ORIGINAL ARTICLE

The application of infection control in intraoral radiographic examinations in various healthcare facilities: an observational study

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ABSTRACT

Introduction: One of the sectors that has been significantly impacted by the COVID-19 pandemic is dentistry. There is a significant chance that an intraoral radiographic examination will facilitate the spread of the COVID-19. One of the radiographers' efforts to prevent the spread of the COVID-19 virus is to carry out infection control. The application of infection control performed by radiographers is influenced by many factors. This study aimed to analyze differences in the application of infection control in intraoral radiographic examinations during the COVID-19 pandemic in various healthcare facilities. **Methods:** This study conducted was an observational analytic study with a cross-sectional design. The research was conducted using a questionnaire consisting of 13 statement items. Thirty intraoral dental radiographers who were employed in radiology departments at various healthcare facilities participated in the study as respondents. The research data that had been collected was then tested using the One Way Anova test to find out the differences in the application of infection control by radiographers from each healthcare facility. **Results:** The results of the study indicated that the significance value was 0.314 ($p>0.05$), which means that there was no significant difference in the score category for each healthcare facility. The lack of complete respondents from all different kinds of existing healthcare facilities was still a weakness of this study. **Conclusion:** During the COVID-19 pandemic, there was no discernible difference in how each healthcare facility implemented infection control during intraoral radiographic examinations.

KEYWORDS

COVID-19, healthcare facilities, infection control, intraoral radiographs, radiographers

INTRODUCTION

The COVID-19 epidemic, which began in 2019, has had disastrous effects on many aspects of life in practically every part of the planet. The World Health Organization (WHO) reported that 6,064,424 people in Indonesia had been infected with the COVID-19 virus. A person infected with the COVID-19 virus would show several signs and symptoms, ranging from the mildest to the most severe. The most common symptoms were fever (occurring in 83% of patients), cough (occurring in 82% of patients), and shortness of breath (occurring in 31% of patients).[1]

One of the groups affected by the pandemic was health workers, especially in the field of dental radiology. The COVID-19 virus could spread through droplets and aerosols that entered the respiratory tract and contaminated surfaces, especially during radiographic examination procedures. The high risk of cross-contamination

due to work procedures that had to be carried out by radiology staff made them very susceptible to exposure to the COVID-19.[2]

It was difficult to avoid the spread of the COVID-19 virus in dental clinics.[3] This is because the virus is easily transferred through the patient's saliva. Nonetheless, health care personnel, particularly those in dentistry, can take a variety of steps to limit the spread of this virus.[4] Washing hands, donning personal protective equipment, instructing patients to use mouthwash before dental treatments, sanitizing dental clinic rooms, and these are all items that can be done. These prophylactic actions are not only in their own best interests to avoid disease, but they can also help reduce the prevalence and population infected with the COVID-19 virus.[5]

Due to the growing responsibility for the operation and maintenance of a facility, many domains contain a comprehensive and effective infection control procedure. Both hospital administrators and health care workers are responsible for demonstrating the effectiveness of infection control programs, ensuring adequate staff infection control training, linking surveillance results to performance measurement improvements, evaluating changing priorities based on ongoing risk assessments, ensuring an adequate number of competent infection control practitioners, and performing program evaluations using quality improvement tools as indicated.[6]

The spread of the COVID-19 virus was quite vulnerable to dental radiographers as frontline workers. Radiographers had to be familiar with the main challenges related to imaging during the COVID-19 era, so they could fulfill their role in maintaining patient safety, and patient care, optimizing image quality as a tool for more accurate diagnosis. Radiographers must also know how to keep themselves safe and healthy during a pandemic to minimize the risk of further infection.[7]

Previous research aimed to determine the level of knowledge among healthcare workers in radiology departments in Saudi Arabia regarding infection control during the COVID-19 pandemic. Some of healthcare professionals, 234 (91%) said they recognized well the precautions to be taken while examining positive COVID-19 cases in radiology departments, and 216 (84%) said they were aware of the precautions to be taken when utilizing portable X-ray machines.[8]

Furthermore, there was an analysis regarding the readiness of radiology installations in the form of room and equipment conditions, worker conditions, radiology services, and radiation protection and safety. The research showed that the radiology installation at the Emergency Hospital (RSD) for handling COVID-19 had SOPs for radiology staff, including always checking Personal Protective Environment (PPE) to be used, conducting rapid tests before carrying out tasks to ensure that each worker was free from COVID-19, and performed decontamination after carrying out radiology service activities.[9] Wearing personal protective equipment (PPE) to cover exposed body parts could help lower the danger. It is uncertain which PPE offered the most protection, how to put it on (donning) or take it off (doffing), and how to advise HCWs on how to use it.[10]

Previous research aimed to evaluate the implementation of occupational safety and health at the Radiology Installation of the Madani Regional Hospital. The results showed that officers have created and socialized standard operating procedures (SOP) for services, but that special SOP for occupational health and safety (K3) is not yet available; radiology installation permits are still being processed; K3 training has not been conducted; installation facilities and infrastructure radiology is adequate, but there are still shortcomings; archive records have been organized neatly and in detail in compliance with applicable regulations; reports cannot be completed because the radiology installation is still pending a permit; some technical, management, and radiation protection requirements are not compliant with applicable regulations; and radiology installation safety verification is in compliance with applicable regulations.[8]

Radiographic infection control in dentistry should be a concern for radiology staff, especially radiographers who are assigned to perform intraoral radiographic

techniques. Infection control that can be carried out by radiology staff is in the form of radiography room infection control, radiology staff infection control, and cross-infection control in each dental radiography technique. The majority of these infection prevention measures are already well recognized to be essential components of routine dental radiology practice; yet, because of the COVID-19 high transmission rate, our lifestyles and routines have undergone significant change. To control the illness and stop the virus from spreading around the world, stricter adherence to the present infection control regulations is vital.[2]

Intraoral radiography is a radiographic technique performed to examine the teeth and surrounding supporting tissues using intraoral receptors placed in the mouth.[11] The use of intraoral radiography has a high risk of infection during a pandemic because it has to insert films into the oral cavity. Intraoral radiography has the potential to cause aerosols, choking, and vomiting which can be transmission routes of the COVID-19 virus. The use of intraoral radiography carries a high risk of spreading disease, especially those originating from the COVID-19.[12]

Intraoral radiography is important to perform because it produces better quality radiographs compared to panoramic techniques and its use is more widespread than the Cone Beam Computed Tomography (CBCT) technique. Intraoral radiography is also the most widely used dental radiographic technique in dentistry because it has more indications for optimal use compared to extraoral radiography, using a lower radiation dose. Radiographers should understand this and always make infection control efforts during their work.[13,14]

The types of health facilities in Indonesia are Type A Hospitals, Type B Hospitals, Type C Hospitals, Type D Hospitals, and clinical laboratories. Type A Hospitals is a hospital of the highest type in comparison to other hospital classes, with four fundamental specialty medical services: internal medicine, pediatrics, surgery and obstetrics, and gynecology. In Type B Hospitals, subspecialist services are prioritized. Subspecialist services are offered by subspecialist doctors who specialize in a variety of specialist specialties. Type C Hospitals is a hospital that prioritizes specialist services. Type D hospitals is a hospital that focuses on basic medical services, specifically general health and dental care.[15] This study aimed to analyze differences in the application of infection control in intraoral radiographic examinations during the COVID-19 pandemic in various healthcare facilities.

METHODS

This type of research is observational research analysis with a cross-sectional design. Data collection was carried out using a questionnaire with all dental radiographers who were working in radiology installations at various healthcare facilities as research subjects.

The population in this study was all dental radiographers who were members of the Sleman's PARI (Indonesian Radiographers' Association) and worked in Radiology Installations at various healthcare facilities in Sleman Regency and Yogyakarta City. A non-probability sampling approach was applied. The sample inclusion criteria for subjects were dental radiographers that work in Radiology Installations at various health care institutions and were at the time employed as radiology personnel in 2020 - 2022.

The sample exclusion criteria were not being an intraoral radiography operator in the radiology installation room and radiographers who were not willing to be used as research samples. A questionnaire was employed as the research instrument, and it was delivered to each radiographer working at the Radiology Installation by Sleman's PARI, which was part of the PARI organization. The questionnaire was designed as a multilevel scale based on the Guttman scale, with positive and negative statements. Each answer to a positive statement would be given a score of 1 and 0, where a score of 1 meant "yes" or the statement in the questionnaire was made by the subject, while a score of 0 meant "no" or the statement in the questionnaire was not made by the subject. In a negative

statement, the scoring would experience a reversal of values, where a score of 1 meant "no" or the statement in the questionnaire was not made by the subject, while a score of 0 meant "yes" or the statement in the questionnaire was made by the subject. The answer "yes" was known from the "during the pandemic" column which was marked with a tick by the subject, while the answer "no" was known from the column "during the pandemic" which was not marked by the subject. Answers were filled in by selecting the most appropriate option in the column provided via the electronic questionnaire. The distribution of questionnaires and collection of survey data was carried out within a predetermined research period, from June to July 2022.

Testing all questions in the questionnaire was carried out using the Pearson correlation test to test the validity of the questions and the Cronbach's Alpha test to test the reliability of the questions. The technique used in testing the validity and reliability of this questionnaire was a used trial technique or a used try-out technique. In this technique, the results of direct testing were used to test the research hypothesis and only data from valid and reliable items would then be analyzed.[14] The validity test was used to determine the accuracy of each questionnaire question item, while the reliability test was used to determine the consistency of the questionnaire. The validity test was based on the value of r, that is, a statement was considered valid if r count > r table.[16]

The data obtained from the results of filling out the questionnaire were then analyzed. The answers that would be analyzed were only the answers in the "during the pandemic" column. Analysis of the research data was carried out using a data processing application for further normality tests. This normality test was carried out to determine whether or not the distribution was normal from the results of data collection using the Shapiro-Wilk test. There were two possibilities from the results of the normality test, namely if the test results showed a significance of >0.05, it meant that the distribution of the data was normal. Conversely, if the test results showed a significance <0.05, it meant that the distribution of the data was not normal.

Data analysis was continued by using a comparative test. If the data was normally distributed, the comparative test was carried out using Way ANOVA. On the other hand, if the data was not normally distributed, the comparative test used was the Kruskal-Wallis test. There was an additional step when carrying out a comparative test using One Way Anova, namely first conducting a homogeneity test. This was one of the requirements that had to be met from the other three conditions to carry out the Way ANOVA test. Among these three conditions were normally distributed data, homogeneous data variants, and samples taken randomly.[17]

The research data were also analyzed using a descriptive test to find out the order of the total score of each health facility. The formula used to categorize data groupings was based on:

Table 1. Questionnaire Score Categorization Formula[17]

Score Range	Category
$X \geq \mu + 1\sigma$	High
$\mu - 1\sigma \leq X < \mu + 1\sigma$	Medium
$X < \mu - 1\sigma$	Low

* μ= hypothetical mean, σ = standard deviation, X = total score of the subjects

Table 1 showed the formula for categorizing data groupings as low, medium, or high. The total score achieved by each health facility would then be classified as high, medium, or low.

RESULTS

The total number of respondents who filled out the research questionnaire was 105 radiographers. Respondents who met the inclusion criteria for this study were 30 radiographers.

Table 2 shows that the respondents involved in this study were dominated by dental radiographers aged 25-34 years with a total of 16 people (53.3%). The number of respondents who were male and female was the same, namely 15 people. Most of the respondents were D3 graduates, amounting to 23 people (76.7%). Out of a total of 30 respondents who met the criteria, 15 people (50%) worked at Type B Hospitals, 6 people (20%) at D Hospital, and 9 people (30%) at clinical laboratories. Not all types of health facilities had several respondents who met the criteria of this study. This happened because there was a limited number of research subjects.

Table 2. Distribution of research subjects based on age, gender, education, and type of health facility where they work.

No	Variabel	Distribution	N
1	Age	25 – 34 years	16
		35 – 44 years	11
		45 – 54 years	2
		55 – 64 years	1
2	Gender	Male	15
		Female	15
3	Education	High School	1
		Associate Degree (D3)	23
		Bachelor (D4)	5
		Bachelor (S1)	1
4	Type of Healthcare Facilities Workplace	Type B Hospital	15
		Type D Hospital	6
		Clinical labs	9

The results of the validity test, namely 13 question items were declared valid with a significance value of p <0.05 and had an r count value greater than r table (table used in this study was 0.361). Question items that were declared valid were then tested for reliability based on Cronbach's Alpha coefficient, that is, a statement is considered reliable or good if it has a Cronbach's Alpha coefficient ≥ 0.60.[15] The results of the reliability test showed that the 13 questions that were declared valid had a Cronbach's Alpha value>0.6. This meant that the 13 valid questions were reliable.

Table 3. Results of the Normality Test of the Shapiro-Wilk Test

No	Type of Healthcare Facilities	Normality Test Results (Saphiro-Wilk)	N	%
1	Type B Hospital	p = 0,353	16	53,3
2	Type D Hospital	p = 0,185	11	36,7
3	Clinical laboratory	p = 0,794	2	6,7

Table 3 shows that the normality test results from the data for Type B Hospitals, Type D hospitals, and clinical laboratories had a significance > 0.05. From the results of the normality test, it was concluded that all data obtained were classified as normally distributed data (significance>0.05).

The homogeneity test was then carried out, followed by conducting the Way ANOVA test. A homogeneity test was carried out to find out whether the data had a different variant or type from two or more groups. The homogeneity test would

provide information on whether the origin of the population from each research data group was very different or not diverse. The variance of the data group was stated to be different if the significance value was p <0.05, while it was declared the same or homogeneous if the significance value was p> 0.05.[17] Furthermore, a comparative test could be carried out using Way ANOVA. Comparative test results using One Way Anova are shown in Table 4.

Table 4. Comparative One-Way Anova Test Results

	Sum of Squares	df	F	Significance
Between Groups	21,733	2	1,210	p = 0,314
Within Groups	242,567	27		
Total	264,300	29		

Table 4 shows that the significance value of the One Way Anova comparative test was p=0.314. This meant that the significance value of the comparative test One Way Anova research data was p>0.05. The calculated F value obtained was 1.210. The F table used in this study was F=5.488. This meant that the value of F count< F Table. Therefore, it could be concluded that there were no statistically significant differences in the values of each type of health service facility that had been studied. Questionnaire answers obtained from the respondents of this study had been converted in the form of a score for each question item, namely "0" which represented a "no" answer, and "1" which represented a "yes" answer. Scores for each question item are presented in Table 5.

Table 5 shows that the questions that received the most "yes" answers were question 8 with a total of 26 respondents (86.7%). In the second and third order, question items 2 and 11 got the most "yes" answers with 22 respondents (73.3%). On the other hand, the questions that received the least "yes" answers were questions 13 with 9 respondents (30%). Question 3 ranked second lowest with 11 respondents (36.7%) answering "yes". Question 6 received the answer "yes" from a total of 13 (43.3%) respondents.

Table 5. Distribution of Questionnaire Answer Scores

Question Number	Statement	Total Answer (Yes %)
1	Do you use disposable film?	16 (53,3)
2	Do you wrap the receptor image?	22 (73,3)
3	Do you wrap the tube head?	11 (36,7)
4	Do you wrap the x-ray cones?	14 (46,7)
5	Do you wrap the exposure button?	16 (53,3)
6	Do you wrap the head rest?	13 (43,3)
7	Do you wrap adjustment control?	14 (46,7)
8	Do you disinfect equipment every time you change patients?	26 (86,7)
9	Do you provide tissue or absorbent paper in the installation room?	19 (63,3)
10	Do you do radiographic examinations by at least 2 radiographers for 1 patient?	15 (50)
11	Do you sterilize the film holder every time you change patients?	22(73,3)
12	Do you use gloves when setting up an x-ray tube head?	21 (70)
13	Do you not use gloves when pressing the exposure button?	9 (30)

The question with the highest answer score indicated that the implementation of the infection control mentioned in the question items was carried out by the majority of the health facilities in this study. This also showed that infection control in these question items received more attention to be carried out by radiographers

from each health facility than the application of infection control mentioned in other question items. Conversely, the question that had the lowest answer score indicated that the infection control mentioned in the question item was still less optimally implemented than the application of infection control mentioned in the other question items. The research data were grouped into several categories using the average score of each health facility in the study. These values were then grouped into 3 categories, namely low, medium, or high.

Table 6. Distribution of Score Categories of Respondents' Answers for Each Type of Health Facilities

Tipe Healthcare Facilities	Category Answer Score						Total	
	Low		Medium		High			
	N	%	N	%	N	%	N	%
Type B Hospitals	2	13,3	9	60	4	16,7	15	100
Type D Hospitals	2	33,3	4	66,6	0	0	6	100
Clinical Labs	2	22,2	6	66,7	1	11,1	9	100

N = Frequency of Respondents, % = Percentage of Respondents

Table 6 shows that in Type B Hospital, 9 out of 15 respondents were included in the moderate category. At Type D Hospital, as many as 4 out of 6 respondents were included in the moderate category. In the clinical laboratory, 6 out of 9 respondents also fell into the moderate category. Based on the results of the data analysis, it was found that the majority of respondents in each type of health facility were included in the same category (moderate category), with the highest score sequence being the clinical laboratory 66.7%, Type D Hospital 66.6%, and Type D Hospital. B 60%.

DISCUSSION

Based on Table 3, all data obtained were classified as normally distributed. The results of data analysis (Table 4) on the One-Way Anova comparative test showed that the statistical value of each health service facility (healthcare facilities) consisting of Type B Hospitals, Type D Hospitals, and Clinical Laboratories was not significantly different. Previous research aimed to assess and compare knowledge and self-reported practices of infection control among various occupational groups in a rural and urban hospitals in Vietnam. The median knowledge scores did not differ significantly between the two hospitals ($p = 0.17$).

In both institutions, most respondents demonstrated good knowledge (rural hospital: 65.3%, urban hospital: 73.4%).[18] This shows that each health facility does not have a significant difference in the score category or does not have a significant difference in applying infection control to intraoral radiographic examinations during the COVID-19 pandemic. The moderate category obtained by each health facility shows that the application of infection control carried out by radiographers is still not optimal and can be improved further. This can be seen from the fact that there were still several respondents who had not carried out infection control according to the items listed in the questionnaire.

There are still several issues with strategies and policies for combating the COVID-19 pandemic, one of which being the government's lack of readiness and flaws in the national health system.[1] During the COVID-19 pandemic, there were lack of health facilities and infrastructure. Various types of health facilities did not appear to be optimal in managing health human resources, had a dependence on imported medicines and medical devices, had low-quality health infrastructure, health service standards were still not well organized, and health service performance was still low.[19]

These problems can lead to ineffective implementation of infection control in various types of healthcare facilities, especially during the COVID-19 pandemic. Apart from the facilities available at the workplace, the application of infection control is also influenced by many other factors. The longer the duration of a person's experience at work, the more work experience that is carried out, and the

better the skills and expertise of the work performed.[20] A person's main capital for being skilled in a particular job is previous work experience. [7]

Based on the results of calculations through statistical tests, the scores for each health facility were not significantly different, but descriptively (Table 6), each health facility had a different score distribution. The order of health facilities based on the distribution of respondents' answers scores from the highest scores were Clinical Laboratories at 66.7%, Type D Hospitals at 66.6%, and Type B Hospitals at 60%. The clinical laboratory ranked highest. A literature search was performed to assess the scientific literature quality of clinical laboratory quality improvement from 2001 to 2020; the result was 6.8, showing continuing high-quality progress in the clinical laboratory sector.[21] Clinical laboratories continue to make efforts to improve the quality of their services so that they are not unable to compete with one another.

This is especially the case for private laboratories which are known to have careful management and calculations related to market needs for the sake of sustainable business. Adequate facilities are the main thing needed in implementing infection control.[2] Infection control can run smoothly if each health service unit has facilities according to predetermined standards. The types of healthcare facilities can be one of the factors that influence the application of infection control by radiographers. Three domains that affect the formation of behavior, including knowledge, attitudes, and psychomotor. When the knowledge and attitudes possessed by a person are good, compliance will not be formed without the support of the availability of complete facilities.[10,14]

According to Table 5, the question with the highest answer score was item 8, "Disinfect tools every time you change a patient." There was a total of 26 (86.7%) respondents who carried out infection control during the pandemic. Previous research aimed to review the risk of disease transmission during radiologic operations that can be decreased by using personal protective equipment and infection control measures based on current best practices and research; Also consider how intraoral radiography, which may have a higher risk of disease transmission.

Most dental offices in North America decontaminate the film of digital radiography between patients with 70% alcohol wipes (or other CDC-approved disinfectant solutions) and then insert these sensors into sealable plastic envelopes before their next use.[14] Inter-patient shift breaks must be allocated for at least 15 minutes to allow radiographers to disinfect equipment and radiograph rooms from droplets produced during previous procedures.[14]

Desinfection must be carried out, especially on surfaces that are prone to contamination by body fluids or other infectious material.[19] Diluted iodophor, chlorine, and synthetic phenolic are effective liquids to be used as disinfectants. In the radiographic examination, the intraoral film must be covered with protective plastic, the radiographer must use gloves or gloves when placing and holding the film, holding the tube, and selecting or selecting radiographic images. Disinfection should also be carried out on the tube head and its surfaces. [22]

Question number 13, namely "Using gloves when placing film receptors or digital sensors into the patient's mouth" got the lowest answer score (Table 5). There were a total of 9 respondents (30%) who carried out infection control during the pandemic. Previous research aimed to assess nursing student’s compliance to standard precautions during the COVID-19 pandemic.

Participants reported 93% compliance with using gloves while exposed to bodily fluids, blood products, and any excrement of patients.[23] Radiographers who did not use PPE completely can be caused by the lack of available facilities.[10] Policies and patterns of supervision also had a statistically significant influence on the use of PPE by radiographers. Meanwhile, knowledge, attitudes, training, and counseling provided to radiographers did not significantly influence the radiographer's behavior in using PPE.

Availability of complete PPE can affect good behavior for carrying out universal precautions procedures or using PPE. Personal protective equipment (PPE) can reduce the risk by covering exposed body parts. It is unclear which type of PPE protects best, what is the best way to put PPE on (i.e. donning) or to remove PPE (i.e. doffing), and how to train HCWs to use PPE as instructed. PPE must be available in the workplace according to the risks that may occur in each job.[24]

Infection control that can be carried out by radiographers is radiography room infection control, radiology staff infection control, and infection control in each dental radiography technique.[2,10] This was one of the weaknesses in this study because the infection control aspects listed in the questionnaire were incomplete. Researchers analyzed the behavior of health workers who worked at various health facilities from 23 countries during the COVID-19 pandemic.[5,7] The results of this study stated that as many as 65% respondents always used PPE when carrying out procedures that generated aerosols. Research conducted in Southeast Nigeria showed that 47 (29.38%) out of 160 dentists indicated that they practiced waste management at Dental Hospitals/Clinics And Laboratories.[25,26]

Practical waste management was carried out by categorizing medical and non-medical waste. This was an attempt by dentists to prevent the transmission of COVID-19. Radiography installations must sort and standardize medical waste according to applicable regulations to minimize the risk of infection that can occur to people who touch this waste.[5] Room infection control is important by disinfecting the surfaces of walls, floors, furniture such as tables, chairs, light switches, and others.[27]

Based on the characteristics of the research respondents (Table 1,2), it is known that this study still has drawbacks in the form of incomplete respondents from all types of existing health facilities. There were not enough respondents from Type A Hospitals and Type C Hospitals. This could happen because most radiographers who were members of Selman's PARI did not work in the intraoral radiography department. Therefore, further research is needed, especially to compare the implementation of infection control with other types of health facilities that did not exist in this study.

It is important to stress the limitations related to sampling error in this research, including the relatively limited sample group. This could have been caused by data collection being carried out in a narrow scope, leading to the health facilities that were the subject of research being also limited in participating in the study.

CONCLUSION

There was no discernible difference in the way each healthcare facility carried out infection control during intraoral radiography examinations. The implication of research is that the healthcare facilities have implemented and maintained standardized infection control protocols for intraoral radiography examinations; however, continuous monitoring, assessment, and possible enhancements are necessary to uphold optimal levels of patient safety and care quality.

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Data Availability Statement: We encourage all authors of articles published in PJD journals to share their research data. In this section, please provide details regarding where data supporting reported results can be found, including links to publicly archived datasets analyzed or generated during the study. Where no new data were created, or where data is unavailable due to privacy or ethical restrictions, a statement is still required.
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