Waste management in laboratories of a Brazilian public university: a challenge for environmental health and occupational health

Gerenciamento de resíduos em laboratórios de uma universidade pública brasileira: um desafio para a saúde ambiental e a saúde do trabalhador

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ABSTRACT Higher education institutions, as generators and disseminators of knowledge, are increasingly in need to assume their roles in regional context, especially in the creation of sustainable and environment preservation public policies. In this sense, the aim of this article was to understand the management of health care waste practices in teaching and research laboratories of the Institute of Agrarian Sciences of the Federal University of Minas Gerais – Montes Claros campus. It is a research with quantitative and qualitative approaches, carried out through survey application with workers engaged in the activities of the teaching labs. For the analysis, absolute and relative frequencies, position measurements, central tendency and dispersion were used. Among the problems detected, it should be highlighted: non-compliance with current legislation, concerned to laboratories waste management; absence reported by workers, of training for the accomplishment of their functions, as well as education for risk prevention and proper waste management; insufficient immunization coverage against hepatitis B and tetanus. Although the places researched manage their waste, this work concludes that many practices are at odds with the current legislation and need to be adequate.

KEYWORDS Waste management. Universities. Occupational health. Environmental health.

RESUMO *As instituições de ensino superior, enquanto geradoras e difusoras de conhecimento, precisam cada vez mais assumir seu papel no contexto regional, especialmente na criação de políticas sustentáveis e de preservação do meio ambiente. Neste sentido, o presente artigo objetiva compreender as práticas de gerenciamento de resíduos de serviços de saúde nos laboratórios de ensino-pesquisa do Instituto de Ciências Agrárias da Universidade Federal de Minas Gerais – campus Montes Claros. Trata-se de uma pesquisa com abordagem qualitativa e quantitativa, realizada mediante a aplicação de questionário com os trabalhadores inseridos em atividades dos laboratórios de ensino. Para a análise, foram utilizadas as frequências absolutas e relativas, medidas de posição, tendência central e dispersão. Entre os problemas identificados, ressaltam-se: as não conformidades com a legislação vigente, em relação ao gerenciamento de resíduos nos*

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laboratórios; a ausência relatada pelos trabalhadores, de capacitações para a realização de suas funções, como também de treinamentos para a prevenção de riscos e para o manejo adequado de resíduos; e a cobertura vacinal baixa contra hepatite B e tétano. Apesar de os locais pesquisados realizarem o gerenciamento dos seus resíduos, constata-se que muitas práticas estão em desacordo com a legislação vigente e precisam ser adequadas.

PALAVRAS-CHAVE *Gerenciamento de resíduos. Universidades. Saúde do trabalhador. Saúde ambiental.*

Introduction

Solid waste has become the symbol of a consumerist society and its shortcomings, explained by its constant presence in urban and rural landscapes. Daily production of municipal solid waste in Brazil reached a total of 214.869 tons in 2017. Data from the Panorama of the Brazilian Association of Public Cleaning and Special Waste Companies (Abrelpe) show that 29.6% of Brazilian municipalities do not yet have initiatives for selective collection[1].

The proper disposal of urban solid waste advanced little in 2017, compared to 2016. The volume of waste sent to dumps increased by 3% during this period, which is considered as the worst form of disposal of these materials. Another important fact concerns the management of health services waste, carried out by municipalities and not by generators. In 2017, Brazilian municipalities collected about 256.941 tons of health care waste. Summing the amounts under municipal management, it appears that the Brazilian municipalities managed, that year, approximately 117 million tons of solid waste[1].

In the year of 2010, was established, by Law nº 12.305, the National Policy on Solid Waste (PNRS)[2], which provides for principles, objectives and instruments, as well as guidelines for integrated management and waste management. Among the principles of PNRS, prevention, precaution and sustainable development stand out, as well as a systemic view on solid waste management that considers such as environmental, social, economic, cultural and public health variables.

In its seventh article, first paragraph, the PNRS states that the protection of public health and environmental quality are central objectives. It is interesting to note the intertwining of public health (and here one cannot forget to mention the health of workers) with the health of the environment, having a direct relationship with the proper management of waste generated[2].

The incorporation of the role of work/environment/health relations in determining the health-disease process of the population can be identified in the Brazilian public health system, since its creation. The relationship between health and environment is established in Law nº 8.080/90 (Organic Health Law), whose third article (wording given by Law nº 12.864/13) states that 'health levels express the social and economic organization of the Country, with health as determinants and conditions, among others, food, housing, basic sanitation, the environment, work, income, education'[3,4].

The worker health/environment interface was also pointed out in the National Occupational Health Policy (PNSTT)[5]. In this context, among the objectives of this policy, the promotion of health, healthy environments and work processes is emphasized. Therefore, it is assumed the strengthening and articulation of health surveillance actions, with the

identification of environmental risk factors, for an intervention in work environments and processes. In addition, the development of risk communication strategies and actions, environmental education and occupational health is also proposed.

In 2018, the Resolution of the Collegiate Board (RDC) 222 was published, replacing RDC 306/2004, providing for the requirements on good health care waste management practices. The current resolution considers as waste generators of health services all services whose activities are related to human or animal health care. RDC 222/2018 addresses aspects that should be observed when preparing the Health Services Waste Management Program (PGRSS), and the elaboration, implantation, implementation and monitoring are the responsibility of the Health Services Waste (RSS)[6] generating service.

Higher Education Institutions (HEI) began to introduce the environmental theme in their management processes from the 1960s. The first experiences in this regard were reported at universities in the United States. In the 1980s, more specific policies for waste management and energy efficiency were observed in universities. The most effective participation of HEI in environmental policies came in the 1990s, from various documents, such as the Talloires Declaration (1990), the Halifax Declaration (1991) and the Kyoto Declaration (1993), through which universities from several countries have declared their concern about environmental degradation, stimulating the creation of projects aimed at sustainability[7].

In this scenario, it has been observed, in recent years, that waste management has become a major concern for HEI in Brazil, mainly due to the increased number of surveys and the variety of waste generated at these areas. This study aimed to understand the waste management process of health services generated in the teaching-research laboratories of the Montes Claros regional *campus* of the Federal University of Minas Gerais, considering that the information obtained can help in the actions for the improvement of the process of waste management on *campus*, in particular, aiming at the protection of workers' health and environmental health.

Methods

This is a descriptive research, with a qualitative and quantitative approach, developed as a case study at the Institute of Agrarian Sciences (ICA) of the Federal University of Minas Gerais (UFMG), in the municipality of Montes Claros (MG).

Located in the northern region of the state, the ICA began with the Antônio Versiani Athayde Agricultural School, created by Law nº 4.323, on April 11, 1964[8], and was incorporated into UFMG by Decree nº 63.416, of October 11, 1968[9]. The unit has six undergraduate courses (Administration, Agronomy, Food Engineering, Agricultural and Environmental Engineering, Forest Engineering and Zootechnics). The institute has also a *lato sensu* specialization course in Environmental and Water Resources and four *stricto sensu* postgraduate courses, three of which are master's degree courses (Plant Production, Animal Production and Forest Sciences) and one doctorate course (Plant Production). The ICA has also a master's degree course in Society, Environment and Territory associated with the Montes Claros State University (Unimontes).

For this study, the *campus* laboratories were selected, taking into account the activities performed and the generation of RSS from Group A (biological) or Group B (chemicals) (RDC 222/2018) in these locations and, consequently, proposing possible interventions on risk factors, environments and work processes, including actions to prevent associated risks. The laboratories were catalogued and, out of the total of 55,

16 laboratories were excluded from the research because they did not generate RSS from groups A or B.

For the inclusion criterion of the workers, it was established that the participants were directly involved in the activities of the teaching-research laboratories of the selected places or engaged in coordination activities. Twenty-four workers from a universe of 50 who met the inclusion criteria participated in this study. These workers act in 20 *campus* teaching-research labs.

Data collection began in November 2018, being completed in January 2019, through a set of qualitative and quantitative issues that covered issues related to waste management, such as: site characterization, employees and work routines, generation, segregation, storage, collection, transportation, treatment and final waste disposal. For the elaboration of the questionnaire, previous researches on the subject were consulted, mainly the work of Silva[10] and the Health-Care Waste Management – Rapid Assessment Tool, of the World Health Organization[11], used for the evaluation of the health services waste management. The issues considered important for the achievement of the objectives were selected and adapted, including some not covered in the consulted materials.

In the descriptive analysis, the categorical variables of interest were coded and grouped by themes. For the analysis, absolute and relative frequencies were used, while in the description of the numerical variable, a measure of central tendency (average) was used. The software used in the analysis was R (version 3.5.1).

This research met the fundamental ethical and scientific requirements, contemplating the precepts of Resolution nº 466/12 of the National Health Council[12]. Before starting the fieldwork, this project was submitted to the Research Ethics Committee of the Sergio Arouca National School of Public Health, of the Oswaldo Cruz Foundation (Ensp/Fiocruz), and the Federal University of Minas Gerais, also in accordance with Resolution nº 466/12, of the National Health Council, being approved by the Consubstantiated Opinion nº 2.797.172. All research participants signed the Informed Consent Form (ICF).

Results

Twenty-four staff members of the UFMG – Montes Claros *campus*, who worked in teaching-research laboratories of the ICA/UFMG, RSS generators of groups A or B, participated in the study. Of the respondents, 66.67% (n=16) were administrative technicians in education, with a high school or higher education level; and 33.33% (n=8) were coordinating professors of the institute's teaching-research laboratories.

As for the axes of the activities performed by the workers in the researched laboratories *(table 1)* – whether teaching, research or extension –, the results revealed that: (i) 91.67% of the interviewees performed activities in the research area; (ii) teaching activities were reported by 83.33% of respondents; (iii) regarding the extension, 75% of respondents performed activities in this axis.

Table 1. Activities developed in the laboratories. Institute of Agrarian Sciences/UFMG, Montes Claros, MG, 2019

Variable		
Axis of activities carried out in the laboratories, according to the interviewees[a]	**n**	**%**
Research		
Yes	22	91.67
No	2	8.33
Teaching		
Yes	20	83.33
No	4	16.67
Extension		
Yes	18	75
No	6	25

Source: Own elaboration.

[a]=24.

The average number of technicians per laboratory *(table 2)* was 1 (one), and some laboratories did not have a technical server. The maximum number of technicians per laboratory was 3 (three). Regarding the performance of the technicians who followed the activities in the laboratories *(table 2)*, 41.67% of the workers were not exclusive, that is, they worked in more than one place during the workday. Regarding the training of servers to perform their activities *(table 2)*, 45.83% of respondents reported that the employees of the laboratories surveyed did not receive training to perform their activities in the institution.

Regarding the vaccination of workers *(table 2)*, respondents were asked about their vaccination status for hepatitis B and tetanus vaccines, aiming at their protection against the risks inherent to the developed activity. Regarding hepatitis B, 62.5% of workers reported that they were immunized; and 33.33% of the workers did not know or were partially immunized. Regarding tetanus, 62.5% of workers reported that they were immunized.

Table 2. Variables related to workers who work in teaching-research laboratories. Institute of Agrarian Sciences/UFMG, Montes Claros, MG, 2019

Variable		
Number of workers per laboratory		
Average	Minimum	Maximum
1	0	3
Execution of activities by technical support in more than one laboratory[a]	**n**	**%**
Yes	10	41.67
No	12	50
No local technician	2	8.33

Table 2. (cont.)

Training of laboratory technicians to perform activities		
No	11	45.83
Yes	11	45.83
No local technician	2	8.34
Vaccination status of workers[a]		
No	1	4.17
Don't know	5	20.83
Partially	2	8.33
Partially, Hepatitis B don't know, tetanus yes	1	4.17
Partially, Hepatitis B yes, Tetanus don't know	1	4.17
Yes	14	58.33

Source: Own elaboration.

[a]=24.

Waste generation in *campus* laboratories

Regarding the types of waste generated, the following results were found (*table 3*): (i) biological waste were generated in the laboratories of 62.5% of respondents; (ii) sharps objects residues were generated in the laboratories of 87.5% of workers; (iii) chemical and common waste were generated in all laboratories; (iv) organic and pharmaceutical waste were generated in the workplace by 83.33% and 20.83% of respondents, respectively. Radioactive waste was not generated in any laboratory.

Table 3. Frequency of workers reporting waste generation in laboratories, by type of waste. Institute of Agrarian Sciences/UFMG, Montes Claros, MG, 2019

Variable	n[a]	%
Biological		
No	9	37.5
Yes	15	62.5
Sharp objects		
No	3	12.5
Yes	21	87.5
Chemical		
No	0	0
Yes	24	100
Pharmaceutical		
No	19	79.17
Yes	5	20.83

Table 3. (cont.)

Common		
No	0	0
Yes	24	100
Organic		
No	4	16.67
Yes	20	83.33
Radioactive		
No	24	100
Yes	0	0

Source: Own elaboration.

[a]=24.

Waste segregation and packaging in laboratories

In terms of waste segregation at the place of origin *(table 4)*, in relation to biological waste, respondents who generated this type of waste during their activities (n=15) stated that they did not perform segregation according to RDC 222/2018. Chemical waste was segregated from other types of waste by 87.5% (n=21) of respondents (n=24). As for sharp objects residues, 79.17% (n=19) stated that they performed segregation of this type of waste. The segregation of common waste had the highest percentage among respondents (91.7%).

Regarding the container used for the packaging of biological waste *(table 4)*, the most used was the rigid plastic container (33.33%). However, the biological waste was stored in the same container for common waste, which is contrary to RDC 222/2018. Only 12.5% of respondents reported using an appropriate plastic bag for the packaging of this waste. Regarding sharp objects residues, the research identified that no place had sharp objects collector, and that other types of containers were used for packaging. Among the most used containers, 50% of respondents cited the cardboard box.

Table 4. Segregation and packaging of waste in teaching-research laboratories. Institute of Agrarian Sciences/UFMG, Montes Claros, MG, 2019

Variable	n[a]	%
Workers who carry out segregation by RSS type		
Chemicals		
No	1	4.17
Yes	21	87.5
Did not answer	2	8.33

Table 4. (cont.)

Biological		
No	15	62.5
Yes	0	0
Not applicable	9	37.5
Sharp objects		
No	0	0
Yes	19	79.17
Did not answer	2	8.33
Not applicable	3	12.5
Pharmaceutical		
No	4	16.67
Yes	1	4.16
Not applicable	19	79.17
Common		
No	0	0
Yes	22	91.67
Did not answer	2	8.33
Type of RSS conditioning used by workers		
Biological		
Rigid Plastic Container		
No	7	29.17
Yes	8	33.33
Not applicable	9	37.5
Appropriate plastic bag		
No	12	50
Yes	3	12.5
Not applicable	9	37.5
Common plastic bag		
No	8	33.33
Yes	7	29.17
Not applicable	9	37.5
Sharp objects		
Sharps objects collector		
No	21	87.5
Yes	0	0
Not applicable	3	12.5
Other containers		
No	3	12.5
Yes	18	75

Table 4. (cont.)

Cardboard box	12	50
Reused plastic box or flask	2	8.33
Aluminum can	1	4.17
Petri dish	2	8.33
Glass jar	1	4.17
Not applicable	3	12.5
Chemicals		
Rigid Plastic Container		
No	11	45.83
Yes	11	45.83
Did not answer	2	8.34
Glass		
No	10	41.67
Yes	12	50
Did not answer	2	8.33

Source: Own elaboration.

[a]=24.

Waste treatment and final disposal

Table 5 shows that no worker replied that the waste generated was fully treated; 33.33% of workers replied that the waste was partially treated. A considerable percentage of workers (29.17%) could not answer the question.

Workers were also asked who was treating the waste. Most of them (54.17%) could not answer the question or stated that there was no treatment. Regarding the treatment of biological waste, 25% of the workers said to perform autoclaving before disposal, however, this waste was discarded along with the common waste.

In the study, the attitudes of the workers were verified when they were faced with a residue that had no treatment option *(table 5)*. Most of the workers (45.83%) answered that, faced with this situation, they used to carry out the storage of the residue. Waste disposal in the sewage system or the environment was reported by 25% of the respondents. Regarding the treatment options offered by the institution, 50% of the respondents answered that they were dissatisfied. Only 25% of workers were satisfied with the waste treatment options at the institution.

Table 5. Waste treatment and final disposal of teaching-research laboratories. Institute of Agrarian Sciences/UFMG, Montes Claros, MG, 2019

Variable	n[a]	%
Is the generated waste treated?		
No	8	33.33
Yes, partially	8	33.33
Yes	0	0
Don't know	7	29.17
Did not answer	1	4.17
Who performs waste treatment?		
Server himself – autoclaved and discarded in ordinary trash	2	8.33
Third-party company	6	25
There is no treatment	3	12.5
Don't know	7	29.17
Did not answer	6	25
What does he/she do to dispose of waste when there are no treatment options?		
Storage	11	45.83
Disposal to sewage system or environment	6	25
All waste generated have treatment options	3	12.5
Other	1	4.17
Did not answer	3	12.5
How are chemical waste treated?		
Storage	1	4.17
Disposal to sewage system	5	20.83
Incineration	4	16.67
There is no treatment/other	2	8.33
Don't know	5	20.83
Did not answer	7	29.17
How are biological waste treated?		
Autoclave process before disposal	6	25
Intended for the environment without treatment	5	20.83
Storage	1	4.17
Don't know	2	8.33
Did not answer/not applicable	10	41.67
What type of local is used for final disposal of waste within the institution?		
Animal cemetery of the Experimental Farm	1	4.17
Store near the Experimental Farm Fehan* (chemical waste)	5	20.83
Store near the garage (common waste)	2	8.33
Other locations reported as deposit, but not used or do not exist	6	25
Don't know	9	37.5
Did not answer	1	4.17

Table 5. (cont.)

How satisfied or dissatisfied are you with the treatment options offered?		
Very dissatisfied	2	8.33
Unsatisfied	12	50
Satisfied	6	25
Very satisfied	1	4.17
Did not answer	3	12.5

Source: Own elaboration.

[a]=24.

*Fehan – Experimental Farm Professor Hamilton de Abreu Navarro.

Discussion

Among the problems identified, it is emphasized: (i) non-compliance with current legislation regarding waste management in laboratories; (ii) the absence reported by the workers, of training for the accomplishment of their functions, as well as training for the prevention of risks and for the adequate management of waste; (iii) low hepatitis B and tetanus vaccine coverage; (iv) access to information on laws and standard operating procedures for proper waste management; (v) poor infrastructure in the laboratories for the correct management of waste. Among the risks identified to human health and the environment, those related to accidents with sharp objects in the researched places are emphasized; environmental contamination; explosion due to the nature of the chemicals used; and human intoxication and possible accidents.

Decree nº 5.707/06[13(4)] established the policy and guidelines for the development of direct, autarchic, and foundational federal public administration personnel, with the purpose of permanently developing the public servant, as well as adapting the competencies required for meeting the objectives of the institutions.

The policy has as its guideline:

> offer and guarantee introductory or training courses, in compliance with the specific rules applicable to each career or position, to employees entering the public sector, including those without effective ties with the public administration.

Given the above, 50% of respondents reported that they did not receive training to perform their activities in the institution. Thus, there is a discrepancy between the assumptions of the legislation and the research results. Siqueira (2014) points out that one of the challenges at UFMG for the effectiveness of correct solid waste management depends on constant training, commitment and legitimation of all procedures by the actors involved.

Sangioni et al.[14], regarding the prevention of accidents in laboratories, state that, as the human factor is implicated in the causes of accidents, the greatest effort should be directed to the aspects of biosafety education, which should be present in the daily life of educational institutions.

Regarding the vaccination status of workers, 62.5% of respondents in this survey reported complete vaccination for hepatitis B. A study conducted in 2015 on the vaccination status of health workers against hepatitis B found that the prevalence of complete vaccination was 59 9%[15,16]. And in a cross-sectional study

on occupational exposure and hepatitis B vaccination, 59.7% of workers surveyed reported complete vaccination. These results are similar to those found in the present study.

Regulatory Standard (NR) 3217, which provides for the Occupational Health Medical Control Program (PCMSO), states that it should indicate how surveillance of potentially exposed workers will be performed and address the vaccination program. It is observed that a high percentage of workers (41.67%), of the total of respondents, was susceptible to immunopreventable diseases, which indicates failures in health surveillance of professionals.

With regard to the generation of waste in laboratories, in research on the diagnosis of the hazardous waste management situation in laboratories/services of the University of São Paulo (USP) *campus*, of Ribeirão Preto (SP), in 2010, regarding the frequencies of waste generation, were identified: (i) biological waste in 65.3% of laboratories; (ii) common waste in 97.5% of laboratories; and (iii) chemical waste in 80.9% of respondents. These data are similar to those of the present research[18].

Regarding the packaging of sharp objects, RDC 222/2018, in article 86, states that these materials must be disposed of in identified containers, rigid, fitted with a lid, resistant to puncture, rupture and leakage. The research found that none of the places surveyed have sharp objects collectors and that other types of containers are used for their packaging *(table 4)*. Among the most used alternative containers, 50% of respondents cited the cardboard box[6].

Liquid waste must be put up in containers made up of liquid-compatible material stored, resistant, rigid and leak-proof, with a lid to ensure that the RSS is contained and properly identified. *Table 4* shows that, rigid plastic (45.83%) and glass (50%) are the most commonly used containers for the packaging of chemical waste.

Regarding the treatment of chemical waste (Group B), 20.83% of respondents answered that they dispose of the sewage system. This practice is at odds with RDC 222/2018. Many reagents used in laboratories are toxic to humans and the environment, therefore, disposal of these wastes into the sewer system can cause serious harm to human health and the environment.

As for biological waste, 25% of workers said they perform autoclaving prior to disposal, however, they are disposed of together with common waste, that is, no environmentally sound disposal is made. According to RDC 222/2018, biological residues (Group A) – specifically subgroups A1 and A2 – must be treated using procedures that must be validated for microbial load reduction or elimination in equipment compatible with level III microbial inactivation, for an environmentally appropriate disposal of such tailings[6].

Final considerations

In compliance with Law nº 12.305/10, the establishment of PGRSS in the ICA – Montes Claros *campus* is essential, not only in the laboratories, but in all the RSS generating sectors of the institution. Although there are waste management practices in the places visited, it was found that many of them are in disagreement with current legislation and need to be adequate. The major difficulties were related to the disposal and treatment of biological waste in laboratories and improper storage of chemical waste.

The PNSTT[5] has as one of its objectives the realization of the analysis of the health situation and identification of the needs, demands and health problems of workers in the territory. With regard to immunoprevention, it is necessary that the Occupational Health Sector of ICA keeps the vaccine situation of the institute workers updated.

The present research was conceived with the purpose of contributing to the implementation of actions for the improvement of the environmental and health conditions of the workers of UFMG – Montes Claros *campus*.

It should be noted that, during its development, this research provided discussions on the subject, and some actions were promoted by the administration, such as the appointment of a waste manager to the *campus*, aiming at improving waste management in laboratories.

In 2018, the Commission of Socio-environmental Management was set up at the Montes Claros *campus*. The committee is multidisciplinary and has teachers and administrative technicians from different areas of training. It was established with the objective of making the ICA/UFMG *campus* an environmental management model in semiarid regions, as well as implementing, formalizing, expanding and improving solid waste management. Through the Commission, the collection and treatment of chemical residues that were stored in the institute were carried out. There was a large accumulated liability, and many flasks were without any identification or packaging date. This was the first time that chemical waste had a proper destination.

Regarding training for proper waste management, the 'Waste management, health and safety Course' was held in 2019, after identifying, in the present research, the need for training on waste management. As a course audience, workers who worked in laboratories of the *campus* were invited, and the event was also open to the academic and external communities, with debates on occupational safety, recycling of discarded materials and conscious consumption, in addition to the PNRS, of chemical waste inventories and the RDC 222/2018.

The course used a participatory methodology, through which the workers themselves were responsible for conducting most of the themes. In this way, they have acquired knowledge that can be applied in their workplaces. At the same time, a support network was created among professionals to assist in the adequacy of their practices.

Higher education institutions, as generators and diffusers of knowledge, increasingly need to assume their role in the regional context, as agents of innovation and articulation with society, in the creation of sustainable policies and preservation of the environment. Therefore, it is essential that universities have a coherent attitude, implementing waste management programs in line with other sectors of society, in search of new solutions for recycling and waste treatment.

Collaborators

Oliveira ACR (0000-0003-1168-7584)* contributed to the conception, planning, collection, analysis and interpretation of data; critical review of the content and approval of the final version. Braga AMCB (0000-0002-8538-5880)* contributed to its elaboration with the following activities: conception, planning, critical revision of the content and approval of the final version of the manuscript. Villardi JRW (0000-0003-3221-6052)* and Krauss TM (0000-0003-2504-0538)* also contributed to the draft revision and approval of the final version. ■

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