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A STUDY ON THE SAFETY MANAGEMENT STATUS OF DIAGNOSTIC X-RAY EQUIPMENT ACCORDING TO YEARS OF USE

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ABSTRACT

This study aimed to evaluate the current status of safety management and the level of awareness among radiologic technologists regarding diagnostic X-ray generators, focusing on variations according to equipment age. The findings provide baseline data for establishing an efficient safety management system that accounts for equipment aging and performance degradation. The study population consisted of radiologic technologists working in medical institutions across South Korea who perform diagnostic radiographic examinations. A total of 207 structured questionnaires were distributed and collected using Google Forms, and the data were analyzed with SPSS version 22.0 through frequency analysis, cross-tabulation, and chi-square (χ^2) testing. The mean operational lifespan of diagnostic X-ray generators was 8.84 years, with over 20 % of the equipment in use for more than 16 years. Regular safety inspections were performed in 95.7 % of institutions, and preventive maintenance in 89.4 %. However, the possession rate of personal dosimeters (48.3 %) and the implementation of institutional safety management programs (53.6 %) were relatively low. Most respondents considered the current three-year inspection cycle appropriate, whereas 74.9 % recognized the need to shorten inspection intervals for equipment operated for more than ten years. Respondents employed at tertiary or general hospitals were more likely to support annual inspection cycles. No statistically significant differences were observed according to gender or years of professional experience ($p > 0.05$). These findings suggest that the safety management framework for diagnostic X-ray equipment in South Korea should transition from a uniform three-year inspection cycle to a risk- and age-based system that reflects operational duration and performance decline. Furthermore, performance and radiation safety evaluations should be conducted at least annually for units older than ten years, and targeted support programs should be implemented to strengthen safety management in small and medium-sized healthcare facilities.: diagnostic X-ray generator; radiologic technology; radiation protection; safety management; equipment lifespan; inspection interval; tube voltage; tube current.

KEYWORDS: diagnostic X-ray generator, medical radiation, safety management, years of use, periodic inspection cycle, tube voltage, tube current.

1. INTRODUCTION

Ionizing radiation produced by diagnostic X-ray generators plays an essential role in modern medical imaging by enabling visualization of internal anatomical structures and physiological functions. Diagnostic radiology is indispensable for disease diagnosis and therapeutic decision-making. According to the Korea Disease Control and Prevention Agency (KDCA), the number of diagnostic X-ray generators increased from 94,187 units in 2020 to 97,745 units in 2021, representing a 3.8 % increase (3,558 units) [1]. This continuous growth reflects both the rising clinical demand for imaging and the replacement of obsolete equipment due to aging and technological advancement. Under Article 37 of the Medical Service Act and the Regulation on Safety Management of Diagnostic X-ray Generating Equipment, medical institution directors and designated radiation safety officers (RSOs) are required to conduct safety inspections at least once every three years [2–3]. Inspection items include grounding integrity tests, leakage current tests, radiation output reproducibility, tube voltage (kVp) accuracy, tube.

current (mA) stability, X-ray field congruence, and beam alignment accuracy. These periodic evaluations ensure operational stability and radiation safety. However, there is no legal restriction on the maximum service life of diagnostic X-ray equipment in South Korea. According to the KDCA's *National Statistics on the Safety Management of Diagnostic X-ray Generating Equipment (2020)*, among 94,187 registered units, 8,681 (9.2 %) were reported as non-operational, and 842 had unknown manufacturing years [4–5]. The average operational lifespan of inactive systems was 18.26 years, while that of active units was 8.84 years. These data indicate that a substantial number of obsolete systems remain clinically operational. Even though aging equipment may temporarily meet regulatory inspection criteria, performance drift, electrical instability, and increased patient dose can occur in routine use. Such degradation can reduce image quality and compromise diagnostic reliability [6–7]. Furthermore, older systems tend to exhibit variability in radiation output beyond acceptable tolerance levels, increasing the potential exposure risk for both patients and occupationally exposed radiologic personnel. Therefore, the safety management framework for diagnostic X-ray generators should evolve from uniform, time-based inspections to a differentiated, condition-based approach that considers equipment aging, utilization rate, and performance stability. Accordingly, this

study aims to (1) analyze the current installation and utilization patterns of diagnostic X-ray generators in Korean medical facilities, and (2) assess the perceptions of radiologic technologists regarding safety management based on the years of equipment use, thereby providing foundational evidence to support policy improvements and optimized inspection cycles tailored to equipment lifespan.

2. METHODS

2.1 Survey Design

This study employed a quantitative, cross-sectional research design utilizing a structured, self-administered questionnaire to evaluate safety management practices related to diagnostic X-ray equipment. The research protocol was reviewed and approved by the Institutional Review Board (IRB) of Hanseo University (Approval No. HS-07-01). Data collection was conducted from July 1 to September 30, 2025, subsequent to IRB approval. The questionnaire was distributed online via Google Forms, enabling participants to complete and submit their responses electronically. The introductory page of the questionnaire provided detailed information on the study's objectives, confidentiality of personal data, and the voluntary nature of participation. Electronic informed consent was obtained by having participants select the statement, "I voluntarily agree to participate in this study." To minimize investigator bias and maintain objectivity, the survey employed a self-administered response format without direct researcher involvement. This approach aligns with ethical principles for human subject research and ensures the reliability of self-reported data in radiologic workforce studies.

2.2 Participants

Eligible participants were licensed radiologic technologists (RTs) in South Korea who were currently employed in, or had prior experience within, diagnostic radiology departments of medical institutions and were directly involved in general diagnostic X-ray imaging procedures. The minimum required sample size was determined using G*Power software (Version 3.1.9.4). A medium effect size ($w = 0.3$), significance level ($\alpha = 0.05$), and statistical power ($1 - \beta = 0.95$) were specified, yielding a minimum required sample size of 111 participants to achieve statistical validity. Exclusion criteria were as follows: RTs with no direct experience performing general radiographic examinations; Respondents who completed less than 50 % of the questionnaire; and Individuals who withdrew participation after submission. To enhance data integrity and statistical

robustness, a total of 210 radiologic technologists were initially recruited. After excluding three incomplete responses (completion rate < 50 %), 207

valid datasets were retained for the final statistical analysis.

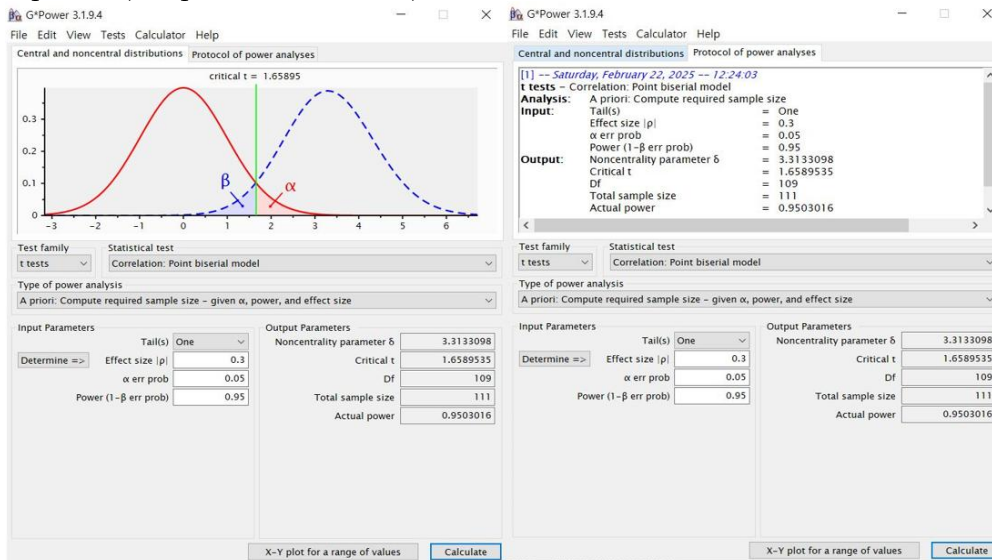


Fig 1: G-Power Program.

2.3 Questionnaire Composition

The questionnaire used in this study consisted of 14 items. Based on a review of prior research, the survey was designed to assess both the operational status of diagnostic X-ray generators and the perceptions of safety management among radiologic technologists. Specifically, the questionnaire included, Six items on the operational status of diagnostic X-ray equipment, covering the type of medical institution, duration of use, maintenance cycle, frequency of safety inspections, and availability of radiation dose measurement instruments. Six items addressing perceptions of safety management according to equipment lifespan, including awareness of appropriate inspection intervals, perceived adequate service life, recognition of the need to adjust inspection cycles for aging equipment, appropriateness of internal safety management standards, and perceived necessity for improvements in regulatory frameworks. Four items on general demographic characteristics, including gender, age, type of employing institution, and years of work experience.3. Statistical Analysis All data were analyzed using SPSS software (Version 28.0; IBM Corp., Armonk, NY, USA). Descriptive statistics, including frequency analysis, were conducted to examine participants' general characteristics and

variables related to equipment operation and safety management. To identify associations between categorical variables, the chi-square test (χ^2 -test) was employed, examining relationships between independent variables (gender, age, work experience, and institution type) and dependent variables related to safety management awareness and attitudes. Statistical significance was determined at $p < 0.05$. Values below this threshold were interpreted as indicating statistically significant differences.4. RESULTS4.1 General Characteristics Among the 207 respondents, 169 (81.6%) were male and 38 (18.4%) were female. In terms of age distribution, 51 participants (24.6%) were under 39 years, 57 (27.5%) were aged 40–49 years, and 99 (47.8%) were aged 50 years or older, indicating that older radiologic technologists constituted the largest proportion. Regarding the type of employing institution, 74 (35.7%) worked in tertiary hospitals, 75 (36.2%) in general hospitals, 14 (6.8%) in hospitals, and 21 (10.1%) in clinics, while 23 participants (11.1%) were employed in educational or research institutions. In terms of work experience, 39 respondents (18.8%) had less than 10 years of experience, 58 (28.0%) had 10–20 years, and 110 (53.1%) had more than 20 years, showing that over half of the participants had more than two decades of professional experience (Table 1).

Table 1: General Characteristics.

Variables		N	%
Gender	Male	169	81.6
	Female	38	18.4

Ages	≤ 39 years		51	24.6
	40-49 years		57	27.5
	≥ 50 years		99	47.8
Institution	Medical	Tertiary hospital	74	35.7
		General hospital	75	36.2
		Hospital	14	6.8
		Clinic	21	10.1
	Education / Research		23	11.1
Work experience	< 10 years		39	18.8
	< 20 years		58	28.0
	≥ 20 years		110	53.1

4.2 Operational Status and Safety Management of Diagnostic X-ray Generators

Analysis of the operational lifespan of diagnostic X-ray generators revealed that 76 units (36.7%) had been in use for 11–15 years, representing the largest proportion. This was followed by 60 units (29.0%) in use for 6–10 years, 29 units (14.0%) for 1–5 years, 23 units (11.1%) for 16–20 years, and 19 units (9.2%) for more than 21 years. Overall, approximately 20% of all devices had been in operation for 16 years or longer, indicating a considerable presence of aging equipment in clinical settings. Regarding regular safety inspections, 198 institutions (95.7%) reported performing periodic inspections, while 9 institutions (4.3%) did not. In terms of maintenance, 185 institutions (89.4%) conducted regular maintenance,

whereas 22 institutions (10.6%) did not have an established maintenance routine. With respect to dosimeter ownership, 100 institutions (48.3%) possessed radiation measuring devices, while 107 institutions (51.7%) did not. Among the owned dosimeters, multimeters were the most common (72 institutions, 57.6%), followed by dose meters (34 institutions, 27.2%), tube current meters (10 institutions, 8.0%), and tube voltage meters (9 institutions, 7.2%). Concerning the operation of institutional safety management systems, 111 institutions (53.6%) reported having an internal safety management framework in place, whereas 96 institutions (46.4%) did not operate a dedicated system (Table 2).

Table 2: Equipment Maintenance.

Variables		n	%	
Equipment operating years	1-5 years	29	14.0	
	6-10 years	60	29.0	
	11-15 years	76	36.7	
	16-20 years	23	11.1	
	≥ 21 years	19	9.2	
Regular inspection	No	9	4.3	
	Yes	198	95.7	
Maintenance	No	22	10.6	
	Yes	185	89.4	
Dosimeter possession	No	107	51.7	
	Yes	100	48.3	
	Type	Multimeter	72	57.6
		Tube current meter	10	8.0
		Tube voltage meter	9	7.2
Exposure dose meter		34	27.2	
In-house safety management	No	96	46.4	
	Yes	111	53.6	

4.3 Perceptions of Safety Management According to Equipment Lifespan

Regarding the perceived adequacy of the current safety management cycle for diagnostic X-ray generators, 164 respondents (79.2%) considered the existing system to be appropriate, whereas 43 respondents (20.8%) viewed it as inadequate. When asked about the appropriate service life of diagnostic X-ray equipment, 112 respondents (54.1%) identified

10 years as suitable, followed by 53 (25.6%) who selected 15 years, 30 (14.5%) who chose 20 years, and 12 (5.8%) who believed 5 years to be appropriate. Concerning the need to revise the safety inspection interval for equipment used for more than 10 years, a substantial majority of 155 respondents (74.9%) answered that revision is necessary, while 52 respondents (25.1%) indicated that it is not necessary. In terms of the preferred safety management cycle for

devices older than ten years, 142 respondents (68.6%) recommended annual inspections, 13 respondents (6.3%) suggested semiannual inspections, and 52

respondents (25.1%) preferred to maintain the current inspection cycle (Table 3).

Table 3: Radiation Equipment Safety Management Period.

Variables		n	%
Current safety management period adequacy	No	43	20.8
	Yes	164	79.2
Recommended service life of equipment	5 years	12	5.8
	10 years	112	54.1
	15 years	53	25.6
	20 years	30	14.5
Need for change in safety management period of equipment used ≥ 10 years	No	52	25.1
	Yes	155	74.9
Appropriate safety management period for equipment aged ≥ 10 years	Every 6 months	13	6.3
	Annually	142	68.6
	Same as current practice	52	25.1

4.4 Perception of the Appropriateness of the Safety Management Cycle

A cross-tabulation analysis was conducted to examine differences in perceptions of the appropriateness of the three-year safety management cycle for diagnostic X-ray generators according to gender, type of institution, and years of work experience. By gender, 132 males (78.1%) and 32 females (84.2%) responded that the current three-year inspection cycle is appropriate. No statistically significant difference was found between the two groups ($\chi^2 = 0.702$, $p = 0.40$). Analysis by institution type showed that respondents from tertiary hospitals (68.9%), general hospitals (89.3%), hospitals (78.6%),

clinics (81.0%), and educational or research institutions (78.3%) considered the three-year cycle appropriate. The differences across institution types approached statistical significance ($\chi^2 = 9.487$, $p = 0.05$), with general hospital employees demonstrating the highest rate of agreement. Regarding work experience, respondents with less than 10 years of experience (92.3%) most frequently perceived the three-year inspection interval as appropriate, followed by those with 10–20 years (81.0%) and over 20 years (73.6%) of experience. This difference was found to be statistically significant ($\chi^2 = 6.259$, $p = 0.04$) (Table 4).

Table 4: Appropriateness of a 3-Year Safety Management Interval for Diagnostic Radiation Devices.

Variables	No	Yes	χ^2	p	
Gender	Male	37(21.9)	132(78.1)	0.702	0.40
	Female	6(15.8)	32(84.2)		
Institution	Tertiary hospital	23(31.1)	51(68.9)	9.487	0.05
	General hospital	8(10.7)	67(89.3)		
	Hospital	3(21.4)	11(78.6)		
	Clinic	4(19.0)	17(81.0)		
	Education / Research	5(21.7)	18(78.3)		
Work experience	< 10 years	3(7.7)	36(92.3)	6.259	0.04
	< 20 years	11(19.0)	47(81.0)		
	≥ 20 years	29(26.4)	81(73.6)		

4.5 Perception of the Appropriate Service Life of Diagnostic X-ray Generators

A cross-tabulation analysis was conducted to assess differences in perceptions of the appropriate service life of diagnostic X-ray generators according to gender, type of medical institution, and years of work experience. By gender, the highest proportion of male respondents (55.0%) considered 10 years to be the appropriate service life, followed by 15 years (24.9%), 20 years (14.8%), and 5 years (5.3%). Among

female respondents, 50.0% selected 10 years, followed by 15 years (28.9%) and 20 years (13.2%). No statistically significant difference was observed between male and female respondents ($\chi^2 = 0.759$, $p = 0.86$). Analysis by institution type indicated that 71.6% of respondents from tertiary hospitals and 56.0% from general hospitals perceived 10 years as the appropriate lifespan for X-ray generators. In contrast, lower proportions were reported among respondents from hospitals (35.7%), clinics (38.1%), and educational or research institutions (30.4%).

These differences were statistically significant ($\chi^2 = 32.532$, $p = 0.001$). In terms of work experience, 51.3% of respondents with less than 10 years, 48.3% with 10–20 years, and 58.2% with more than 20 years of

experience regarded 10 years as the appropriate service life. However, the differences among experience groups were not statistically significant ($\chi^2 = 6.13$, $p = 0.41$) (Table 5).

Table 5: Appropriate Service Life of Diagnostic Radiation Devices.

Variables		5 years	10 years	15 years	20 years	χ^2	p
Gender	Male	9(5.3)	93(55.0)	42(24.9)	25(14.8)	0.759	0.86
	Female	3(7.9)	19(50.0)	11(28.9)	5(13.2)		
Institution	Tertiary hospital	3(4.1)	53(71.6)	13(17.6)	5(6.8)	32.532	0.001
	General hospital	5(6.7)	39(52.0)	23(30.7)	8(10.7)		
	Hospital	1(7.1)	5(35.7)	6(42.9)	2(14.3)		
	Clinic	0(0.0)	8(38.1)	5(23.8)	8(38.1)		
	Education/Research	3(13.0)	7(30.4)	6(26.1)	7(30.4)		
Work experience	< 10 years	1(2.6)	20(51.3)	13(33.3)	5(12.8)	6.13	0.41
	< 20 years	6(10.3)	28(48.3)	13(22.4)	11(19.0)		
	≥ 20 years	5(4.5)	64(58.2)	27(24.5)	14(12.7)		

4.6 Perception of the Need to Revise the Safety Inspection Cycle for Equipment Used Over 10 Years

Differences in the perception of the need to revise the safety inspection cycle for diagnostic X-ray generators used for more than 10 years were analyzed according to gender, type of medical institution, and work experience. The results are summarized in Table 6. By gender, 123 males (72.8%) and 32 females (84.2%) responded that a revision of the inspection cycle is *necessary*. However, the difference between genders was not statistically significant ($\chi^2 = 2.155$, $p = 0.14$). Similarly, no statistically significant difference was observed

among institution types ($\chi^2 = 7.578$, $p = 0.108$). Nonetheless, the perception that revision is necessary was relatively higher among respondents from tertiary hospitals (85.1%) and general hospitals (72.0%), compared with those from hospitals (71.4%), clinics (61.9%), and educational or research institutions (65.2%). Analysis by work experience revealed that 82.1% of respondents with less than 10 years of experience, 67.2% with 10–20 years, and 76.4% with more than 20 years of experience agreed on the need to revise the safety inspection interval. However, these differences were not statistically significant ($\chi^2 = 2.994$, $p = 0.22$) (Table 6).

Table 6: Need for Changing Safety Management Interval of Devices Aged ≥10 Years.

Variables		No	Yes	χ^2	p
Gender	Male	46(27.2)	123(72.8)	2.155	0.14
	Female	6(15.8)	32(84.2)		
Institution	Tertiary hospital	11(14.9)	63(85.1)	7.578	0.10
	General hospital	21(28.0)	54(72.0)		
	Hospital	4(28.6)	10(71.4)		
	Clinic	8(38.1)	13(61.9)		
	Educational / Research	8(34.8)	15(65.2)		
Work Experience	< 10 years	7(17.9)	32(82.1)	2.994	0.22
	< 20 years	19(32.8)	39(67.2)		
	≥ 20 years	26(23.6)	84(76.4)		

4.7 Perception of the Appropriate Safety Inspection Interval for Equipment Used Over 10 Years

Differences in perceptions of the appropriate safety inspection interval for diagnostic X-ray generators used for more than 10 years were analyzed by gender, type of institution, and years of work experience. The results are summarized in Table 7. By gender, 66.3% of male and 78.9% of female respondents indicated that annual inspections

were appropriate. In contrast, 27.2% of males and 15.8% of females preferred to maintain the current inspection interval, while 6.5% of males and 5.3% of females favored semiannual inspections. These gender differences were not statistically significant ($\chi^2 = 2.417$, $p = 0.30$). Analysis by institution type showed that respondents from tertiary hospitals (71.6%), general hospitals (70.7%), and hospitals (71.4%) most frequently selected annual inspections

as appropriate, whereas lower proportions were observed among those from clinics (57.1%) and educational or research institutions (60.9%). These institutional differences were found to be statistically significant ($\chi^2 = 16.619$, $p = 0.03$). Regarding work experience, 82.1% of respondents with less than 10

years of experience, 63.8% with 10–20 years, and 68.2% with more than 20 years indicated that annual safety inspections were necessary. However, the differences among experience groups were not statistically significant ($\chi^2 = 6.967$, $p = 0.14$) (Table 7).

Table 7: Appropriate Safety Management Interval for Devices Aged ≥ 10 Years.

Variables		Every 6 months	Annually	Same as current practice	χ^2	p
Gender	Male	11(6.5)	112(66.3)	46(27.2)	2.417	0.30
	Female	2(5.3)	30(78.9)	6(15.8)		
Institution	Tertiary hospital	10(13.5)	53(71.6)	11(14.9)	16.619	0.03
	General hospital	1(1.3)	53(70.7)	21(28.0)		
	Hospital	0(0.0)	10(71.4)	4(28.6)		
	Clinic	1(4.8)	12(57.1)	8(38.1)		
	Education/Research	1(4.3)	14(60.9)	8(34.8)		
Work Experience	< 10 years	0(0)	32(82.1)	7(17.9)	6.967	0.14
	< 20 years	4(6.9)	35(60.3)	19(32.8)		
	≥ 20 years	9(8.2)	75(68.2)	26(23.6)		

4.8 Analysis of In-House Safety Management Practices in Medical Institutions

Differences in whether medical institutions operate their own in-house safety management systems for diagnostic X-ray generators were analyzed according to gender, institution type, and work experience. The results are presented in Table 8. By gender, 55.6% of male and 44.7% of female respondents reported that their institutions operate internal safety management systems. However, the difference between genders was not statistically significant ($\chi^2 = 1.478$, $p = 0.22$). Analysis by institution type revealed statistically significant

differences ($\chi^2 = 15.009$, $p < 0.001$). Specifically, 62.2% of respondents from tertiary hospitals, 78.6% from hospitals, and 65.2% from educational or research institutions reported operating internal safety management systems. In contrast, the proportion was lower among respondents from general hospitals (44.0%) and clinics (28.6%). These results indicate that larger or institutionally structured facilities tend to maintain formal safety management frameworks, whereas smaller private medical institutions show relatively lower implementation rates (Table 8).

Table 8: In-House Safety Management in Medical Institutions.

Variables		No	Yes	χ^2	p
Gender	Male	75(44.4)	94(55.6)	1.478	0.22
	Female	21(55.3)	17(44.7)		
Institution	Tertiary hospital	28(37.8)	46(62.2)	15.009	0.00
	General hospital	42(56.0)	33(44.0)		
	Hospital	3(21.4)	11(78.6)		
	Clinic	15(71.4)	6(28.6)		
	Educational / Research	8(34.8)	15(65.2)		
Work experience	< 10 years	16(41)	23(59)	0.831	0.66
	< 20 years	26(44.8)	32(55.2)		
	≥ 20 years	54(49.1)	56(50.9)		

5. DISCUSSION

Diagnostic X-ray generators are subject to performance degradation due to aging, unstable external power supply, and wear of internal components. Therefore, systematic inspection and maintenance of diagnostic X-ray equipment are essential to ensure reliable performance and radiation safety. [9-10] Since tube voltage (kVp), tube

current (mA), and exposure time directly determine both image quality and radiation dose, these parameters must be regularly monitored to maintain consistent output. When output reproducibility is unstable, variations in dose can lead to decreased image contrast, sharpness, and density, and potentially increase patient radiation exposure. Under the Regulations on the Safety Management of Diagnostic X-ray Generating Equipment in Korea,

safety inspections are mandated once every three years. However, even if older equipment passes an inspection, it may still deteriorate within the next three-year cycle, resulting in operation outside of the reference tolerance limits. In practice, such aged equipment may continue to be used clinically, posing potential risks to both image quality and radiation safety. Despite these concerns, there has been no systematic study in South Korea examining safety management cycles in relation to the years of equipment use. According to Cummings, K. E., in a study on the Renewal of Radiological Equipment, older imaging systems pose higher risks of malfunction and safety failure [9]. Equipment that is more than 10 years old is no longer considered state-of-the-art and often entails higher operating costs and maintenance difficulties due to limited availability of spare parts. Replacement is therefore essential to maintain clinical reliability and patient safety. In this study, approximately 20% of the diagnostic X-ray generators used in medical institutions were found to be over 16 years old. Although 89.4% of institutions performed regular maintenance, 10.6% did not. Moreover, while 53.6% of institutions operated internal safety management systems, 46.4% lacked such systems. These findings indicate that although most institutions comply with mandatory inspection and maintenance requirements, the implementation of autonomous safety management frameworks remains suboptimal, with considerable variation between institutions depending on scale and resources. According to Cho, J. P., who investigated quality control for medical diagnostic X-ray equipment, test items, intervals, and timing should be strictly managed to optimize equipment performance according to each manufacturer's specifications. However, in Korea, current regulations do not differentiate inspection items or intervals by manufacturer or by equipment age, applying uniform standards instead [14-15]. In this study, approximately 75% of respondents recognized the need to revise the current three-year inspection cycle for equipment used over 10 years, regardless of gender. Differences were observed by institution type and work experience, suggesting that radiologic technologists working in larger hospitals or with more professional experience were more aware of the necessity to adapt inspection cycles and methods. These findings emphasize the need for a differentiated safety management approach based on equipment age, as aging directly affects both performance stability and radiation exposure control. Furthermore, analysis of perceptions

regarding the appropriate inspection interval for equipment used over 10 years revealed a strong consensus across all demographic groups for annual inspections. Respondents from large medical institutions exhibited a particularly high awareness of the importance of mitigating performance degradation and maintaining exposure control, reflecting a tendency to prefer shorter inspection intervals. These results suggest that the current triennial safety inspection cycle is inadequate for aging equipment and that annual inspections or more frequent evaluations should be implemented to ensure diagnostic reliability and radiation safety. This study holds significance in that it analyzed the safety management status and awareness of radiologic technologists according to the years of equipment use in Korean medical institutions, thereby providing an evidence-based foundation for improving safety management policies in the context of equipment aging. However, this study has certain limitations. The survey sample was regionally limited, and thus, its representativeness may be constrained. Future studies should include nationwide samples, stratified by institution size and region, to ensure greater generalizability. In addition, further research should aim to develop differentiated management models by equipment age and inspection frequency. Integrating empirical performance data and measured radiation dose variations would enable the development of evidence-based guidelines for optimized safety inspection intervals and long-term quality assurance.

6. CONCLUSION

This study analyzed the current status of safety management and the perceptions of radiologic technologists regarding diagnostic X-ray generators according to the years of equipment use, aiming to identify directions for improving safety inspection cycles and regulatory systems in response to equipment aging. The key findings are as follows: First, the average operational lifespan of diagnostic X-ray generators was 8.8 years, and approximately 20% of devices had been in use for over 16 years, indicating a significant presence of aging equipment in clinical practice. Second, regarding the appropriateness of the current safety inspection cycle, 79.2% of respondents considered the three-year inspection interval appropriate, yet 74.9% recognized the need to shorten the inspection cycle for equipment that had been in use for more than ten years. Third, respondents working in tertiary and general hospitals exhibited a stronger awareness of the necessity to reduce the inspection cycle, whereas

no significant differences were found by gender or years of work experience. Overall, the results of this study provide foundational evidence for revising the safety management system of diagnostic X-ray generators in South Korea. Given the aging of installed equipment and the variability in safety management practices across institutions, it is essential to establish age-dependent, performance-based safety inspection intervals supported by

empirical data. Future research should integrate equipment performance testing outcomes and radiation dose variation data to develop a scientifically grounded model for determining optimal inspection frequencies. Nationwide studies with regionally and institutionally balanced samples are also warranted to generalize findings and strengthen the evidence base for policy development.

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REFERENCES

- Korean Radiological Technologists Association. Diagnostic radiation generator safety management statistics report. Korea Disease Control and Prevention Agency; 2020.https://www.kdca.go.kr/board/board.es?mid=a20607020000&bid=0034&list_no=717571&act=view[2] Yeji
- Heo, Kyotae Kim, Sicheul Noh, Sanghee Nam, Jikoon Park., A Base Study on the Constancy Quality Control Test and Clause of Diagnosis Radiation Equipment. J. Korean. Soc. Radiol., Vol. 8, No. 3, 2014 <https://scienceon.kisti.re.kr/srch/selectPORSrchArticle.do?cn=JAKO201413252437942>
- Kim HJ, Lee JE, Lee BY. Safety management status of diagnostic radiation equipment in Korea. Journal of Radiological Science and Technology. 2017;40(4):315-322.
- Ko JK, Jeon YR, Han EO, Cho PG, Kim YM. Comparison of laws applied to diagnostic radiation generators. J Radiol Sci Technol. 2015;38(3):277-286. <https://koreascience.or.kr/article/JAKO201530360959092.page>
- Seo JR. Problems and improvements of safety management of diagnostic radiation generators. J Korean Radiogr Assoc. 2001;27(2):260-268.
- American Association of Physicists in Medicine. Protocols for the Radiation Safety Surveys (Report No. 25). College Park (MD): AAPM; 1991. <https://www.aapm.org/pubs/reports/detail.asp?docid=24>
- Pandey A, Singh M, Sonawane AU, Rawat PS. FMEA-based risk assessment of component failure modes in industrial radiography. arXiv preprint. 2016; arXiv:1610.01364. <https://ijettjournal.org/archive/ijett-v39p237>
- Paulis LE, Schnerr RS, Halton J, Qin ZZ, Chua A. Assessment of scattered and leakage radiation from ultra-portable digital chest X-ray systems: an independent study. arXiv preprint. 2024; arXiv:2406.10044. <https://journals.plos.org/globalpublichealth/article?id=10.1371/journal.pgph.0003986>
- Cummings K E, Shepherd JE. Renewal of radiological equipment. Radiography. 2014;20(3):244-9. <https://pubmed.ncbi.nlm.nih.gov/25230589/>
- Delis H, Tsapaki V, Bolt R, Padovani R. Moving beyond quality control in diagnostic radiology and radiotherapy: a review of the evolution of quality assurance. Eur J Radiol. 2017;95:210-8. <https://www.sciencedirect.com/science/article/pii/S1120179717300935>
- Choi JG, Kim KS, Kim BK, Ahn NJ. Improvement plan for mobile radiographic examinations following the revision of safety management rules for diagnostic X-ray generators. J Radiol Sci Technol. 2007;30(1):53-59. <https://www.kci.go.kr/kciportal/ci/sereArticleSearch/ciSereArtiView.kci?sereArticleSearchBean.artiId=ART001044828>
- Bjarnason TA, Asante A, et al. A survey of radiation safety regulations for medical imaging X-ray equipment in Canada. J Appl Clin Med Phys. 2020;21(9):136-145. <https://pubmed.ncbi.nlm.nih.gov/31539193/>
- Alyami J, Alzahrani Y. Assessment of diagnostic radiology facilities: technical radiation protection and regulatory compliance. Appl Sci. 2022;12(14):7284. <https://www.mdpi.com/2076-3417/12/14/7284>
- Cho PG, Oh S. Quality control of diagnostic radiation generators in the medical field. J Korean Med Device Ind. 2021;26(2):77-84. <https://www.kci.go.kr/kciportal/ci/sereArticleSearch/ciSereArtiView.kci?sereArticleSearchBean.artiId=ART002711431>
- The impact of regular maintenance on the longevity and performance of radiology equipment. Int J Eng Res Dev. 2024;16(3):88-95. https://www.researchgate.net/publication/384638056_The_Impact_of_Regular_Maintenance_on_the_Longevity_and_Performance_of_Radiology_Equipment