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Research article

Korean radiographers' awareness, experiences, and education needs in forensic medicine and forensic radiology

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ABSTRACT

This study assesses the need for education in forensic medicine and forensic radiology among radiographers by investigating the perceptions and experiences of Korean radiographers working in medical institutions. A structured questionnaire was administered to participants, collected, and analyzed. The results showed that despite receiving frequent forensic cases, Korean radiographers face difficulties in taking appropriate measures about forensic radiology due to a lack of awareness and knowledge of its forensic aspects. The participants indicated that university education in forensic medicine and forensic radiology is necessary. Therefore, it is imperative to develop and implement policies for forensic education programs to enhance radiographers' forensic knowledge and capabilities. Universities should conduct courses on forensic radiology and provide continuing education for radiographers working in this field.

1. Introduction

In South Korea, progress has been continually made in various fields such as the economy, society, and science, and medical development in Korea has increased both quantitatively and qualitatively. Therefore, people's quality of life has improved, life expectancy has increased, and a wide range of tests and treatments are conducted owing to the development of innovative medical technologies [1]. Along with economic growth, human rights have improved due to political and social stability [2]. People's human rights are guaranteed irrespective of whether their lives are sustained through medical assistance or whether they die. The introduction of an autopsy system must be guaranteed as one of people's basic rights. The American Forensic Science Association contributes to human rights by providing education and research presentations in various fields such as forensic medicine, forensic nursing, and forensic radiology [3]. However, given Korea's Confucian culture, awareness of forensic medicine and autopsy is low [4]. There is a need for professional education to increase the knowledge of radiographers participating in forensic radiology [5].

Forensic radiology is a discipline that includes the performance of medical imaging examinations and the interpretation of results based on forensic medicine [6]. Forensic radiological evaluation can estimate the cause of injury or death and make individual identification possible by comparing and analyzing images before and after death [6,7]. In this field of study, it is also possible to analyze the musculoskeletal system, blood vessel abnormalities, organ lesions, and ruptures caused by external forces using radiation medical equipment [8]. Evidence collection and investigation of forensic causes of death, acquired using post-mortem computed

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tomography (PMCT), are performed [9–11]. Since it is challenging to confirm the lumen of blood vessels during an autopsy, a previous study used post-mortem computed tomography angiography to identify coronary arteries [12]. Another study used magnetic resonance imaging (MRI) for post-mortem analysis to estimate the age of children and adolescents [13]. Recently, computed tomography (CT) has been used to prevent the contagion of COVID-19 (SARS-CoV) during autopsies [14,15].

With the development of modern science and technology, radiologic technology has made a variety of post-mortem analyses and forensic research possible, and reliable results have been reported [16,17]. Furthermore, through post-mortem imaging, it is possible to scientifically assist forensic pathologists and forensic anthropologists in drawing conclusions on issues related to law enforcement [11]. Hence, forensic expertise is required for radiographers who perform post-mortem imaging examinations. Although radiographers are fully acquainted with examination methods for medical diagnosis and treatment, most of them are unaware of forensic methods and their precautions [18]. Therefore, various programs and activities have been initiated to improve knowledge of forensic radiology. For instance, the American Society of Radiologic Technologists proposed training on forensic examination methods for radiographers in 2010 [19], and the International Society of Forensic Radiology and Imaging was established in 2011 with the aim of researching and advancing forensic radiology and imaging [20]. Furthermore, the Society and College of Radiographers and the International Association of Forensic Radiographers presented judicial guidelines for radiographic imaging in 2014 [21].

The Korea National Forensic Service employs radiographers to apply forensic radiographic imaging to the collection of forensic evidence [22]. If a radiographer lacks forensic experience and education, it may be difficult to communicate with a forensic pathologist, and a forensic radiographer is needed to examine high-quality diagnostic images [23]. In particular, post-mortem image evaluation in the field of forensic radiology is increasing, so sub-specialized education in forensic medicine is necessary [24]. However, since no Korean colleges have explored forensic medicine or forensic radiography in the departments of radiology [25], forensic medicine and forensic radiology education remains inadequate.

Consequently, Korean radiographers do not receive the education necessary to secure high-quality post-mortem imaging, making it difficult to provide data for post-mortem investigations. Therefore, it is essential to provide forensic medicine and forensic radiology education to radiographers in Korea. Several studies have examined the forensic knowledge and status of medical personnel working in emergency departments worldwide [26,27]. Despite multiple searches for forensic radiology-related words in search engines such as PubMed, Google Scholar, KoreaMed, and other domestic databases in November 2020, it was difficult to find studies that had investigated the awareness, experiences, and educational needs of forensic medicine among radiographers. It transpired that researchers had not found any institutions in other countries that teach forensic radiology [28–31]. However, some studies have investigated the knowledge and educational needs of forensic medicine and forensic science for nurses [32–34] and, based on these studies, forensic nursing education was developed and its effectiveness evaluated [35,36]. In Korea, forensic nursing is a new discipline and descriptive research is still in progress, establishing the foundation upon which the necessity of educational development in this field is presented [33,37,38].

To develop forensic radiology education programs and provide qualitative education in universities, it is necessary to analyze the development of forensic radiology in different countries and to ascertain the awareness, experience, and educational needs of radiographers working therein. Designing education based on the awareness of the learners (or absence thereof) can enhance its effectiveness. Training effectiveness is optimized when it includes real-life examples from abundant experience and addresses topics in high demand for the required training. Thus, it is necessary to evaluate the awareness, experience, and educational needs of radiographers in forensic medicine and forensic radiology and, based on the results, present critical data for educational development. We consequently conducted a survey on Korean radiographers' awareness and educational needs in forensic medicine and forensic radiology and their experience performing forensic radiological examinations.

2. Materials and methods

2.1. Study design and participants

This is a descriptive research study that investigated the awareness and educational needs of Korean radiographers in forensic medicine and forensic radiology, focusing on the frequency of experienced forensic cases and the procedures performed during examinations. Radiographers working at medical institutions throughout Korea were targeted. The minimum sample size, i.e., 202 participants required for the correlation, was calculated at 0.05 level of significance, correlation ρ H1 0.25, and power 0.95 using the G*Power 3.1.9.4 program [39].

2.2. Instruments

A questionnaire was developed by researchers based on literature reviews, and the content validity was evaluated by experts: two radiographers and two forensic nurses, all with doctor's degrees and four years' educational experience in forensic medicine and forensic nursing on average. Based on these experts' feedback, the questionnaires were revised and supplemented. The questionnaire included 40 items grouped into four sections: a) demographic characteristics, b) level of awareness of forensic medicine and forensic radiology, c) educational needs in forensic medicine and forensic radiology, and d) experience in types of forensic cases. Section 1 included questions on participants' educational backgrounds, expertise, the kind of hospital and department they worked at, and their experience. Section 2 consisted of questions on cognizance and interest in forensic medicine and forensic radiology and awareness of licenses and terms in related fields necessary for forensic radiology. Section 3 comprised four questions on the need for forensic medical and forensic radiology education. Participants were asked to respond on a 5-point Likert scale (strongly disagree, disagree,

neutral, agree, strongly agree). Section 4 required participants to respond on a 5-point frequency scale (never, rarely, sometimes, most of the time, always) about the types of forensic cases and the performance of related procedures in forensic radiology that radiographers experience on duty. Cronbach's α for the questionnaire was 0.809.

2.3. Procedure

Ethics approval for this study was obtained from the Institutional Review Board of the Catholic university of Pusan, South Korea (CUPIRB-2021-005) to ensure that participants' information was duly protected. It was confirmed that the risk to the study participants was extremely low even if consent was waived, and a written consent exemption was consequently received from the Board. Participants' responses were kept anonymous. To increase the response rate, researchers visited the hospitals in person, explained the purpose of the study, and furnished participants with a printed questionnaire. The study was conducted between May and July 2021. In total, 220 questionnaires were collected, of which 213 were selected for final analysis, having discarded seven that were incomplete. The SPSS version 26 software package was used for the analysis of the collected data. The demographic characteristics of the participants were calculated as frequencies and percentages; and the perception, experience, and educational needs were calculated as frequencies, percentages, means, and standard deviations. The correlation between each variable was analyzed by performing Pearson's correlation coefficient. The level of significance was set at $p = 0.05$.

3. Results

3.1. Demographic characteristics of study participants

The average and median age of the participants were 33.6 and 31 years, respectively, and most of the respondents (84.5 %) were male. The educational level of respondents included Ph.D. degrees (1.9 %), master's degrees (7 %), bachelor's degrees (48.4 %), and associate's degrees (42.7 %). The types of medical institutions where respondents worked were tertiary hospitals (50.2 %), general hospitals (34.7 %), hospitals (3.8 %), and medical clinics (11.3 %). Most participants (71.3 %) were working in diagnostic radiology. After obtaining a radiographer's license, most of them had worked for less than five years (39.4 %), and the average working period was 9.28 (±8.7) years (Table 1).

3.2. Radiographers' awareness of forensic medicine and forensic radiology

In the survey, 19.7 % and 13.6 % of the respondents said they had knowledge of forensic medicine and forensic radiology, respectively. A total of 24 % and 24.4 % of the respondents were interested in forensic medicine and forensic radiology, respectively. Among forensic cases, 74.2 % of respondents agreed with the need for imaging examinations in patients who died from sharp-force injuries. Most participants (88.2 %) opined that a radiographer's license was necessary for imaging examinations of patients who have been declared dead, while in the same situation, 31 % of radiographers were of the view that a general license for radioisotope handling was necessary (Table 2).

Table 1
Participants' demographics ($N = 213$).

Characteristics	Categories	*N*	%
Age (years)	20–24	15	7.0
	25–29	73	34.3
	30–34	48	22.5
	35–39	30	14.1
	40–49	27	12.7
	50 ≤	20	9.4
Gender	Male	180	84.5
	Female	33	15.5
Level of education	Associate's	91	42.7
	Bachelor's	103	48.4
	Master's	15	7.0
	Doctorate	4	1.9
Type of hospital	Tertiary hospital	107	50.2
	General hospital	74	34.7
	Hospital	8	3.8
	Medical clinic	24	11.3
Work department	Diagnostic radiology	152	71.3
	Radiation oncology	49	23.0
	Nuclear medicine	12	5.6
Total years of work	≤5	84	39.4
	5–≤10	53	24.9
	10–≤15	37	17.4
	15–≤20	15	7.0
	20>	24	11.3

Of all the participants, 62.4 % responded negatively to whether they could recognize incisions, stabs, and chopping wounds. Also, 24 % of participants responded negatively to whether they could distinguish between suicide, homicide, and accidental death, which are frequently encountered in daily life (Table 2).

3.3. Education needs in forensic medicine and forensic radiology for radiographers

When asked about the need for forensic medicine education for radiographers, 2.8 % of the respondents strongly agreed, 34.7 % agreed, and 1.4 % strongly disagreed. In the survey about "the intention to take forensic medicine education if given a chance," 44.6 % of the respondents said they were willing, 38.5 % were neutral, and 16.9 % responded negatively, indicating that most respondents were broadly interested. Responding to whether it was necessary to have a forensic medicine course in universities' health departments, 7.5 % strongly agreed, 33.8 % agreed, and 39.4 % were neutral (Table 3).

When asked about "the need for education in forensic radiology for radiographers," 41.8 % were willing, while only 15 % disagreed, indicating that education was generally deemed necessary. A total of 48.8 % of the respondents were willing to take further education in forensic radiology if given the opportunity, and 38.5 % of the participants responded positively to the necessity of initiating a forensic radiology course in universities' health departments, whereas only 15.9 % returned a negative response (Table 3).

3.4. Forensic cases experienced by radiographers

Regarding the type of forensic cases radiographers usually encountered in their clinical work, most respondents mentioned examining victims of traffic accidents (60.1 %) and victims with blunt-force injuries such as knives, axes, and sickles (51.6 %). Only 5.2 % of the participants had performed an imaging examination of gunshot victims (Table 4). Radiographers who had experience with forensic cases provided information on the total number of experiences they had encountered, as well as the number of experiences during the previous year. Analysis confirmed the average frequency per year, with a notable observation of a large standard deviation due to variations in the number of experiences reported by each radiographer (Table 4).

When asked about "the manner of performing forensic radiological procedures on patients in the examination room," 15.1 % of the participants indicated they kept the patients' belongings individually in designated paper bags for use as evidence; 15 % mentioned cutting off clothing for examination, avoiding areas that could be evidence, such as stab wound areas; and 25.8 % stated that they did not pull on the clothing when moving the patient from the bed to the test equipment to prevent damage to the clothing. When handing over collected clothing and belongings, only 16 % of the respondents recorded the name of the receiver and their relationship with the victim (Table 5).

3.5. Correlation among multiple variables

The correlation between radiographers' interest in forensic medicine and forensic radiology, knowledge of forensic terms, educational needs, and performance in imaging examinations were analyzed. Interest in forensic medicine was found to have a statistically significant positive relationship with the knowledge of forensic terms ($r = 0.221$, $p = 0.001$), the necessity of forensic medical education ($r = 0.235$, $p = 0.001$), and the necessity of forensic radiology education ($r = 0.166$, $p = 0.015$). However, there were no statistically significant correlations between interest in forensic medicine and forensic radiological performance. Interest in forensic

Table 2
Awareness of forensic medicine and forensic radiology ($N = 213$).

Variables	Categories	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	$M \pm SD$
				N (%)			
Forensic medicine	Knowledge	24 (11.3)	80 (37.6)	67 (31.5)	38 (17.8)	4 (1.9)	2.62 ± 0.97
	Interest	18 (8.5)	59 (27.7)	85 (39.9)	44 (20.7)	7 (3.3)	2.82 ± 0.96
Forensic radiology	Knowledge	40 (18.8)	88 (41.3)	56 (26.3)	25 (11.7)	4 (1.9)	2.36 ± 0.98
	Interest	18 (8.5)	62 (29.2)	81 (38.0)	49 (23.0)	3 (1.4)	2.79 ± 0.94
Need for imaging	Patients who died from sharp-force injury	5 (2.3)	17 (8.0)	33 (15.5)	102 (47.9)	56 (26.3)	3.88 ± 0.97
License necessity	Radiographer	2 (0.9)	11 (5.2)	25 (11.7)	92 (43.2)	83 (39.0)	4.14 ± 0.88
	General license for radioisotope handling	35 (16.4)	62 (29.1)	50 (23.5)	37 (17.4)	29 (13.6)	2.83 ± 1.28
Recognition of forensic terminology	Incision, stab, and chopping	42 (19.7)	91 (42.7)	45 (21.1)	28 (13.1)	7 (3.3)	2.38 ± 1.05
	Suicide, homicide, and accidental deaths	18 (8.5)	33 (15.5)	45 (21.1)	83 (39.0)	34 (16.0)	3.38 ± 1.17

Table 3
Educational needs in forensic medicine and forensic radiology ($N = 213$).

Variables	Categories	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	$M \pm SD$
				N (%)			
Forensic medicine	Education needs	3 (1.4)	26 (12.2)	104 (48.8)	74 (34.7)	6 (2.8)	3.25 ± 0.76
	Intention for further education	7 (3.3)	29 (13.6)	82 (38.5)	78 (36.6)	17 (8.0)	3.32 ± 0.92
	Necessity for regular courses in university health departments	6 (2.8)	35 (16.4)	84 (39.4)	72 (33.8)	16 (7.5)	3.27 ± 0.92
Forensic radiology	Education needs	4 (1.9)	28 (13.1)	92 (43.2)	80 (37.6)	9 (4.2)	3.29 ± 0.82
	Intention for further education	7 (3.3)	26 (12.2)	72 (35.7)	87 (40.8)	17 (8.0)	3.38 ± 0.92
	Necessity for regular courses in university health departments	6 (2.8)	28 (13.1)	97 (45.5)	70 (32.9)	12 (5.6)	3.25 ± 0.86

Table 4
Forensic cases experienced by radiographers ($N = 213$).

Forensic patients	Experience of exam *n* (%)		Annual mean experiences per year over total work
	No	Yes	Mean ± *SD*
Traffic accident victims	85 (39.9)	128 (60.1)	72.07 ± 186.31
Assault victims	102 (47.9)	111 (52.1)	37.77 ± 57.98
Victims of sharp-force injuries	103 (48.4)	110 (51.6)	29.51 ± 79.08
Victim with amputated body parts	128 (60.1)	85 (39.9)	14.00 ± 38.14
Hanging victims	156 (73.2)	57 (26.8)	7.27 ± 16.31
Drowned body	169 (79.3)	44 (20.7)	1.79 ± 3.89
Gunshot victims	202 (94.8)	11 (5.2)	0.18 ± 0.16

Table 5
Forensic radiological procedures in the examination room ($N = 213$).

Categories	Strongly not doing	Not doing	Neutral	Doing	Strongly doing	$M \pm SD$
			N (%)			
Meticulous storage of belongings	76 (35.7)	50 (23.5)	55 (25.8)	24 (11.3)	8 (3.8)	2.24 ± 1.16
Cutting the clothing carefully	72 (33.8)	33 (15.5)	76 (35.7)	23 (10.8)	9 (4.2)	2.36 ± 1.18
Moving the patient carefully to prevent damage to clothing	50 (23.5)	45 (21.1)	63 (29.6)	43 (20.2)	12 (5.6)	2.63 ± 1.20
Keeping the receiver's record when handing over belongings	69 (32.4)	47 (22.1)	63 (29.6)	23 (10.8)	11 (5.2)	2.34 ± 1.19

Table 6
Correlation between variables ($N = 213$).

Variables	FM knowledge of terms	Need for FM education	Need for FR education	Meticulous storing	Care in cutting off the clothing	Preventing damage to clothing	Keeping receivers' record
				r (*p*)			
FM interest	0.221 (0.001)	0.235 (0.001)	0.166 (0.015)	0.092 (0.181)	0.110 (0.110)	0.063 (0.361)	0.143 (0.037)
FR interest	0.221 (0.001)	0.238 (0.000)	0.231 (0.001)	0.010 (0.885)	0.015 (0.826)	0.022 (0.750)	0.084 (0.223)
Meticulous storing	0.235 (0.001)	−0.069 (0.316)	−0.039 (0.573)	1			
Care in cutting off the clothing	0.165 (0.016)	−0.034 (0.617)	0.018 (0.799)	0.826 (0.000)	1		
Preventing damage to clothing	0.217 (0.001)	−0.006 (0.927)	0.018 (0.797)	0.598 (0.000)	0.634 (0.000)	1	
Keeping receivers' record	0.211 (0.002)	−0.029 (0.676)	0.018 (0.791)	0.706 (0.000)	0.655 (0.000)	0.637 (0.000)	1

r = correlation coefficient, p = probability value.
Abbreviations: FM = forensic medicine, FR = forensic radiology.

radiology had a statistically significant positive relationship with the knowledge of forensic terms ($r = 0.221$, $p = 0.001$), the necessity of forensic medicine education ($r = 0.238$, $p < 0.001$), and the necessity of forensic radiology education ($r = 0.231$, $p = 0.001$). Knowledge of forensic terms had a statistically significant positive relationship with the meticulous storing of the evidence in an envelope ($r = 0.235$, $p = 0.001$), cutting off clothing while avoiding the evidence areas ($r = 0.165$, $p = 0.016$), preventing damage to clothing ($r = 0.217$, $p = 0.001$), and recording the receiver's details when handing over the patient's belongings ($r = 0.211$, $p = 0.002$). No statistically significant correlations were found between the necessity of forensic medical education, the necessity of forensic radiological education, and forensic radiological activities in the examination room. However, a statistically significant positive correlation was found between forensic radiological actions ($p = 0.000$) (Table 6).

4. Discussion

This study is one of the first attempts to investigate the perceptions, experiences, and educational needs of forensic medicine and forensic radiology among Korean radiographers.

This study confirms that Korean radiographers have considerable experience in forensic cases, but their lack of awareness and knowledge of forensic medicine and forensic radiology remains inadequate in terms of performance. It has been reported that forensic care has not developed to its potential and needs in Korea and other countries due to a lack of knowledge in forensic medicine [26,27,32]. Korean emergency nurses, similar to the radiographers who participated in this study, often encounter traffic accidents as a significant aspect of their clinical experience [33]. Accordingly, Han et al. developed and applied forensic nursing simulation training to forensic cases with the highest level of experience and high training requirements, and it proved effective [35]. Therefore, it is necessary for radiographers in Korea to reflect the results of this study and conduct research to develop training appropriate for them and confirm its effectiveness. If adequate evidence is found, the rate of convictions in court is higher, and the perpetrator is often given a longer sentence [40,41]. Since foreign substances or types of bloodstains on patients' clothing can be used as vital evidence to prove an offense, it is imperative to prevent the loss of crucial evidence until the patient's first-aid care has been completed and while the evidence is being collected. Moreover, radiographers who perform imaging examinations also need to acquire knowledge regarding preserving the integrity of evidence as far as possible and, if necessary, collecting evidence while maintaining the chain of custody in evidence management.

Radiographers who participated in the present study were aware of the need for radiological examinations for deaths but lacked knowledge of the forensic medical use of imaging. In Korea, a general license for radioisotope handling is not required at medical institutions when examining deaths. However, it is required in the National Forensic Service [42,43]. Imaging examinations are commonly used for diagnosis in hospitals. However, radiography is also performed at the incident site or the mortuary to forensically identify the deceased, specifically in cases of mass disasters [44]. Therefore, it is necessary to educate radiologists about imaging examinations for deaths.

Radiographers with intrinsic knowledge of forensic terms in this study have been reported to perform forensic radiological procedures better when imaging patients. In addition, radiographers who implemented forensic radiological activities in imaging examinations accurately were more likely to take appropriate forensic actions in radiology, such as meticulous storing of the evidence, cautious pulling or cutting of clothing to prevent damage, and maintaining precise records of the receiver when handing over the evidence, which may otherwise lead to the destruction of crucial evidence instrumental in proving the causal relationship with the incident. However, the current results indicate that high interest in forensic medicine and forensic radiology does not necessarily mean that it will be reflected in the actions performed during imaging examinations. Therefore, besides interest, education toward improving awareness and knowledge of forensic medicine and forensic radiology is essential in preventing the loss of evidence during imaging examinations. Radiographers in this study acknowledged the need for education in forensic medicine and forensic radiology. This is consistent with Donaldson's research findings, which showed a high demand for education in forensic medicine for nurses due to their lack of knowledge in providing forensic nursing care to patients [32].

Post-mortem autopsy using images is called virtual autopsy and is used as an auxiliary means to determine the cause of death in cases where an autopsy cannot be performed, and research on its efficacy is in progress [8]. Effective testing methods such as X-ray, CT, MRI, and others differ by the age group of the deceased [7], and the types of post-mortem imaging sensitive to identifying the area of the damage also vary [45]. Even if radiologists with knowledge of the differences between these clinical and post-mortem images select the appropriate test method [46], the test is performed on the same "as is" basis as that of a clinical patient in case the radiographer does not have knowledge of testing the deceased. In clinical practice, the radiation dose needs to be considered when performing an examination on a patient; however, there is no need to consider the radiation dose for the deceased [47]. Therefore, to obtain a high-quality PMCT image for high sensitivity when examining the deceased, it is necessary to adjust the parameters by applying a different standard than that of the clinical patient [47]. If radiographic images are to be accepted as evidence in court, they must be of high quality, requiring examination by radiographers adept at adjusting the parameters for the deceased [48]. Studies are presently conducted on using PMCT to confirm death due to SARS-CoV-2 [14,49], and there are institutions of legal medicine providing radiographers with medicolegal education to help them become forensic radiographers [48]. Considering the present circumstances, it is expected that the scope of forensic radiographers' activities will expand to include using imaging to identify the cause of death and engage in multidisciplinary cooperation with medicolegal teams. In addition, it is necessary to defend the legal rights of patients by preserving evidence during imaging that can be used in future trials. Therefore, radiographers need to be educated in forensic medicine and forensic radiology.

Despite the high incidence of forensic cases encountered by Korean radiographers, few can perform forensic radiological activities in imaging on forensic cases due to a lack of knowledge, encouraging them to consider the need for further education and training in

forensic medicine and forensic radiology. Therefore, it is necessary to develop and establish education programs in forensic medicine and forensic radiology for radiographers presently working at medical institutions and for undergraduate students studying radiology at universities. Due to the authors' efforts, forensic radiology was established as a regular course for 2 credits (32 h) in the radiology department of one university out of 43 such departments in Korea in March 2023 [5]. If this is expanded, it will ensure high-quality imaging examinations of victims and deceased patients, accurate identification of the cause of death or the mechanisms of damage, and the causal relationship of the case by minimizing the damage to the evidence that will be valid in court. It would also contribute toward upholding the human rights of the victims and justice for the deceased. This study is expected to be a reference for the further development of research and educational programs for forensic radiology.

In this study, survey respondents were distributed across various regions; however, a limitation is that the survey had been predominantly conducted in major cities in Korea. This is due to the limited availability of medical institutions capable of conducting forensic radiological examinations on a widespread basis. However, since this is the first study to investigate the perception, experience, and educational needs of forensic medicine and forensic radiology among radiographers in Korea, it is meaningful in providing essential data for descriptive research studies for radiographers in Korea and across the glove in the future.

5. Conclusion

Korean radiographers exhibit a low level of knowledge concerning forensic medicine and forensic radiology yet recognize the necessity to introduce forensic radiology subjects within university curricula. Notably, traffic accident patients emerge as the most frequently encountered forensic cases in clinical practice, averaging 72 cases per year. Reflecting upon this survey's results, it becomes imperative to develop foundational knowledge and educational frameworks in forensic medicine and forensic radiology, emphasizing a forensic perspective that radiographers should adhere to in each forensic case. This approach underscores the need for tailored education in different countries to suit their unique circumstances, ultimately safeguarding the legal rights of patients undergoing radiological examinations.

CRediT authorship contribution statement

Kyeonghwan Jeong: Data curation, Investigation, Writing – original draft, Writing – review & editing. **Jeongmin Seo:** Data curation, Investigation, Writing – original draft, Writing – review & editing. **Mihyun Han:** Data curation, Investigation. **Dongkyung Jung:** Data curation, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e32219.

References

[1] K.Y. Kim, Changes in the prospect of modern medicine and legal responsibility, Bio-Medical and Law 25 (2021) 5–42, https://doi.org/10.22397/bml.2021.25.5.
[2] H.C. Jeon, The impact of economic growth on human rights (Master's thesis), 2017. Retrieved from, https://dlps.nanet.go.kr/SearchDetailView.do?cn=KDMT1201723979&sysid=nhn.
[3] American Academy of Forensic Sciences, Membership in the General Forensics Section. Retrieved From URL; https://www.aafs.org/membership/general.
[4] D.G. Jones, J.B. Nie, Does Confucianism allow for body donation? Anat. Sci. Educ. 11 (5) (2018) 525–531, https://doi.org/10.1002/ase.1771.
[5] K.H. Jeong, S.H. Han, A survey of radiologic science students' awareness and educational needs of forensic medicine, J. Korean Soc. Radiol. 17 (6) (2023) 977–983, https://doi.org/10.7742/jksr.2023.17.6.977.
[6] M.A. Clemente, L. La Tegola, M. Mattera, G. Guglielmi, Forensic radiology: an update, J. Belg. Soc. Radiol. 101 (Suppl 2) (2017) 21, https://doi.org/10.5334/jbr-btr.1420.
[7] F.P. Cafarelli, G. Grilli, G. Zizzo, G. Bertozzi, N. Giuliani, P. Mahakkanukrauh, A. Pinto, G. Guglielmi, Postmortem imaging: an update, Semin. Ultrasound CT MR 40 (1) (2019) 86–93, https://doi.org/10.1053/j.sult.2018.10.012.
[8] S.J. Decker, M. Braileanu, C. Dey, L. Lenchik, M. Pickup, J. Powell, M. Tucker, L. Probyn, Forensic radiology: a primer, Acad. Radiol. 26 (6) (2019) 820–830, https://doi.org/10.1016/j.acra.2019.03.006.
[9] A.J. Jeffery, G.N. Rutty, C. Robinson, B. Morgan, Computed tomography of projectile injuries, Clin. Radiol. 63 (10) (2008) 1160–1166, https://doi.org/10.1016/j.crad.2008.03.003.
[10] T. Michiue, T. Sakurai, T. Ishikawa, S. Oritani, H. Maeda, Quantitative analysis of pulmonary pathophysiology using postmortem computed tomography with regard to the cause of death, Forensic Sci. Int. 220 (1–3) (2012) 232–238, https://doi.org/10.1016/j.forsciint.2012.03.007.
[11] Z. Obertová, A. Leipner, C. Messina, A. Vanzulli, B. Fliss, C. Cattaneo, L.M. Sconfienza, Postmortem imaging of perimortem skeletal trauma, Forensic Sci. Int. 302 (2019) 109921, https://doi.org/10.1016/j.forsciint.2019.109921.
[12] M.K. Chainchel Singh, S.N. Abdul Rashid, S. Abdul Hamid, M.S. Mahmood, S.S. Feng, H. Mohd Nawawi, E. Omar, Correlation and assessment of coronary artery luminal stenosis: post-mortem computed tomography angiogram versus histopathology, Forensic Sci. Int. 308 (2020) 110171, https://doi.org/10.1016/j.forsciint.2020.110171.

[13] R. Scendoni, M. Cingolani, A. Giovagnoni, M. Fogante, P. Fedeli, Y.I. Pigolkin, L. Ferrante, R. Cameriere, Analysis of carpal bones on MR images for age estimation: first results of a new forensic approach, Forensic Sci. Int. 313 (2020) 110341, https://doi.org/10.1016/j.forsciint.2020.110341.

[14] F. De-Giorgio, F. Cittadini, A. Cina, E. Cavarretta, G. Biondi-Zoccai, G. Vetrugno, L. Natale, C. Colosimo, V.L. Pascali, Use of post-mortem chest computed tomography in Covid-19 pneumonia, Forensic Sci. Int. 325 (2021) 110851, https://doi.org/10.1016/j.forsciint.2021.110851.

[15] A.S. Williams, J.M. Dmetrichuk, P. Kim, M.S. Pollanen, Postmortem radiologic and pathologic findings in COVID-19: the Toronto experience with pre-hospitalization deaths in the community, Forensic Sci. Int. 322 (2021) 110755, https://doi.org/10.1016/j.forsciint.2021.110755.

[16] S.J. Decker, J.M. Ford, Forensic personal identification utilizing part-to-part comparison of CT-derived 3D lumbar models, Forensic Sci. Int. 294 (2019) 21–26, https://doi.org/10.1016/j.forsciint.2018.10.018.

[17] R. Ogawa, N. Takahashi, T. Higuchi, H. Shibuya, M. Yamazaki, N. Yoshimura, H. Takatsuka, H. Aoyama, Assessment of a simple method of heart weight estimation by postmortem computed tomography, Forensic Sci. Int. 296 (2019) 22–27, https://doi.org/10.1016/j.forsciint.2018.12.019.

[18] A. Offiah, R.R. van Rijn, J.M. Perez-Rossello, P.K. Kleinman, Skeletal imaging of child abuse (non-accidental injury), Pediatr. Radiol. 39 (5) (2009) 461–470, https://doi.org/10.1007/s00247-009-1157-1.

[19] M. Kudlas, T. Odle, L. Kisner, The State of Forensic Radiography in the United States. Academy of Scientific Research and Technology, 2010. https://www.asrt.org/docs/default-source/research/whitepapers/forensic_radiography_white_paperfin.pdf?sfvrsn=21dc3b81_10.

[20] M.C. Aalders, N.L. Adolphi, B. Daly, G.G. Davis, H.H. de Boer, S.J. Decker, J.J. Dempers, J. Ford, C.Y. Gerrard, G.M. Hatch, P.A.M. Hofman, M. Iino, C. Jacobsen, W.M. Klein, B. Kubat, P.M. Leth, E.L. Mazuchowski, K.B. Nolte, C. O'Donnell, K. Wozniak, Research in forensic radiology and imaging; Identifying the most important issues, J. Forens. Radiol. Imaging 8 (2017) 1–8, https://doi.org/10.1016/j.jofri.2017.01.004.

[21] Society of Radiographers, Guidance for Radiographers Providing Forensic Radiography Services, Society of Radiographers, 2014, May 30. https://www.sor.org/getmedia/bc61002d-654e-4d03922b6f4283a4b8b3/GuidanceforRadiographersprovidingForensicRadiographyServices_4.

[22] [a] National Forensic Service, Job posting. https://www.nfs.go.kr/site/nfs/main.do, 2021;
[b] C.H. Nguyen, T.T. Nhan, H.T.T. Ta, Joint-training programs in Vietnam: Operation and quality management aspects gathered from institutional practices, Asia Pac. Educ. Rev. 22 (2) (2021) 333–347, https://doi.org/10.1007/s12564-021-09672-2.

[23] K.S. Sangonuga, M. Kekana, C.U. Eze, Forensic radiography services: the experiences of radiographers and forensic pathologists in Nigeria, Radiography 28 (2) (2022) 513–517.

[24] C.L. Elliott, O.J. Arthurs, J. Young, Current status of UK radiology trainee experience in post-mortem imaging: a questionnaire-based survey, Journal of Forensic Radiology and Imaging 9 (2017) 31–35.

[25] Higher Education in Korea, Curriculum with the Word "forensic.", Korean Council for University Education, 2021. https://www.academyinfo.go.kr/brd/brd0520/selectDetail.do?ntce_sntc_sno=110&bbs_gubun=rfbr&no=2#none.

[26] J. de Oliveira Musse, V.S. Santos, D. da Silva Santos, F.P. dos Santos, C.M. de Melo, Preservation of forensic traces by health professionals in a hospital in Northeast Brazil, Forensic Sci. Int. 306 (2020) 110057, https://doi.org/10.1016/j.forsciint.2019.110057.

[27] E.T. Topçu, E. Erek Kazan, E. Büken, Healthcare personnel's knowledge and management of frequently encountered forensic cases in emergency departments in Turkey, J. Forensic Nurs. 16 (1) (2020) 29–35, https://doi.org/10.1097/JFN.0000000000000275.

[28] J. Gonzalez-Rodriguez, Forensic science educational program (V)—validated Programs in the UK and Ireland, Forensic Sci. Rev. 29 (2) (2017) 99–108. https://link.gale.com/apps/doc/A499599188/AONE?u=anoñ9eb55793&sid=googleScholar&xid=4c7ed1e1.

[29] P. Margot, J. Gonzalez-Rodriguez, Forensic science educational programs (Iv)—europe (excluding UK and Ireland), Forensic Sci. Rev. 29 (1) (2017) 9–12. https://link.gale.com/apps/doc/A490551789/AONE?u=anoña4d56022&sid=googleScholar&xid=e42f1115.

[30] C.A. Rarrick, A.M. Cetnarowski, E.A. Gardner, Forensic science educational programs (VI) — programs in the US, Forensic Sci. Rev. 32 (2) (2020) 129–154. https://www.proquest.com/openview/eee66f80437e6cd5e623df2462255678/1?pq-origsite=gscholar&cbl=2042922.

[31] Y.J. Yao, Forensic science educational programs—asian pacific region, Forensic Sci. Rev. 28 (2016) 8–11. https://www.proquest.com/openview/6f54703d446fefb823aa3155bfd3cc41/1?pq-origsite=gscholar&cbl=2042922.

[32] A.E. Donaldson, New Zealand emergency nurses knowledge about forensic science and its application to practice, Int. Emerg. Nurs. 53 (2020) 100854, https://doi.org/10.1016/j.ienj.2020.100854.

[33] M. Han, N.J. Lee, Forensic nursing in South Korea: assessing emergency nurses' awareness, experience, and education needs, Int. Emerg. Nurs. 65 (2022) 101217.

[34] E. Henderson, N. Harada, A. Amar, Caring for the forensic population: recognizing the educational needs of emergency department nurses and physicians, J. Forensic Nurs. 8 (4) (2012) 170–177, https://doi.org/10.1111/j.1939-3938.2012.01144.x.

[35] M. Han, N.J. Lee, S. Lee, Development and evaluation of a forensic nursing competency-based hybrid simulation education program: a quasi-experimental design, Nurse Educ. Pract. 73 (2023) 103819.

[36] D. Özden, H. Özveren, İ. Yılmaz, The impact of forensic nursing course on students' knowledge level on forensic evidence, J. Forensic Leg. Med. 66 (2019) 86–90, https://doi.org/10.1016/j.jflm.2019.06.012.

[37] M.H. Han, H.S. Hong, The awareness and performance of the forensic nursing role in emergency departments, J. Korean Biol. Nurs. Sci. 14 (4) (2012) 291–299, https://doi.org/10.7586/jkbns.2012.14.4.291.

[38] Y.S. Yoo, K.S. Cha, O.H. Cho, S.K. Lee, Emergency department nurses' recognition of and educational needs for forensics nursing education, Korean J. Adult Nurs. 24 (5) (2012) 499–508, https://doi.org/10.7475/kjan.2012.24.5.499.

[39] F. Faul, E. Erdfelder, A.-G. Lang, A. Buchner, G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences, Behav. Res. Methods 39 (2007) 175–191.

[40] T. McEwen, W. Regoeczi, Forensic evidence in homicide investigations and prosecutions, J. Forensic Sci. 60 (5) (2015) 1188–1198, https://doi.org/10.1111/1556-4029.12787.

[41] J.L. Peterson, M.J. Hickman, K.J. Strom, D.J. Johnson, Effect of forensic evidence on criminal justice case processing, J. Forensic Sci. 58 (Suppl. 1) (2013) S78–S90, https://doi.org/10.1111/1556-4029.12020.

[42] Ministry of Health and Welfare, Medical service act, in: 17069, Ministry of Government Legislation, 2020.

[43] Nuclear Safety and Security Commission, Nuclear safety act, in: 16575, Ministry of Government Legislation, 2021.

[44] G.N. Rutty, M.J.P. Biggs, A. Brough, B. Morgan, P. Webster, A. Heathcote, J. Dolan, C. Robinson, Remote post-mortem radiology reporting in disaster victim identification: experience gained in the 2017 Grenfell Tower disaster, Int. J. Leg. Med. 134 (2) (2020) 637–643, https://doi.org/10.1007/s00414-019-02109-x.

[45] G. Ampanozi, D. Halbheer, L.C. Ebert, M.J. Thali, U. Held, Postmortem imaging findings and cause of death determination compared with autopsy: a systematic review of diagnostic test accuracy and meta-analysis, Int. J. Leg. Med. 134 (1) (2020) 321–337, https://doi.org/10.1007/s00414-019-02140-y.

[46] P.M. Flach, M.J. Thali, T. Germerott, Times have changed! Forensic radiology—a new challenge for radiology and forensic pathology, Am. J. Roentgenol. 202 (4) (2014) W325–W334, https://doi.org/10.2214/AJR.12.10283.

[47] D. Gascho, M.J. Thali, T. Niemann, Post-mortem computed tomography: technical principles and recommended parameter settings for high-resolution imaging, Med. Sci. Law 58 (1) (2018) 70–82, https://doi.org/10.1177/0025802417747167.

[48] B. Schneider, C. Chevallier, A. Dominguez, C. Bruguier, C. Elandoy, P. Mangin, S. Grabherr, The forensic radiographer: a new member in the medicolegal team, Am. J. Forensic Med. Pathol 33 (1) (2012) 30–36, https://doi.org/10.1097/PAF.0b013e31820c6aa3.

[49] C. O'Donnell, L. Iles, N. Woodford, Post-mortem CT lung findings at a medicolegal institute in SARS-CoV-2 RT-PCR positive cases with autopsy correlation, Forensic Sci. Med. Pathol. 17 (4) (2021) 611–620, https://doi.org/10.1007/s12024-021-00389-7.