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Disposal of radiographic effluents in health care facilities: a review of the literature

Descarte de efluentes radiográficos em instalações de saúde: uma revisão da literatura

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ABSTRACT

Introduction: Radiographic effluents in the health field originate from the processing of radiographs that use developing and fixing solutions containing substances harmful to the environment and human health. **Objective:** To identify in the literature national and international evidence on the forms of disposal of radiographic effluents from health services. Methods: This is an integrative literature review carried out in the Virtual Health Library (VHL), U.S. National Library of Medicine (PubMed) and Scientific Electronic Library Online (SciELO). 14 scientific pieces of evidence published between 1995 and 2020 were selected. **Results:** Most studies showed that the disposal of radiographic effluents was carried out inappropriately, preferably in sanitary sewers without any treatment. Little evidence pointed to recovering silver present in the effluents and sending it for treatment and final disposal by specialized companies. Only one Brazilian survey showed that the disposal of these effluents was carried out following the standards established by regulatory bodies. **Conclusions:** From the evidence found, it was concluded that the disposal of radiographic effluents is still a global environmental problem, since establishments producing these wastes do not follow the legislation for the correct disposal and treatment. That is why the replacement by digital technology is recommended.

KEYWORDS: Chemical Waste; Radiography; Environment

RESUMO

Introdução: Os efluentes radiográficos no campo da saúde são originados do processamento das radiografias, que utilizam soluções reveladoras e fixadoras contendo substâncias danosas ao meio ambiente e à saúde humana. **Objetivo:** Identificar na literatura as evidências nacionais e internacionais sobre as formas de descarte de efluentes radiográficos provenientes de serviços de saúde. **Método:** Trata-se de uma revisão integrativa da literatura realizada nas bases de dados Biblioteca Virtual em Saúde (BVS), *U.S. National Library of Medicine* (PubMed) e *Scientific Electronic Library Online* (SciELO). Selecionou-se 14 evidências científicas publicadas entre 1995 e 2020. **Resultados:** A maioria dos estudos mostrou que o descarte dos efluentes radiográficos foi realizado de forma inadequada, preferencialmente em esgotos sanitários sem nenhum tratamento. Poucas evidências apontaram para a recuperação da prata presente nos efluentes e o seu envio para o tratamento e a disposição final por empresas especializadas. Apenas uma pesquisa brasileira mostrou que o descarte desses efluentes foi realizado seguindo os padrões estabelecidos pelos órgãos regulamentadores. **Conclusões:** A partir das evidências encontradas, verificou-se que o descarte dos efluentes radiográficos ainda se configura como um problema mundial ambiental, uma vez que estabelecimentos produtores desses resíduos não seguem as legislações para o descarte correto e tratamento, sendo recomendada a substituição pela tecnologia digital.

PALAVRAS-CHAVE: Resíduos Químicos; Radiografia; Meio Ambiente

INTRODUCTION

Radiographs are an important means of obtaining images of the internal structures of the body, which help in health diagnoses. However, in the processing of radiographic images, developers, fixatives and washing water are used, which can contain chemical substances with toxic properties, and which can confer a certain degree of flammability, corrosiveness, reactivity, toxicity, carcinogenicity, teratogenicity and/or mutagenicity[1,2,3].

The traditional process of obtaining radiographic images requires a radiographic film on which the final image will be observed. Radiographic film consists of a sheet of cellulose acetate coated with a gelatine emulsion containing silver chlorides and bromides[4].

The radiographic film, once exposed to X-ray photons, forms the invisible (latent) image and, when exposed to ionizing radiation, initiates chemical reactions in which silver chloride undergoes oxidation, converting silver ions (Ag^{+}) into metallic silver (Ag^{0}) and the formation of chlorine from chloride (Cl^{-}) and other substances[4]. This is followed by the latent image development stage, in which silver is converted into its visible form (black metallic silver). After this process, fixation takes place, in which the silver chloride unaffected by the exposure is removed, followed by the radiographic film washing phase, which allows the residues left by the developer and fixer solutions to be removed. Finally, the film is dried[4].

The solutions resulting from radiographic processing, developer and fixer are called radiographic effluents. According to the Resolution of the Collegiate Board (RDC) No. 222, of March 28, 2018, of the Brazilian National Health Surveillance Agency (Anvisa)[1,] these effluents are classified as chemical and hazardous health service waste, belonging to Group B, as they can be dangerous to public health and become an environmental problem if they are disposed of improperly.

Radiographic effluents contain compounds of organic and inorganic origin with potential toxicity for the environment and human health, such as heavy metals, hydroquinone, ammonium thiosulphate and glutaraldehyde[5].

Due to their hazardous characteristics, before being disposed of, radiographic effluents must be properly treated in compliance with the parameters established by Resolution 430 of May 13, 2011, of the National Environmental Council (CONAMA)[6], which include: stabilizing the pH between 5 and 9, keeping the temperature below 40°C, removing at least 60% of the biochemical oxygen demand (BOD), limiting total silver to 0.1 mg/L, among others[1,6].

However, some studies show that radiographic effluents are often treated inadequately and end up in waterways[7,8,9].

In the study by Kaster et al.[10] it was found that 35% of the interviewees disposed of radiographic effluent into the common sewer without undergoing any neutralization process. This was corroborated by the study carried out by Oliveira et al.[9], in which 84.8% of participants reported disposing of developer and fixer waste directly into the sink in their offices after processing images.

In Brazil, according to data from the Brazilian Institute of Geography and Statistics (IBGE), the proportion of Brazilian municipalities with sanitation coverage grew from 47.3% in 1989 to 60.3% in 2017. This data shows that many Brazilian cities still lack a satisfactory environmental sanitation and treatment system[11].

The North is the region with the greatest lack of sanitation, since only 21.4% of the population has access to sewage treatment systems[12]. In view of this, it is important that the effluents resulting from radiographic processing undergo the treatment and final disposal determined by the regulatory bodies[1,2].

The authors became interested in researching this topic after observing and experiencing the improper disposal of radiographic effluents in dental office sinks during 2020 and 2021 in cities that do not have sewage treatment plants (STPs), such as Santarém (Pará). This practice highlights the lack of supervision by the competent bodies and non-compliance with current legislation, which may be due to the lack of thought given by the establishments' managers to the consequences for the environment.

In this context, the aim of this study was to identify and compile the evidence available in the national and international literature on ways of disposing of radiographic effluents from health services.

METHOD

The integrative literature review, according to Souza et al.[13], is an instrument that allows the synthesis and critical analysis of research on a subject. This method provides assistance based on scientific evidence. In order to develop the review, the following phases are followed: elaboration of the guiding question, literature search or sampling, data collection, critical analysis of the studies included, discussion of the results and presentation of the integrative review. The articles included were analyzed using the referential and contextual dimensions according to Ferreira and Bonan[14].

The present study began with a guiding question based on the acronym PICO: P - population or problem; I - intervention; C - comparison or control; O - outcome or result[13]. The guiding question was therefore: "How is radiographic effluent disposed of in health services?".

The selection of articles in the databases, the reading of the title and abstract in the screening phase, the full reading of the articles, data extraction, as well as the critical analysis of the articles included were carried out between September and

November 2021, using the following databases: Virtual Health Library (VHL), *U.S. National Library of Medicine (*PubMed), and *Scientific Electronic Library Online (*SciELO).

Firstly, controlled descriptors were selected from the Descriptors in Health Sciences (DeCS) platform: *gerenciamento de resíduos*; *resíduos de serviços de saúde*; *resíduos químicos*; *resíduos tóxicos*; *radiografia*; *waste management*; *medical waste*; *chemical waste*; *toxic wastes*; *radiography*. However, when searching the databases, few articles were in line with the guiding question. For this reason, the controlled descriptors were replaced by non-controlled descriptors.

These search descriptors were in Portuguese: *resíduos*; *resíduos de saúde*; *materiais radiográficos*; *revelador* and *fixador*. And their correspondents in English: *waste*; *health waste*; *radiographic materials*; *developer* and *fixer*. These were combined in pairs using Boolean AND logic as follows: (waste) AND (radiographic materials); (*waste)* AND (*radiographic materials)*; (health waste) AND (developer and fixer) and (*health waste)* AND (developer and *fixer)*.

The search in the databases respected the following inclusion criteria: articles on the disposal of radiographic effluents in healthcare; full articles published between January 1995 and December 2020 and articles in English, Portuguese, or Spanish. While the following were excluded: articles that did not address the disposal of radiographic effluents in healthcare; duplicate texts in the databases; course completion papers (monographs, dissertations, and theses); literature reviews; public opinions and/or case reports.

The selection of articles in the databases was carried out by two independent researchers who found the same number of articles. However, there was a divergence in the number of articles included, so a third researcher, after analysis, decided to include the two divergent articles. All the researchers were from the health sector and were carrying out research into health service waste.

In order to extract and analyze the data from the included articles, a Microsoft Excel® spreadsheet was created detailing: authors, year of publication, journal, profession of the first author, place of research, objectives and outcome.

RESULTS

By combining the search descriptors in the selected databases, 54 publications were obtained: 38 in the VHL (70.4%), 16 in PubMed (29.6%) and there were no records in the SciELO database. In the identification phase, 13 texts were excluded due to duplication, one article in Japanese, one thesis and one review article.

In the screening phase, 38 articles were evaluated, of which, after reading the title and abstract, 24 were excluded for not being related to the topic or for not answering the research question. The review therefore began with a larger sample, and, in the end, 14 articles were considered eligible. After reading the text in its entirety, no article was excluded for not answering the guiding question (Figure). As a result, the final sample of this review consisted of 14 articles, which referred to the disposal of radiographic effluents in different healthcare facilities, as well as covering various professional categories, which allowed the sample to be well represented.

Analysis of the scientific evidence showed that of the 14 articles included, 71.5% (n = 10) were developed in Brazil, 14.3% (n = 2) in India, 7.1% (n = 1) in Australia, and 7.1% (n = 1) in Iran. In terms of language, 50.0% (n = 7) of the articles were published in Portuguese, 42.9% (n = 6) in English, and only 7.1% (n = 1) in Spanish. It was found that 92.9% (n = 13) of the first authors were dental surgeons and 7.1% (n = 1) mechanical engineers.

The results showed that the highest number of publications occurred in 2011 (28.6%; n = 4) and 2012 (28.6%; n = 4), followed by 2005 (14.4%; n = 2), 1997 (7.1%; n = 1), 2014 (7.1%; n = 1), 2015 (7.1%; n = 1), and 2019 (7.1%; n = 1).

The Chart summarizes the evidence selected for this review.

DISCUSSION

Contextual dimension

As for the general characteristics of the studies, it was noted that the majority of the articles included in this review had dental professionals as authors and sample components. This may be related to the lack of commitment on the part of many dental surgeons to complying with legislation on health service waste management and environmental legislation[7,16,20,21].

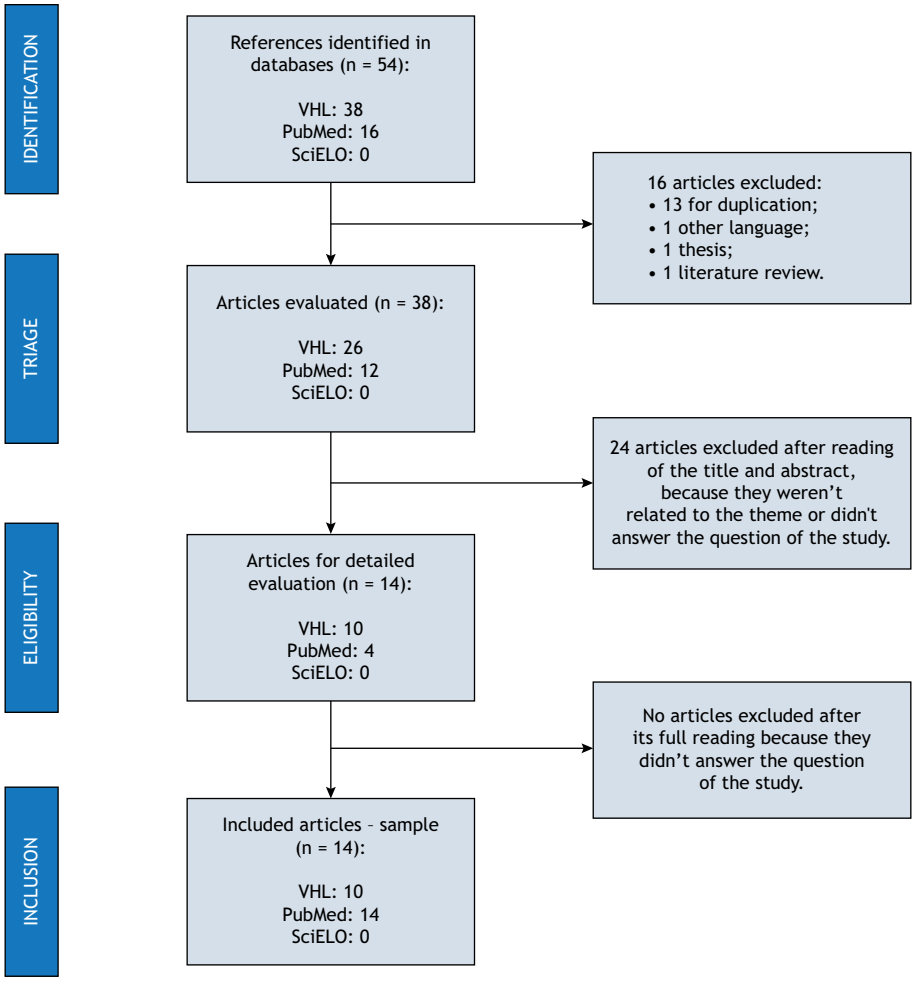
For this reason, the management of radiographic waste should be included in the curricula of health professionals and dentists should have a detailed understanding of this management process, since they will be the professionals closest to these activities in health services. In addition, continuing education after graduation could be an important strategy for updating and training on the correct disposal of radiographic effluents[2,9,17,18,19,20,21].

Legislation on the disposal of radiographic effluents differs from country to country, and in the same country there may be federal, state, municipal and district regulations. In addition, these regulations undergo periodic updates that modify the disposal parameters.

Referential dimension

The studies included showed that the main form of disposal of radiographic effluents in health services was into the sewer and without prior treatment[7,8,9,10,16,17,19,20]. This contradicts international recommendations, such as the *Healthcare Environmental Resource* Center[23], which recommends the responsible disposal of waste generated, and current Brazilian guidelines.

In Brazil, the discharge of radiographic effluents must comply with the guidelines of Anvisa Resolution 222/2018[1] and CONAMA Resolution 430/2011[6]. Both recommend the treatment of all



Source: Prepared by the authors, 2022.

Figure. Flow of the article selection process for the integrative review.

effluents before they are discharged directly into receiving bodies. Brazilian legislation does not specify the forms of treatment, but only indicates that ecotoxicity tests may be carried out. Resolution 430/2011[6] establishes the maximum limit allowed for some inorganic and organic parameters in effluents before they are discharged as up to 0.2 mg/L of cadmium; 1.2 mg/L of toluene; 1.2 mg/L of benzene, among others.

Studies show that radiographic effluents discharged into sewers without prior treatment can have environmental and human health consequences, although these are scarce[2,5]. According to the Material Safety Data Sheet (MSDS), regulated by ABNT 14725-4 of 2009[24] and which provides information on various aspects of chemical products in terms of protection, safety, health and the environment, radiographic effluent can be treated in-house or externally by a specialized company. It is worth noting that, according to national recommendations, each service that generates radiographic effluent has the autonomy to use treatment processes that comply with current regulations.

According to Lunar et al.[25], different forms of treatment have been proposed, such as: chemical precipitation and sedimentation, chemical oxidation, carbon adsorption, biological oxidation and reverse osmosis. Combined methods such as chemical-biological processes, chemical-electrochemical oxidation and oxidation-separation are also being proposed. Recycling radiographic effluents through biological treatment-Cl2, filtration-chelation, adsorption-reverse osmosis-could be another option[2,25]. According to Igarashi-Mafra et al.[26], the photo-Fenton oxidation technique is used to destroy toxic organic compounds present in radiographic effluents and does not require expensive equipment. It can be used *in loco in* small services, whose facilities and small volume of waste would not justify the adoption of other types of process, such as incineration[2,26].

The developer and fixer can cause serious eye damage, skin sensitization, skin corrosion, mutagenicity in germ cells, carcinogenicity, acute oral toxicity, acute and chronic danger to the aquatic environment[27,28]. In addition, after the radiographic film development process, the fixer solution contains a high amount of silver and can therefore be considered hazardous waste for the environment and human health[8].

Chart. Characteristics of the studies included on the disposal of radiographic effluents in healthcare.

N	Journal/ Author/ Year	Study site	Main objective	Outcome
1	Aust. Dent. J. Farmer et al. 1997[15]	Melbourne, Australia	Identify the problems that have occurred due to the lack of dental guidelines for waste disposal.	The sample consisted of ten dental clinics. Of these, only three did not recycle fixative and developer, but used the sink as a method of disposing of radiographic effluents.
2	Radiol. Bras. Fernandes et al. 2005[5]	Rio de Janeiro (RJ), Brazil	Evaluate the conditions in which radiographic effluents are disposed of, proposing solutions that reduce the environmental impact they generate.	The sample consisted of two hospitals. One disposed of the developer solutions and untreated washing water into the sewer and the fixer solution was stored and sold to another company. The other separated the silver from the fixer solution generated and, after this stage, the solution was discharged untreated into the sewer.
3	Rev. Assoc. Paul. Cir. Dent. Manzi et al. 2005[7]	Minas Gerais, Rio de Janeiro, and São Paulo, Brazil	To evaluate the destination given to radiographic waste by dental surgeons in clinics and dental practices.	A sample of 800 dentists, 94% disposed of the developer and fixer in the sewer, 5% sent the developer to specialized companies, 1% diluted the developer in water before disposing of it in the sewer and 6% sent the fixer for treatment by specialized companies.
4	Radiol. Bras Grigoletto et al. 2011[2]	Ribeirão Preto (SP), Brazil	To identify the situation of radiographic effluent management in diagnostic imaging services.	The sample consisted of 12 radiodiagnostic services, three of which had digital radiographic equipment, two disposed of the developer directly into the sewage system without treatment, one disposed of the fixative untreated into the sewage system and nine services disposed of the film washing water into the sewage system without treatment. Only six (50%) had their radiographic effluent collected and treated by private companies.
5	Acta Odontol. Venez. Dias et al. 2011[16]	Juiz de Fora (MG), Brazil	To check how professionals dispose of radiographic waste.	Sample of 74 dentists. Only four (5.40%) reported not having an X-ray machine in their practice. It was found that 42.80% of the developer solution waste was disposed of in the sewer, 37.14% disposed of the waste in the sewer after dilution with water. Around 42.85% disposed of the fixing solution in the sewer without dilution and 34.28% disposed of it in the sewer after dilution with water.
6	Rev. ABRO Sá et al. 2011[8]	Aracaju (SE), Brazil	To ascertain the current situation in dental practices regarding the disposal of radiographic waste.	Sample of 84 dental surgeons. Only 58% of the professionals separated radiological waste, 88% disposed of developer and fixer inappropriately, 50% disposed of fixer directly into the sewage system, 38% diluted it with water and only 12% sent radiological waste to companies specialized in its treatment.
7	Indian J. Dent. Res. Sood and Sood 2011[17]	Near and in Delhi, India	To obtain information on the knowledge, attitude and practices of institutions and dentists regarding waste disposal.	A sample of 100 dental students, dental institute teachers and private dentists. Thirty percent of the dentists used conventional radiography and 47% used both conventional and digital, 34% disposed of the fixative in the sink, 60% disposed of the residual developer down the drain and 25% believed that the used developer and fixative solutions could be mixed and washed down the drain.
8	RSBO Silva et al. 2012[18]	São Luís (MA), Brazil	To evaluate waste management in dental practices and radiology clinics in São Luís, Maranhão, Brazil.	A sample of 100 dentists, 43% of whom disposed of the fixative in the sink; 36% diluted the fixative in water and disposed of it in the sink; 14% sent it for disposal by a specialized company and 7% used another form of disposal. Forty-two percent disposed of the developer in the sink, 36% diluted it in water and then disposed of it in the sink, 13% sent it to a specialized company and 9% used another form of disposal. Regarding the water used to wash the films, 71% disposed of it in the sink; 16% diluted it in water and disposed of it in the sink; 6% sent it for disposal by a specialized company and 7% disposed of it by another method.
9	Dentomaxillofac. Radiol. Shahab et al. 2012[19]	Iran	To investigate the knowledge and behavior of dentists in relation to oral radiology safety standards.	A sample of 700 dentists, only 2% used digital radiography. The processing solutions used were disposed of properly by only 1% of respondents.

Continue

Continuation

10	Arq. Bras. Odontol. Kaster Lund and Baldissera 2012[10]	Pelotas (RS), Brazil	To evaluate the destination of radiographic effluents by dentists and to analyze dentists' knowledge of sustainability.	A sample of 40 dentists, 90.0% of whom said they did not treat developer and fixer and 97.5% did not treat rinse water. Of the professionals who treated the developer and fixer before disposing of them, 35.0% poured the solutions directly into the sewer, 22.5% diluted them in water before disposing of them in the sewer, 35.0% sent them to a specialized company and 7.5% added a large amount of water before disposing of them in the sewer. Regarding washing water, 65.0% disposed of it directly into the sewer, 30.0% diluted it in water before disposing of it into the sewer, 2.5% sent it to a specialized company and 2.5% neutralized it before disposing of it into the sewer.
11	Arq. Bras. Odontol. Oliveira et al. 2012[9]	Montes Claros (MG), Brazil	To assess dental surgeons' knowledge of radioprotection and biosafety measures.	A sample of 112 dentists, 84.8% of whom disposed of the developer and fixer in the sewer without treatment; 15.2% sent it to a specialized company and none of the interviewees carried out prior treatment before disposing of it in the sewer.
12	BioMed Res.Iint. Singh et al. 2014[20]	Two cities in northern India	To evaluate performance in relation to dental waste, including mercury management policy and practices among dentists.	A sample of 160 dentists, 45% of whom dispensed the developer and fixer solutions directly into the sewer, 49.4% diluted and disposed of them in the sewer and only 5.6% returned them to the supplier.
13	Arq. Bras. Odontol. Pereira et al. 2015[21]	Santa Catarina, Brazil	To verify the knowledge of dental graduates in the state of Santa Catarina about health service waste generated in dental practices.	A sample of 138 graduates from the Dentistry course, 82.6% of whom knew how to dispose of liquids used in the processing of X-rays; 16.7% disposed of them incorrectly; 95.7% knew about the storage of residual developer and fixer liquids; 97.92% believed that the correct treatment and final disposal of health service waste preserves public health and the quality of the environment; and 96% believed that there was a special collection service for the waste generated in practices.
14	J. Health Sci. Oliveira et al. 2019[22]	Lagoa Seca, Juazeiro do Norte (CE), Brazil	To evaluate the disposal of waste produced in the outpatient clinic of a dental school, estimating whether it is being disposed of properly.	The sample consisted of students from a university center. Radiographic processing effluents were disposed of in accordance with the guidelines established by Brazilian environmental agencies.

Source: Prepared by the authors, 2022.

It is worth noting that the chemical substances that make up radiographic effluents are not always removed in their entirety by wastewater treatment plants, since many of them do not have sufficient structures to remove inorganic components, including silver, the main chemical contaminant in these solutions[2,8].

In Brazil, sewage treatment is carried out in only 21.4% of cities located in the North, 34.1% in the Northeast, 58.5% in the Midwest, 58.6% in the Southeast and 46.7% in the South[12], a fact that highlights the need for proper treatment and final disposal of effluents before they are discharged into sewage systems, in order to prevent damage to human health and the environment.

Studies included in this review[7,10,16,18,20] showed that, in order to minimize the environmental impact of disposing of radiographic effluents, some services diluted the developer solution in water; however, no details of this process were presented, including the type of water used and its quantity.

As the radiographic effluents, developer and fixer, have different chemical compounds, the *Healthcare Environmental Resource* Center[23] and Resolution No. 222/2018[1] recommend that they not be mixed before disposal, in order to avoid the formation of other chemical compounds harmful to the environment and human health, and also point out different disposal methods.

The *Healthcare Environmental Resource* Center[23] establishes a quantity of silver in the developer below 5 mg/L. It adds that the developer solution can be discharged into the sewer as long as it passes through wastewater treatment plants and recommends that waste generators check with these plants for restrictions and recommendations on the components of these effluents.

In Brazil, Resolution No. 222/2018[1] suggests that developer solutions go through a neutralization process to reach a pH between 7 and 9 and then be disposed of in a treated sewage system. In the same vein, the *Healthcare Environmental Resource* Center[23] suggests three approaches to fixer effluent: dispose of it as hazardous waste, pay a company to collect and recover the silver from the effluent or have a local silver recovery unit. While Resolution 222/2018[1] recommends that fixer solutions, when not subjected to the silver recovery process, should be sent for treatment before environmentally appropriate final disposal and that waste containing heavy metals such as silver, when not subjected to treatment, should be disposed of in a Class I hazardous waste landfill.

The practice of recovering silver from radiographic effluents, especially in the fixer solution, was observed by Fernandes et al.[5] in a hospital where two outsourced companies were working. One of them used the method of taking the fixer solution from the film processor to the silver separator by tubes, and the

silver was recovered through a continuous electrolytic process and then the resulting solution was disposed of through tubes directly connected to the sewage system, without any further treatment. The recovered silver was divided between the hospital and the company. The other company separated the silver from the fixative using a system consisting of a filter for heavy metals and the resulting fixative solution, developer and water went through a decontaminator which was supposed to release the remaining solution with parameters within the limits recommended by Brazilian environmental legislation. However, it was observed that the solutions in the decontaminator were only continuously diluted with running water[5].

Other options mentioned in the articles were: returning the developer and fixer effluents directly to the supplier[20], packaging the fixer effluent in drums for later sale[5] and having the solutions collected by third-party companies specializing in the treatment and environmentally appropriate final disposal of these effluents[2,7,8,9,10,18].

Regarding the collection of solutions by third-party companies specialized in treatment and environmentally appropriate final disposal, no study cited the names of the companies responsible for this treatment, nor did it describe how the effluents were disposed of[2,7,8,9,10,18].

It is important that those responsible for hiring companies that treat health service waste check that they have a license from environmental agencies, technical capacity, qualifications and moral suitability[2].

With regard to the companies that treat these effluents, Grigoletto et al.[2] observed that in Ribeirão Preto they were collected and treated by five outsourced companies, three of which had a license from the Environmental Company of the State of São Paulo (CETESB), one only had a contact telephone number, and one participant was unable to provide the name of the company they hired. These companies were located in the municipalities of Barretos, Diadema, Campinas, Franco da Rocha and São Paulo.

Kaster et al.[10] found that in the city of Pelotas (RS) there was no local company specializing in the collection of health service waste and radiographic waste; however, three companies from other nearby cities were collecting it. They pointed out that the need to travel between cities for collection could result in high collection fees for this waste and, consequently, justify the occurrence of infractions by the generators of this waste. This shows that the high cost can lead professionals to fail to comply with regulatory legislation.

On a positive note, Oliveira et al.[22] reported that the effluent from the developer and fixer was disposed of in accordance with the standards set by the regulatory bodies, but they did not detail the disposal method used.

Regarding film wash water, Grigoletto et al.[2] pointed out that national resolutions should include it as chemical waste, since it contains all the components of the developer and fixer, as well as the products of their chemical reactions, so it would also need to be treated before being disposed of in the sink[5]. Despite this, Grigoletto et al.[2], Kaster et al.[10] and Silva et al.[18] observed that specialized companies sent the wash water for treatment.

One solution to the problem of radiographic effluents is digital radiography. According to Köner et al.[29], the future of radiology would be digital because it has numerous advantages when compared to other forms of imaging. The traditional process of obtaining images has lost ground to digital equipment, which does not require the use of radiographic processing solutions (developer and fixer)[28].

On the other hand, there are challenges to the use of digital radiography, including: the high cost of digital equipment, the cost of converting previous records to digital, the need to train professionals and technicians, the discomfort caused to patients by the thickness and rigidity of the sensor, the high cost of maintaining sensors and the fact that digital radiography is not universally used[2,30].

Although it was not the aim of this study, some articles have shown the uptake of digital radiography. Grigoletto et al.[2] verified the use of digital radiographic equipment by three health services. Sood and Sood[17] mentioned that 47% of the dentists interviewed used both conventional and digital radiography and Shahab et al.[19] found that 2% of the dentists in their sample already used digital radiology.

CONCLUSIONS

The evidence summarized in this study points to important weaknesses in the disposal of radiographic effluents, which could put the environment and human health at risk. The lack of commitment by professionals to comply with specific legislation and guidelines and the lack of inspections by the competent bodies are factors linked to incorrect disposal. Despite the importance of radiographic images in the context of healthcare, during the course of this study it was found that there are few studies published on the subject in Latin America and other parts of the world such as Europe, the United States, Canada and Asia.

Unfortunately, sewage is an option that needs to be considered and looked at more closely, since many Brazilian cities do not have sewage treatment plants and, even when they do, there is a lack of evidence evaluating their impact on the removal of chemical pollutants such as silver.

Negligence on the part of radiographic effluent generators in complying with the guidelines must be punished more strictly and inspections must be frequent in order to prove that radiographic chemical waste is being disposed of properly.

The controlled sale of developer and fixer solutions should also be implemented, so that buyers can prove the means by which they will be disposed of, such as by signing contracts with private companies specializing in environmental treatment and disposal, by sending them to a class I landfill, or by using specific equipment to treat them, which periodically takes samples that

are analyzed by experts to verify the parameters established by legislation.

It is suggested that new studies with a higher level of evidence be carried out to investigate the direct relationship between radiographic effluents and health and the environment. As well as cross-sectional studies to verify the uptake of digital radiography by national and international health services. In addition, it is important to verify how outsourced companies treat and dispose of radiographic effluent waste.

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Authors' Contribution

Figueira Keylla L, Silva VWP, Meschede MSC - Conception, planning (study design), acquisition, analysis, data interpretation, and writing of the work. Figueira Kelly L, Reis ECE, Nascimento VB - Analysis, data interpretation, and writing of the work. All the authors approved the final version of the work.

Conflict of Interest

The authors inform that there is no potential conflict of interest with peers and institutions, political or financial, in this study.