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Research article/
Dossier COVID-19 and Worker's Health

COVID-19: a study of personal protection protocols for health workers

COVID-19: estudo de protocolos de proteção individual para profissionais da saúde

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Abstract

Objective: to make a comparison between countries and between Brazilian states regarding the contents of protection protocols for COVID-19 healthcare workers and to undertake a critical analysis of the prevention model that adopts the recommendation and use of personal protective equipment (PPE) as the only response to a multidimensional problem. *Methods*: exploratory study based on revisions available at the Cochrane Library, articulated with the analysis of the national protocols of Argentina, Brazil, China, and the United States of America and those of the states of Amazonas, Bahia, Minas Gerais, and São Paulo, all selected by convenience criteria. *Results*: there were differences between the recommended types of protection. Only China recommended high filtration efficiency respirators as well equipment covering the whole face for invasive procedures. Reusing the equipment is not recommended, but it was authorized in the Brazilian protocol. There was also no convergency about clothing devices. *Conclusion*: the results reinforce the need for revision of the protocols for the protection of health workers dealing with the COVID-19. Actions to promote institutional, inter-country and interstate debate on prevention models are essential for achieving consistency in the recommendations.

Keywords: COVID-19; health personnel; personal protective equipment; occupational health.

Resumo

Objetivo: *realizar comparação interpaíses e entre estados brasileiros quanto ao conteúdo dos protocolos de proteção para profissionais de saúde que atuam na assistência aos doentes da COVID-19 e desenvolver análise crítica ao modelo de prevenção que adota indicação e uso de equipamentos de proteção individual (EPI) como resposta única a um problema de caráter multidimensional.* Métodos: *estudo exploratório com base em revisões disponíveis na biblioteca Cochrane, articuladas com a análise dos protocolos nacionais de Argentina, Brasil, China e Estados Unidos da América e as normas previstas nos estados do Amazonas, Bahia, Minas Gerais e São Paulo, todos selecionados por critérios de conveniência.* Resultados: *observou-se dissensos quanto aos tipos de proteção recomendados. Somente na China eram indicados respiradores de alta eficiência de filtragem, além de modelos para o rosto inteiro nos casos de procedimentos invasivos. O reuso de equipamentos não é indicado, mas estava autorizado no protocolo brasileiro. Quanto aos dispositivos de vestuário, também não há convergência.* Conclusão: *os resultados reforçam a necessidade de revisão dos protocolos de proteção dos profissionais da saúde que atuam no enfrentamento da COVID-19. Ações em busca de debate institucional, interpaíses e interestaduais sobre modelos de prevenção são essenciais para alcançar consistência nas recomendações.*

***Palavras-chave**: COVID-19; pessoal de saúde; equipamento de proteção individual; saúde do trabalhador.*

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Introduction

The threat of contagion by COVID-19 (Severe Acute Respiratory Syndrome by SARS-CoV-2) has changed the routine of cities and their economies, in addition to increasing the pressure on health systems, sometimes to overwhelming levels. The excessive demands were incompatible with the system capacity in some places, resulting in failure to provide care. It also restricted the routine flow of patient care. Since the first outbreaks, health workers have been affected either by infection or by the mental and social stress of which they are victims[1]. It is worth mentioning the maximum risk of those who are on the front line, as they deal with asymptomatic and symptomatic patients who may or may not have been tested[2].

Most of the tasks performed by the professionals who care for Covid-19 patients involve direct contact, so specific protection protocols are justified[3]. There is a lack of material resources and of expertise to reverse the care vulnerability on the front line [2].

In Wuhan, China, the probability of infection among healthcare workers was three times higher than in the general population. In other countries affected by the pandemic, sick leaves, deaths, community suffering and imbalance in the health system organization were recorded[1].

In response, emphasis was placed on supplying personal protective equipment (PPE), which are clothing and devices used for protection against workplace hazards. Respirators and/or facemasks, gloves, goggles, face shields, gowns, aprons, head covers and footwear are the most commonly used. These devices are crucial, although insufficient to protect health workers[4].

The pandemic requires these workers to adopt such measures for their own protection and the protection of others, in a high-risk setting[5]. Personal Protective Equipment works as a barrier, protecting the face, eyes, hands and other body parts against the pathogen[6]. Its use is recommended by the Brazilian Ministry of Health (MS)[7] and the World Health Organization (WHO)[8] for reducing the virus transmission in healthcare services environment.

Recommending the use of PPE in healthcare services is a draconian measure, that is, it is a sovereign, absolute measure because the risk for the workers lies in contracting the very disease that they are trying to treat and cure.

Low adherence to the use of such equipment is not a recent dilemma. In 1990, the article "Universal precautions are universally ignored"[9] showed important clarifications about this situation. During the H1N1 influenza epidemic, the problem was identified in fourteen Canadian hospitals[10] and in intensive care units of seventeen Chinese provinces[11]. If the importance of intensifying self-protection measures in situations of fatal infectious diseases is relatively documented[12], how to explain the records of low adherence to the use of PPE?

Since the first outbreaks of COVID-19, protocols have been published and updated, both to protect the healthcare workers' health and to mitigate the spread of the novel coronavirus. What is the scope of the measures recommended to protect health workers in the protocols in force in Brazil? Is there a consensus among countries' protocols on the prescription of PPE?

To answer the three questions above, the objective of this study was to make a comparison between countries and between Brazilian states regarding the contents of protection protocols for COVID-19 healthcare workers. We intend to undertake a critical analysis of the prevention model that adopts the recommendation and use of PPE as a single response to a multidimensional problem.

Methods

Design and technical procedures

The empirical material presented is the result of exploratory research covering an analysis of two sets of information. The first concerns the institutional protocols published by WHO, Ministries of Health of four countries (Argentina, Brazil, China and the United States of America) and health secretariats of four States of Brazil (Amazonas, Bahia, Minas Gerais and São Paulo). The second set was extracted from bibliographic reviews systematized into the Special Collection on the COVID-19 Infection Control and Prevention Measures produced and updated by the Cochrane Library[13] between March and May 2020.

The research was designed in four stages. The first consisted of the WHO protocol analysis to identify the axes of the recommended protection measures which, in turn, constituted the criteria we adopted for, in the second stage, to study the recommendations in force in the selected countries. The third stage was the comparison between the four protocols of the selected Brazilian states. The

fourth route corresponded to an exercise to identify scientific evidence regarding factors related to adherence to the use of PPE, as well as the known limits of its effectiveness in preventing infection in health service workers. Reviews from the Cochrane Library reviews[13] were taken as a basis in order to identify results related to barriers, facilitators and effectiveness of the use of PPE to protect health workers exposed to the novel coronavirus.

Two authors independently collected the data. The drafts that they produced were evaluated by the others authors of the study.

Criteria for identification and selection of empirical material

The Chinese protocol[14] was immediately included because of its pioneering effort in producing results on the evaluation of the effectiveness of PPE in the crisis context, which is reflected in the significant participation of authors from that country in the literature consulted[13]. The recommendations of the U.S. institutes specialized in occupational safety and health[15] have been a reference for the production of technical standards, besides guiding the Brazilian infra-legal regulation in this field[7], so they were included. Argentina[16] was selected because, until May 2020, it was among the South American countries with the lowest incidence of cases.

The protocols of the states of Bahia[17], Minas Gerais,[18] São Paulo[19] and Amazonas[20] were selected for convenience reasons. Amazonas State was chosen because of the health system collapse in that state at the time of data collection. The other states are the ones where the authors work.

The protocols were compared to each other in their respective levels (national and state) and in relation to the protocol of the Brazilian Ministry of Health[7]. The data tabulation and systematization concerning the PPE types recommended by the selected countries and Brazilian states was carried out respecting the protocols structure, in order to comprise the set of items present in each of them.

On March 4, 2020, the first Cochrane Library COVID-19 Special Colection was published[13]. Since then, the material initially available in English has also been presented in Simplified Chinese, Czech, German, Farsi, Japanese, Malay, Polish, Portuguese, Russian and Spanish. The purpose of this special dossier is to offer immediate access to the most relevant systematic reviews for infection control consistent with WHO guidelines. The production was systematized according to the regions most severely affected by the pandemic. It is also tuned with the production of three specific networks: *Cochrane Public Health and Health Systems Network*; *Cochrane Musculoskeletal, Oral, Cutaneous and Sensory Network*; and *Cochrane Intensive Care and Emergency Medicine Network*. For this study, we gathered evidence presented in five reviews included in the topic *Coronavirus (COVID-19): measures for Infection Control and Prevention*[13] (**Table 1**).

Table 1 Databases of literature reviews that make up the topic *Coronavirus (COVID-19): measures for Infection Control and Prevention* from the Cochrane Library Special dossier[13], on 25 May, 2020

Literature review title	*Review databases*
Interventions to improve hand hygiene compliance in patient care[21]	*Cochrane Register of Controlled Trials*, PubMed, Embase and CINAHL
Improving adherence to Standard Precautions for the control of health care-associated infections[22]	CENTRAL, MEDLINE, base, CINAHL, LILACS
Personal protective equipment for preventing highly infectious diseases due to exposure to contaminated body fluids in healthcare staff[23]	CENTRAL, MEDLINE, Embase and CINAHL until March 20, 2020
Barriers and facilitators to healthcare workers' adherence with infection prevention and control (IPC) guidelines for respiratory infectious diseases: a rapid qualitative evidence synthesis[24]	COVID MEDLINE on March 26, 2020
Behavioural interventions to promote workers' use of respiratory protective equipment[25]	*Cochrane Work Group Specialized Register*, *Cochrane Central Register of Controlled Trials* (2016), MEDLINE (1980 to 2016), EMBASE (1980 to 2016) and CINAHL

Source: created by the authors.

The selection of evidence cited in Cochrane Library reviews[13] was not guided by pre-established axes. On the contrary, the short two-month period from the recognition of the pandemic crisis by the WHO, in March 2020 until the beginning of this study justified the choice for the open nature of this exploratory investigation.

Results and discussion

Protocols for the use of PPE: a comparison between countries and between Brazilian states

The recommendations on when, what kind and how to use PPE includ knowledge about the transmission routes of the pathogen that we want to bar[11]. The novel coronavirus high potential for transmission and its impacts justify systemic propositions[13], since direct and indirect contamination are possible. The former refers to the direct and immediate transfer of viral materials to a receptive gateway through which infection can be consummated. The most common situations are direct projection of droplets of saliva mucus from the infected subject, when sneezing, coughing or talking, into the nasal and oral mucous membranes of the exposed subject. Indirect transmission occurs by means of a vehicle, materials or objects, which serve to convey the infected particles to the susceptible host.

Knowledge about virus viability on surfaces, however, is still limited, while its transmission through respiratory droplets and aerosols is relatively understood. The plausibility of transmission through contaminated objects is supported by evidence of the viability of the novel coronavirus, which likely retains the properties for infection for days when deposited on materials[12,15]. Until now, it is known that inter-human transmission of the novel coronavirus occurs through aerosols (diameter 5 μm or less) and respiratory droplets (diameter greater than 5 μm) and direct or indirect contact of body parts with these materials. The droplets that carry the virus are expelled when the contaminated person talks, coughs or sneezes. They reach the bodies of those in the surrounding environment or settle on the surfaces of buildings, facilities, furniture and objects[13]. Aerosols containing the virus are produced during procedures performed in the emergency room and in intensive care units, such as endotracheal intubation and airway aspiration. Aerosols are the result of a combination of exhaled respiratory gases, respiratory particles and pathogens that cause infectious diseases. The fourth probable route is fecal-oral transmission[4].

Respiratory protection is crucial to prevent transmission of viral pathogens. Two types of face masks are most used: surgical masks and filtering facepiece (FFP) respirators. For common sense, all appliances used for the purpose of filtering air inhaled by the exposed person are called masks.

Surgical masks are used to protect patients from secretions projected from the healthcare worker's nose and mouth. These masks also provide a barrier for workers against splashes of patients' body fluids (blood, sputum, saliva, cerebrospinal fluid, among others), but they do not provide proper sealing to face region and are not designed or certified to protect from exposure to aerosols[6].

Filtering facepiece respirators are different from surgical masks because they retain aerosols. The retention capacity of these protective equipment refers to the filtration efficiency of particles with an average diameter of 0.3 μm tested in laboratory: 80% (FFP1), 94% (FFP2) and 99% (FFP3)[6].

The size of the particles potentially retained by the three filters is the same. The difference between them lies in their retention capacity, with FFP3 masks being the most efficient. In summary, the level of protection of respirators depends on their filtration efficiency.

Besides the quality of the equipment in terms of filtration, design is crucial to make the respirator fit anthropomorphic characteristics. For respirators with a filter against airborne particles to be effective, the facepiece needs to fit the user's face perfectly in order to provide leakproof facial sealing[26,27]. If not, the air carrying the contaminating material will come into contact with the exposed subject's organism. In this situation, called leakage, unfiltered air will be conducted to the body region which should be protected by the piece. Technically, a correct fit of the respirator could be more important for protection from airborne materials than the filtration capacity of the material. However, necessary gestures to perform tasks make the facepiece move. In addition, discomfort and fatigue are limits for self-protective alertness. In other words, prolonged use of PPE can lead to uncontrolled gestures and increased thermal and tactile discomfort. These situations compromise theoretically guaranteed protection[28].

The protection level of FFP2 equipment (94%) corresponds to the minimum recommendation

against biological agents in health services. The N95 respirator, which meets U.S. standards, is considered similar to PFF2 because it retains at least 95% of inhalable particles[6].

Although PFF models with an exhalation valve are more comfortable, they are not recommended. The valve decreases safety because the air exhaled by the healthcare worker is released into the environment and, if contaminated, it is likely to carry the viral pathogens into the surrounding area[6].

All the protocols analyzed place a greater degree of protection in cases of exposure to aerosol-generating procedures, such as cardiopulmonary resuscitation, differences regarding the type of respirator recommended notwithstanding. **Table 2** summarizes the comparison between the protocols of the selected countries. Except for Argentina[16], which recommends the N95 respirator, the other countries include more effective respirators for aerosol environments. Among the national protocols, China[14] is the only one that recommends full face models for increased risk procedures. Such enhanced security is not surprising coming from China because it was the country where COVID-19 first broke out, and has been severely hit by epidemics prior to the novel coronavirus[29].

The high viral load of COVID-19 discourage the use of surgical masks even in non-invasive procedures. However, research evidence is still limited, which explains the lack of concurrence between the studied protocols, regarding the type of respiratory protective equipment[4].

Reusing masks and respirators is not a procedure included in WHO guidelines[8]. However, the Brazilian protocol provides for this situation by addressing the need to respect the routines of the hospital infection commission , as well as the need to follow the reuse protocol[7] (**Table 3**).

Transocular transmission of the novel coronavirus is likely, which justifies the use of eye protection equipment. The specification of this requirement is variable (googles or face shield equipment) in the protocols studied. Usually, eye protection is used in health care procedures performed in patients with severe clinical conditions.

Regarding protective clothing, gowns with or without long sleeves, for example, and its materials – waterproof or not – are related to the necessary degree of protection. Attention is needed to the protetion limits of aprons, as the neck, legs and back areas remain exposed[30].

Table 2 Types of personal protective equipment included in the protection protocols of health service workers exposed to the novel coronavirus by country and World Health Organization, 2020.

Protection		*WHO*[8]	*Argentina*[16]	*China*[14]	*United States*[15]	*Brazil*[7]
Respiratory	Contact with patients	Surgical mask	Surgical mask	FFP2	Surgical mask	Surgical mask
	Aerosols	N95 or higher	N95	FFRP / PAPR	N95 or higher	N95 or higher
	Reuse	Does not mention	Unauthorized	Does not mention	Unauthorized	Unauthorized
Body		Gown Apron*	Gown	Uniform Head protection Shoe covers	Gown Apron*	Gown Head protection
Eye		Goggles FS	Goggles FS	Goggles	Goggles FS	Goggles FS
Hands		Gloves	Gloves	Gloves	Gloves	Gloves

*In case of aerosols; FFP2: filtering half facepiece with minimum filtration efficiency of 94%; N95: filtering half facepiece with minimum filtration efficiency of 95% (equivalent to PFF2); PFF3: filtering half facepiece part with minimum filtration efficiency of 99%; FFRP: full face respiratory protection; PAPR: powered air-purifying respirator; FS: face shield.

Table 3 Types of personal protective equipment included in the protection protocols of health service workers exposed to the novel coronavirus: Brazil and the states of Amazonas, Bahia, Minas Gerais and São Paulo, 2020.

Protection		*Brazil*[7]	*Amazonas*[20]	*Bahia*[17]	*Minas Gerais*[18]	*São Paulo*[19]
Respiratory	Contact with patients	Surgical mask	Surgical mask	Surgical mask	Surgical mask	Surgical mask
	Aerosols	N95 or higher	N95	N95	N95 or higher	N95 or higher
	Reuse	Unauthorized	No mention	Recommends following manufacturer's instructions	No mention	Recommends following manufacturer's instructions
Body		Gown Head protection	Gown Apron Head protection	Gown Apron	Gown Apron Head protection	Gown Apron Head protection
Eye		Goggles FS	EP FS	Goggles FS	FS	Goggles FS
Hands		Gloves	Gloves	Gloves	Gloves	Gloves

FFP2: filtering half facepiece with minimum filtration efficiency of 94%, equivalent to N95 Protector, whose efficiency is 95%; FFP3: filtering half facepiece with minimum filtration efficiency of 99%; FS: face shield; EP: Eye Protection.

Adherence of workers to PPE: between contradictory imperatives

Scarce supply of PPE under the exceptional COVID-19 circumstances was recorded in the first months of the pandemic. Fifty percent of the physicians interviewed in the Brazilian territory (n = 2,321) were experiencing a shortage of PPE at the beginning of the outbreak[31]. Scarcity, however, was not the only problem, as low adherence to PPE use is a recurring issue[32] that has been interpreted as "lack of information and of interest on the part of the subjects"[33]. In counterpoint, other hypotheses about low adherence to PPE are also mentioned in the specialized literature: it may be an effect of the contradictions between protective recommendations and the ethical dimension of patient care[34], or a pragmatic response in a situation of recognized inefficiency of such equipment.

The workers' accounts provide elements for understanding the rationale underlying adherence to PPE during the treatment of patients with COVID-19. See the reported case:

> […] a 64-year-old obese patient, with a respiratory condition, rapidly worsening […]. At that time, part of the team was transporting another patient to the ICU [Intensive Care Unit]. Though our staff was reduced, we had to perform intubation. […] As the two doctors were wearing glasses, during the procedure the glasses fogged up because they were also wearing a mask and a face shield. As a result, we failed. On the second attempt, one of the doctors deliberately removed his face protection to see better, and he was able to perform the procedure[35] (p. B2).

The doctor's act of removing the face shield, far from showing ignorance or lack of interest, had the aim of getting rid of the fogging on his glasses lenses to be able to see the zones in the oropharynx structures and adjacent areas that guide the correct positioning of the laryngoscope blade during the procedure of orotracheal intubation.

The examples call for a reflection on the dimensions of human activity at work. Instead of being guided exclusively by instrumental or administrative rationality at work, when performing his activities, the subject is also driven by intrinsic purposes, which are elaborated in his relationship with others, in specific contexts[36]. Ethical commitments were confronted with the guidelines for the use of PPE, as health workers expressed concern about the patients' impressions when seeing the caregiver. Considering that the equipment is esthetically unusual, a kind of strangeness may lead patients to the perception that, instead of being cared for, they are being treated with a sort of harshness, and they may come to hasty conclusions about the severity and irreversibility of their clinical condition. This kind of crack in the relationship between health worker and patient is taken into account by health personnel, as it is known that it can have a negative influence on the success of the therapy[24].

Systemic approach in place of single response

The shortage of PPE for frontline health workers has been highlighted as one of the main problems in coping with COVID-19. However, we should review

the problems caused by the use of this equipment, which, though essential, is not sufficient for the kind of protection for which it is intended.

The use of PPE is not harmless, as it interferes with the sensory functions of the carrier, with evidence of communication deficits, decreased visual and hearing acuity, fatigue and effects on performance. They are often perceived as being uncomfortable and even unbearable[37].

Most clothing designed to be resistant to infectious fluids in infected patient care increases body temperature as it prevents heat exchange between the body surface and the environment, which is critical for thermal comfort. In these situations, sweating usually increases and may become a vehicle for viral particles from a region of the body that was protected – the head, for example – to mucous membranes of the eyes or mouth[38].

Several disorders of the body functioning are due to prolonged use of PPE, such as thermal discomfort, local sweating and unusual odors, a sensation of pressure on the face, irritation and itching in the contact region. Clinical trials have shown that none of the face masks were perfectly adjustable in more than a quarter of the participants due to their anthropomorphic characteristics. Misfits cause localized pressures in regions of the skull and face, which are related to triggering of headaches[39]. As an aggravating factor, workers are rarely allowed to choose the mask that they deem most suitable to their characteristics and needs[40].

The risk of contamination when using or removing/disposing of the equipment has been evidenced. Experimental studies confirm that equipment removal acts require a high level of precision so as not to generate contamination zones. However, proficiency in the sequencing of precise gestures requires intensive training[41]. An alternative was having a separate area for the procedure. Under supervision, the pattern of operations is gradually ritualized in order to promote safety and reduce the anxiety of health workers at the end of their shift or after finishing a high-risk procedure[42].

Results of studies conducted on five continents found that management support and adequate facilities influence adherence to precautions[24]. The recommendations of the Ministry of Health are underpinned[7] by a systemic approach with the aim of protecting health workers from COVID-19. Besides providing instructions for correct use of PPE, it includes self-care for mental health, with emphasis on the positive behaviors of coping with emotional overload derived both from exposure to situations of suffering and death and the resulting pressures in an environment sometimes devoid of essential material resources. In this topic, there are nineteen items related to measures to support and strengthen these workers to be conducted by team leaders and managers, such as seeking help from friends and family or replicating successful experiences that were built in other situations.

In the field of occupational safety, the Ministry of Health explains the objectives of identifying and intervening on risk factors and hazard situations in the workplace. Engineering measures to promote protection include physical facilities and layout and supplying alcohol solution dispensers in work environments. Among thirteen recommendations on this topic, we mention the installation of reception and screening spaces to facilitate the isolation of patients with suspected COVID-19, respiratory isolation units with negative pressure and a specific filter for aerosol-generating procedures[7].

Advances and stalemates in protection of health care workers

Determined by personal idiosyncrasies or structural factors, adherence to the use of PPE is part of an occupational health and safety context[43]. Despite the recognized multidimensional genesis of illness at work, interventions in this field have replicated the "single cause" concept in analyses showing poor adherence to the use of PPE. Knowledge about the PPE limits is sufficiently substantiated when programs for deploying these resources are not followed up by other safety measures. Furthermore, prescribing PPE without ensuring good structural prevention measures (engineering, administrative and organizational), included in the Brazilian protocol[7], is an isolated response to a very complex problem, as it concerns protection from exposure to virulent pathogens in health services environments.

The intense confrontation of values between self-protection and patient care remains invisible in most PPE implementation evaluation processes. It is, nonetheless, a founding dimension of the healthcare processes. The need to transform this perspective to undertake successful prevention actions depends on more investments aimed at disentangling critical nodes regarding fundamental knowledge in the elaboration of transformative measures[36,44]. The guidelines for the use of PPE are more effective when articulated to the workers' experiences. Previous experiences have shown the relevance of reflective and participatory involvement of workers when planning interventions[45].

In short, based on the experience in management of respiratory epidemics that preceded COVID-19, as was shown, we should consider the influence of distal factors on self-protection behaviors of health workers instead of focusing the recommendations on the proximal factors to individuals[36,37].

Conclusion

Scientific studies production in the first months of the pandemic crisis is expressive. The results obtained are clues for the proposition of actions to protect health workers from exposure to the risk of infection. There are, however, points of disagreement between the protocols, which calls for interinstitutional, intercountry and interstate debates on prevention models.

There have been advances in several directions, but prevention actions still lack reformulations, given the tensions related to economic and administrative rationality, such as the recommendation for equipment reuse.

The first months of 2020 offered many lessons in different spectrums of life in society. Many challenges lie ahead. To build a resilient health system that can face the impact of the COVID-19 pandemic on a global scale, it will be necessary to strengthen the social environment in order to stimulate research agendas for reviewing the health workers' protection protocols.

Authors' contributions

Assunção AA, Simões MRL, Maia EG, Alcantara MA and Jardim R contributed substantially to the study design, data collection, analysis, and interpretation, as well as to the drafting, critical revisions and approval of the final version of this paper. They take full responsibility for the work carried out and the published content.

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