Injuruty: Interdiciplinary Journal and Humanity
Volume 2, Number 7, July 2023
e-ISSN: 2963-4113 and p-ISSN: 2963-3397

DENTAL RADIATION SAFETY IN RADIOGRAPHY POLICIES: SCOPING REVIEW AND FINDINGS IN INDONESIA

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Abstract

Radiation safety is important to prevent deterministic and stochastic effects on patients. The aims of this review are to summarize and provide an overview of radiography policies on dental radiation safety and to identify the gaps between Indonesia's radiography policies with worldwide best practices. The review is based on the PRISMA-ScR. Articles are searched through Embase, Pubmed and Scopus. Articles focused on dental radiation safety are included with addition of policy documents found by manual searching. Results are summarized in a table and in-text and analyzed by comparing with policies in Indonesia.Ten articles are collected and identified as policy statement (n = 2), guideline (n = 2), and recommendation (n = 6). Three themes are used to summarize the findings: (1) target, (2) qualified expert, and (3) best practice. The result shows that all policies have incorporated safety radiation principles. Radiography policies regulates: dental practitioners and trained operators as personnel qualified to conduct radiography examination; appropriate technique and practical measures; x-ray maintenance and radiological testing. The scope of radiography policies in Indonesia is extensive, with health facilities and service providers as the primary policy targets.

Keywords: radiation safety; dental practices; policy

INTRODUCTION

Dental and oral health practices are related to invasive procedures on patients and have a different scope from general health practices. They are generally carried out through the stages of establishing a diagnosis which forms the basis for determining a treatment plan. Radiology as a supporting examination is often needed to assist dental practitioners ─ as in the case of impaction by evaluating the position and type of impacted teeth, the depth of impaction, bone density, and the relationship of impacted teeth to the surrounding anatomical structures.(Mardiyantoro et al., 2019; Toppo, 2012)

The importance of radiology cannot be separated from the negative effects of radiation produced from radiographic equipment. If it is not addressed properly, radiation exposure will cause deterministic and stochastic effects on patients. The deterministic effect is an effect that is seen if the radiation exposure to organs or tissues exceeds a certain threshold with a severity proportional to the dose. The stochastic effect is caused by DNA damage due to sublethal radiation and the severity does not depend on the dose (all-or-none responses).(White & Pharoah, 2014)

The radiation protection must have been incorporated into radiography policy. Three principles of protection radiation by ICRP are justification, optimization and limitation. Justification means that the decision to give radiation exposure must consider the benefits of radiographic examination that is greater than the possible risks (Sonafist, 2023). Optimization

emphasizes that the possibility of exposure, the number of people exposed, and the size of the dose received must be kept to a minimum. Limitation provides exposure dose limits that do not exceed a predetermined threshold.(ICRP, 2007) Therefore, it is necessary to have a policy to regulate the use of equipment with radiation modalities in accordance with the rules to protect patients from the dangers of radiation exposure. The aims of this review are: (1) to to summarize and provide an overview of radiography policies on dental radiation safety, and (2) to identify the gaps of policy between Indonesia's radiography policies with worldwide best practices.

METHOD RESEARCH

The scoping review will be conducted in accordance with the Joanna Briggs Institute methodology by using PRISMA flow diagram for the scoping review process.(Peter M, Godfrey M Christina, Mcinerney P, 2015) Scoping reviews are evidence synthesis methodology that organise available evidences, identify characteristics of particular issues or topics, and find gaps. Unlike systematic reviews, they address broad questions and can be used as preliminary methodology (Munn et al., 2022) Therefore, scoping review is used to find out more about what are the important factors in radiation safety particularly in dentistry area.

Search strategy and selection process

Articles are retrieved thorugh database searching of Embase, Pubmed and Scopus. The search query ("dental radiation safety" AND "radiography OR radiology OR imaging" AND "policy") is used to identify articles on the topic. Articles screening is initially performed by removing duplicates and identifying irrelevant articles through titles and abstracts. Full text screening are conducted with the inclusion criteria for articles include: (1) published after 2010; (2) published in English; (3) focused on dental radiation safety; (4) included but not be limited to regulation, guideline, and recommendation; and (5) full text accessible. Additional articles are included through manual searching which fulfilled the inclusion criteria of articles

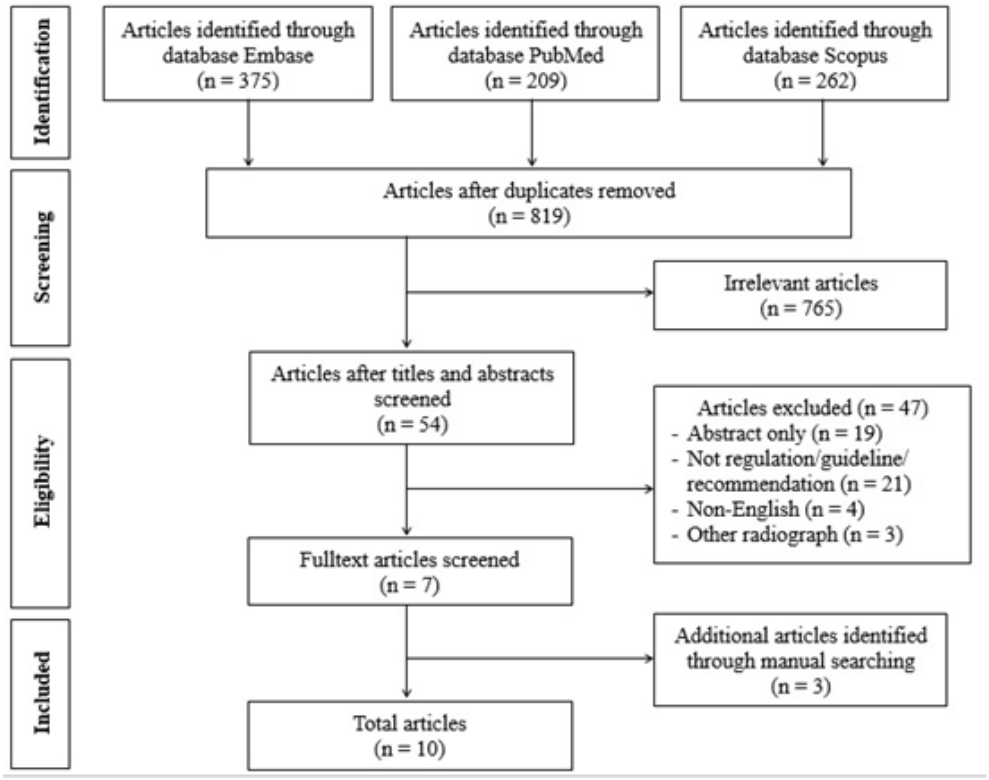

Figure 1. Flow diagram of literature selection process

Data extraction and analysis

All data relevant to the topic are extracted and presented by using table. Extracted data are identifed as: characteristics (title, author, year, type of document); context (country/region); basic regulation and year issued; and key finding. The data are compared to findings in Indonesia in terms of: type and target of policy; radiation safety; institutional coordination; and harmonization with other regulations.

RESULT AND DISCUSSION

A total of ten articles are obtained and reviewed (Table 1). An analysis is conducetd by using descriptive summary which organized by aspects of: target of policy; role of qualified expert; and implementation of best practice.

Table 1. Dental radiation safety articles, published after 2010

Title Author, year	Country/region	Type	Basic regulation	Year issued	Key finding
Best clinical practice guidance for prescribing dental radiograph in children and adolescents: an EAPD policy documment Kühnisch *et al.*, 2020	Europe	Recommendation	The European Council Directive 2013/59/Euratom	2013	*Target* Pediatric patient. *Best practice* The workflow of radiograph examination by taking into consideration of principles of radiation protection (justification, optimization, and limitation) and cooperation of the child, as follows: determine the benefit of radiographic examination based on the clinical examination, select the appropiate type and technique, giving informed consent, implementing protective measures, positioning the patient and aligning the image receptor correctly.
FDI policy statement on radiation safety in dentistry FDI, 2014	World wide	Policy statement	FDI World Dental Federation Radiation Safety in dentistry	2014	*Target* All age patient. *Qualified expert* Appropriate training, education and certification of operator are needed. *Best practice* The use of radiograph examination based on the diagnosis with measures to reduce radiation exposure, such as: - technique: use fastest film and receptor holder, collimate the beam, use CBCT only when lower dose technique are not sufficient. - exposure time and dose: use automatic exposure control or

Title Author, year	Country/region	Type	Basic regulation	Year issued	Key finding
					appropriate technique to prevent overexposure and underexposure. - patient and operator protection - ensure the quality of radiograph examination by developing quality assurance protocol.
Prescribing dental radiograph for infants, children, adolescents, and persons with special health care needs American Academy of Pediatric Dentistry, 2018	USA	Guideline	ADA/FDA Dental Radiographic Examinations: Recommendations for Patient Selection and Limiting Radiation	2012	*Target* Pediatric patient. *Best practice* Prescribing dental radiograph for children is based on age and dental development age and accompanied by good practice to minimize radiation include: use fastest film, collimate the beam, proper technique, use protective measures, and limit the radiograph examination.
National guidelines for dental diagnostic imaging in the developmental age Firetto *et al.*, 2019	Italia, Europe	Recommendation	Italian Legislative Decree 187/00 The European Council Directive 2013/59/Euratom	2000 2013	*Target* Pediatric patient. *Best practice* Proposing the best practice to do radiograph examination in pediatric patient by using evaluation of scientific data, such as: reducing area and intensity of the beam and using lead thyroid collar in orthopantomography, cephalometric, and CBCT examination.
Radiation protection in Dental Radiology – the safe use of radiographs in dental practice Nisha, *et al.*, 2014	India, Asia	Recommendation	-	-	*Target* All age patient. *Best practice* The machine has undergone testing. Protection from radiation exposure is obtained from: lead barrier surrounding the radiation area, the use of aprons for patients, the use of screens or room settings that place operator outside of the beam and monitoring of operator doses, particularly for pregnant women.

Title Author, year	Country/region	Type	Basic regulation	Year issued	Key finding
Lowering the radiation dose in dental offices Radan, 2017	USA	Recommendation	ADA/FDA Dental Radiographic Examinations: Recommendations for Patient Selection and Limiting Radiation	2012	*Target* All age patient. *Qualified expert* Dental practitioners or specialists have technological knowledge. *Best practice* For 2D radiographs, the exposure can be minimized by adopting patient selection, and using proper technique, the fastest film or digital, rectangular collimation and thyroid collar. For 3D CBCT, optimizing radiographs by using the smallest FOV, adjusting the exposure setting to patient size and age, and using thyroid collar.
Guidelines for the safe use of dental and maxillofacial cbct: a review with recommendations for south africa Noffke, *et al.*, 2011	South Africa	Recommendation	-	-	*Target* All age patient. *Qualified expert* The operators have received training in imaging software and radiation safety. The referrer should have received sufficient training in software usage and interpretation. *Best practice* Professional judgment should be the basis for prescribing CBCT. CBCT should be used when conventional radiographs are unable to provide sufficient information.
Radiation shielding in dentistry an update Crane and Abbott, 2016	Australia	Recommendation	ARPANSA/ Code of Practice and Safety Guide in Dentistry UK National Radiation Protection Board/Guidance Notes for Dental Practitioner	2005 2001 2004	*Target* All age patient. *Best practice* For intraoral radiograph, it is mandatory to use thyroid shield whereas apron is used when the beam is pointed at pregnant patient's trunk. For extraoral radiograph, i.e. panoramic and cephalometric, thyroid shield is optional since it can obscure anatomical structure. It is recommended to use rectangular collimation and F-speed film.

Title Author, year	Country/region	Type	Basic regulation	Year issued	Key finding
			s on the Safe Use of-X-ray Equipment European Guidelines on radiation Protection in Dental Radiology		
Dental radiographic examinations: recommendations for patient selection and limiting radiation exposure American Dental Association, 2012	USA	Guideline	ADA/FDA Dental radiographic examinations: recommendations for patient selection and limiting radiation exposure	2012	*Target* All age patient. *Qualified expert* Dentists conduct a clicnical examination. Appropiate education of the operator and training to improve the quality of examination are needed. *Best practice* The clinical assessment of the patient is used in determining the need and the type of radiographic images. To minimize the radiation exposure by: selecting receptor, using appropriate collimation and techniques, using protectors for patients and operators, developing quality assurance protocols, communication of radiation risk to patients, training and education of practitioners.
Policy statement 6.14 radiation safety Australian Dental Association, 2019	Australia	Policy Statement	ADA Federal Council Policy Statement 6.14	2019	*Target* All age patient. *Qualified expert* Dental radiograph should only be administered by a trained and qualified dental practitioner. *Best practice* Dentists and staff should make efforts to minimize radiation risk. Optimization of radiograph quality and quality control must be carried out.

Worldwide review of dental radiation safety

All articles have incorporated three principles of radiation protection (i.e. justification, optimisation, and limitation) by ICRP.(ICRP, 2007) Justification is used to determine the benefits of radiograph examination outweighing the possible risks. The decision to proceed with the radiograph examination is proposed by dental practitioners only after conducting clinical examination.(American Dental Association, 2012; Policy Statement 6 . 14 – Radiation Safety, 2019; Kühnisch et al., 2020; Noffke et al., 2011) The risks of radiograph examination are communicated to patients through informed consents. All risks associated with the procedures must be disclosed to the patient by the practitioners to protect against any claim of negligence, legal and medico-legal litigation.(Bhadauria et al., 2018; Gambhir et al., 2014)

Several important aspects to optimize the quality of radiograph with minimum to zero radiation exposure are identified. Collimation of the beam with fixed or handheld equipment is required to reduce the exposure dose.(American Academy of Pediatric Dentistry, 2018; American Dental Association, 2012; Crane & Abbott, 2016; FDI World Dental Federation, 2014; Radan, 2017) Using collimators have benefit of reducing scatter radiation which enhances image quality.(White & Pharoah, 2014) This has been proven in a study that a rectangular collimator can reduce effective dose by 51% in adults and 66% in children.(Johnson & Ludlow, 2020) Image receptor selection based on the type of image acquisition technique (i.e. analog, computed and digital radiography). For analog and computed radiography, it is recommended to use the fastest film receptor. CCD (charged coupled device) and PSP (photostimulable phosphor plates) are commonly used in digital radiography.(American Academy of Pediatric Dentistry, 2018; American Dental Association, 2012; Crane & Abbott, 2016; FDI World Dental Federation, 2014; Radan, 2017) When comparing the time for the acquisition of image, CCD is the best option because it requires little time.(Sudarsini et al., 2020)

Protective equipments are used to shield the sensitive and compromised patients from unnecessary radiation exposure.(American Academy of Pediatric Dentistry, 2018; American Dental Association, 2012; Crane & Abbott, 2016; FDI World Dental Federation, 2014; Firetto et al., 2019; Kühnisch et al., 2020; Nisha et al., 2014; Radan, 2017). A study found that children are more likely than adults to get cancer following radiation exposure because their tissues and organs are still in the development stage.(Kutanzi et al., 2016) Protective measures, such as standing behind protective barrier and increasing the distance between operators and the x-ray machine, are also required to protect operators from unnecessary radiation exposure.(American Dental Association, 2012; FDI World Dental Federation, 2014; Nisha et al., 2014) In a research study, the positioning of handhelds x-ray devices has an impact on radiation received by operators, therefore it is important to use anti-scatter grid to provide a safe zone.(Makdissi et al., 2016) According to other studies, there is correlation between dental x-ray exposure to cancers and tumors in the head and neck regions of dental practitioners and radiographers.(Hwang et al., 2018)

It is imperative for radiology installation to develop quality control and quality assurance protocols which includes maintenance procedures. The protocols are required to ensure that the x-ray machine is functioning and safety precautions are implemented.(American Dental Association, 2012; Policy Statement 6 . 14 – Radiation Safety, 2019; FDI World Dental Federation, 2014; Nisha et al., 2014; Noffke et al., 2011) Lack of x-ray equipment maintenance may cause late detection of equipment failure, results in increased repair costs and delayed services.(Ngoye et al., 2022) All information and test results are recorded and reviewed on annual basis.

Radiography policies in Indonesia

Policies related to radiology have been issued by the government of Indonesia as a policy maker and Bapeten (nuclear energy regulatory agency of Indonesia) as an institution that supervise

the use of equipment with radiation (Table 2). These policies are issued by different institutions, some of them are without any interrelationship between policies. In this situation, it creates disharmony which prevented regulations from being implemented effectively and efficiently, and are unable to provide guidance for the community. Coordination between institutions is not carried out, therefore the objectives of the policies will not be reached. It is known that good regulations have the ability to integrate implementing agencies.(Sabatier & Mazmanian, 1980)

. **Table 2. Radiography policies issued based on years**

Type of policy	**2000 - 2010**	**2011 - 2022**
Government regulation	Regulation number 63/2000 consists of radiation dose and safety management.	
	Regulation number 33/2007 consists of management, radiation protection, technique, and safety verification.	
Regulation of Minister of Health	Regulation number 780/2008 includes diagnostic, radiotherapy, and nuclear radiology services.	Regulation number 24/2022 regulates radiology services based on the capabilities of health facilities according to human resources and equipment.
	Decision number 1014/2008 standardises radiology services according to the type and class of health facilities.	
Bapeten regulation		Bapeten chairman's regulation number 8/2011 regulates permit requirements, radiation safety requirements, interventions, and records and reports in the use of x-ray equipment.
		Bapeten chairman's regulation number 4/2020 provides requirements of radiation safety in diagnostic and interventiontal radiology include: management, radiation protection, technique and verification.
		Technical guideline provides practical guidance and recommendations for practitioners and operators to

Type of policy	2000 - 2010	2011 - 2022
		ensure the radiation protection in dental radiology facilities.

Radiography policies in Indonesia regulates the requirements of personnel, equipment, technique, quality control and quality assurance. In this sense, these policies share much in common with radiography policies in other countries or regions. However, the policies target groups are health facilities and person involved in services while foreign policies recognise and emphasise on patients as policy beneficiaries ─ especially those who are at greater risk.

The scope of radiology stated in regulations is mostly broad and general in nature, therefore the regulations can be implemented in various health services and facilities regardless of the type. However, it raises the weaknesses of regulations in areas that have not been specifically regulated. It is found that there is no state regulation in Indonesia that regulates the radiology services in dentistry despite radiology is often needed to determine diagnosis and treatment plan. Technical guideline is provided by Bapeten but it does not have the force of regulations or laws, and as a means to comply with regulatory standards.

Table 3. Comparison of national and international policies

Aspect of policy		National	International
Type		Only technical guide for dental radiography	Regulation (American Dental Association, 2012; Policy Statement 6 . 14 – Radiation Safety, 2019) Guideline/recommendation (American Academy of Pediatric Dentistry, 2018; American Dental Association, 2012; Firetto et al., 2019; Kühnisch et al., 2020; Nisha et al., 2014; Noffke et al., 2011; Radan, 2017)
Target		Health facilities, service provider	Service provider Patient/specific age and groups are mentioned (American Academy of Pediatric Dentistry, 2018; Firetto et al., 2019; Kühnisch et al., 2020)
Radiation safety	Qualified expert	Doctors, specialist, operator, protection officer	Specifically mention dental practitioner, operator
	X-ray equipment	CBCT is regulated only in Bapeten regulation.	Mention all type of dental x-rays, including CBCT

Aspect of policy		National	International
	Justification	In general, radiograph examination must be recommended by doctors or specialists with a clinical examination	Dental radiograph examination must be recommended by dentist with a clinical examination (American Dental Association, 2012; Policy Statement 6 . 14 – Radiation Safety, 2019; Kühnisch et al., 2020; Radan, 2017)
	Optimization and limitation	Not specifically mentioned but elaborated in Bapeten regulations	Stated
	QC and QA	Annual x-ray maintenance test, dosimetry	Protocols are needed
Coordination		Across institutions and professionals. Bapeten conducts utilization supervision.	There are institutions providing guideline and recommendation (Policy Statement 6 . 14 – Radiation Safety, 2019)
Harmonization of regulations		Not all of the policies mentioned it, such as Bapeten is missing in Regulation of Minister of Heath No.24/2020.	Regional regulations as the basic for formulation of state regulations/guidelines

CONCLUSION

Dental radiography policies provide dental practitioners and operators with detailed practices to ensure the quality of diagnostic imaging while maintaining the protection of both patients and operators, leads to the following conclusion: dental radiography should be prescribed by dental practitioners and conducted by trained operators; appropriate technique and practical measures must be taken to minimize the risks of radiation; x-ray maintenance and radiological testing are required regularly. In Indonesia, the scope of radiography policies is broad with health facilities and service providers as the main target of policy. Radiation safety in dental practices is provided in Bapeten's technical guideline as written guidance on minimum standards for facility design, specifications for dental x-ray equipment quality assurance program.

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