology diseases should help increase the knowledge and attitudes of healthcare providers [44, 45].

This study had some limitations. It was performed in a single hospital, and it was a cross-sectional study. A major limitation of all KAP surveys is that they provide a picture of a specific population at a precise point in time, resulting in low generalizability [13, 14]. The

Table 4 Analysis of the factors influencing good knowledge

Knowledge scores > 33%	Univariable logistic regression		Multivariable logistic regression	
	OR (95%CI)	*P*	OR (95%CI)	*P*
Gender				
Male	REF		REF	
Female	0.517 (0.363–0.738)	< 0.001	1.244 (0.758–2.042)	0.387
Age				
< 30 years old	REF		REF	
30–39 years old	0.923 (0.620–1.374)	0.693	0.776 (0.451–1.335)	0.360
≥ 40 years old	1.582 (1.012–2.473)	0.044	0.781 (0.378–1.614)	0.505
Education				
Bachelor's degree and below	REF		REF	
Master's degree	1.402 (0.932–2.109)	0.105	0.770 (0.415–1.429)	0.407
Ph.D. degree	2.488 (1.556–3.978)	< 0.001	0.867 (0.418–1.796)	0.700
Occupation type				
Medical	REF		REF	
Nursing	0.409 (0.290–0.577)	< 0.001	0.301 (0.159–0.571)	< 0.001
Other	0.349 (0.187–0.652)	0.001	0.426 (0.200-0.905)	0.027
Professional title				
Primary title and below	REF		REF	
Middle title	1.118 (0.782–1.597)	0.542	1.060 (0.627–1.790)	0.829
Vice-senior title and above	2.884 (1.780–4.671)	< 0.001	1.725 (0.783–3.798)	0.176
Departmental situation				
The department with a high number of PET/CT scan requests	2.647 (1.814–3.862)	< 0.001	0.419 (0.269–0.652)	< 0.001
The department with a low number of PET/CT scan requests	REF		REF	
Trained in radiation hygiene				
Yes	2.566 (1.714–3.842)	< 0.001	2.520 (1.576–4.030)	< 0.001
No	REF		REF	
Had a PET/CT scan of you or your relatives				
Yes	0.644 (0.421–0.986)	0.043	1.713 (1.063–2.761)	0.027
No	REF		REF	
Frequency of contact with patients who undergo ^{18}F-FDG PET/CT imaging examination				
No contact with patients	REF		REF	
1–10 cases per month	3.324 (2.335–4.733)	< 0.001	2.429 (1.627–3.627)	< 0.001
> 10 cases per month	3.991 (2.085–7.640)	< 0.001	3.575 (1.762–7.252)	< 0.001

present study was performed in a large city hospital, preventing generalizability to rural areas or in smaller settings. In addition, the questionnaire was developed by local investigators who are probably biased by the local guidelines and practices. In addition, online data collection may have affected the outcomes by excluding those without Internet access or less familiar with online questionnaires. Nevertheless, the results of the present study could be considered baseline data to evaluate the effect of future training interventions. Another major bias common to all KAP surveys is the social desirability bias, in which the participants are tempted to provide a socially acceptable answer instead of what they are really doing [46].

Conclusion

Non-radiologist medical staff had poor knowledge but positive attitudes toward PET/CT. Nursing, other occupations, departments with high volumes of PET/CT prescriptions, radioprotection training, underwent (or know someone) a PET/CT, and contact with 1–10 or > 10 patients per month were independently associated with good knowledge. Only the knowledge scores were independently associated with a positive attitude. This study identified knowledge areas worth including in future training interventions. Improving knowledge should translate into better attitudes. Future studies should design and investigate an educational intervention to improve the knowledge regarding ^{18}F-FDG PET/CT.

Table 5 Analysis of the factors influencing positive attitudes

Attitude scores > 65%	**Univariable logistic regression**		**Multivariable logistic regression**	
	OR (95%CI)	***P***	**OR (95%CI)**	***P***
Knowledge Score	1.083 (1.055–1.112)	< 0.001	1.063 (1.032–1.094)	< 0.001
Gender				
Male	REF		REF	
Female	0.515 (0.360–0.738)	< 0.001	0.745 (0.474–1.171)	0.202
Education				
Bachelor's degree and below	REF		REF	
Master's degree	2.168 (1.435–3.277)	< 0.001	1.571 (0.879–2.808)	0.127
Ph.D. degree	1.792 (1.118–2.872)	0.015	1.120 (0.587–2.139)	0.730
Occupation type				
Medical	REF		REF	
Nursing	0.484 (0.345–0.680)	< 0.001	0.912 (0.510–1.631)	0.756
Other	0.378 (0.212–0.675)	0.001	0.659 (0.339–1.281)	0.219
Years of work experience				
< 5 years	REF		REF	
5–10 years	0.670 (0.421–1.065)	0.090	0.812 (0.497–1.327)	0.406
≥ 10 years	0.565 (0.383–0.834)	0.004	0.658 (0.432–1.004)	0.052
Frequency of contact with patients who undergo ^{18}F-FDG PET/CT imaging examination				
No contact with patients	REF		REF	
1–10 cases per month	2.048 (1.455–2.882)	< 0.001	1.403 (0.959–2.052)	0.081
> 10 cases per month	1.861 (0.977–3.547)	0.059	1.504 (0.753–3.006)	0.248

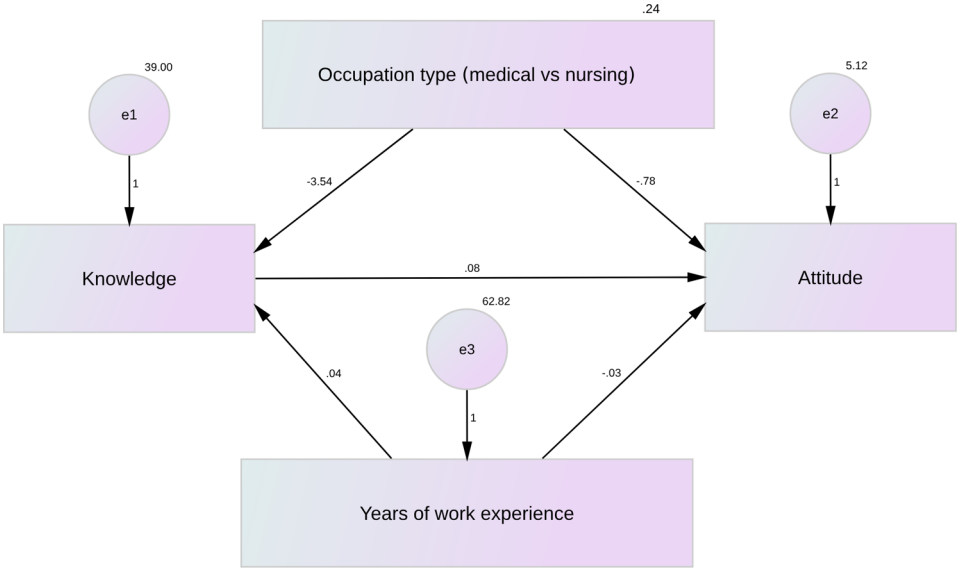

Fig. 1 Pathway analysis

Table 6 Pathway analysis in physicians and nurses

			β	*P*
Knowledge	<---	Occupation type	-3.543	< 0.001
Knowledge	<---	Years of experience	0.037	0.165
Attitude	<---	Knowledge	0.081	< 0.001
Attitude	<---	Years of experience	− 0.035	< 0.001
Attitude	<---	Occupation type	-0.775	< 0.001

Abbreviations

PET	Positron emission tomography
CT	Computed tomography
18 F-FDG	[18 F] fluorodeoxyglucose
KAP	Knowledge, attitude, and practice

Supplementary Information

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Supplementary Material 1

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Not applicable.

Author contributions
LZ carried out the study, participated in its design, and collected data. HY and TXX performed the statistical analysis. DDH and HYT participated in the design, analysis of data, and draft the manuscript. All authors read and approved the final manuscript.

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Data availability
All data generated or analyzed during this study are included in this published article.

Declarations

Ethics approval and consent to participate
The study was exempted from the Ethics Committee of the First Affiliated Hospital of Army Medical University, PLA. Informed consent was obtained from the participants before completing the survey. I confirm that all methods were performed in accordance with the relevant guidelines. All procedures were performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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