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SUMÁRIO

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ORIGINAL ARTICLE

Handmade face mask can be sterilized without compromising their efficacy

Máscara facial artesanal pode ser esterilizada sem comprometer sua eficácia

La mascarilla facial hecha a mano se puede esterilizar sin comprometer su eficácia

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ABSTRACT

Background and Objectives: COVID-19 caused by SARS-CoV-2 is transmitted by contact, droplets and aerosols. The World Health Organization recommends the mandatory use of surgical masks for health professionals and encourages countries to adhere to their use, en masse, in order to minimize the transmission of the virus. Since the lack of this personal protective equipment is a cause for concern, the objective of this study was to evaluate the characteristics of facial masks regarding (i) the mechanical properties of elongation, rupture stress and resistance to air passage and (ii) the morphometric properties of thickness, fiber diameter and pore distribution after autoclave sterilization. **Methods:** The masks were made in TNT Spunbonded (100% polypropylene, 60 g/m²), autoclaved at 70 ºC for 5 minutes and stored in plastic films at room temperature. Then, the mechanical properties were determined in an Instron universal testing machine and Gurley type automatic densimeter and the morphometric properties in a semi-automatic thickness gauge and scanning electron microscope. **Results**: It was observed that a cycle of sterilization of facial masks, by moist heat under pressure, increased the blanket's stiffness, did not produce physical damage and did not reduce the blanket's barrier capacity. **Conclusion**: The sterilization of face masks made of TNT can be considered a strategy to increase safety in their production and use.

Keywords: Communicable Disease Prevention. Disease Control. SARS-CoV-2. Coronavirus infections. Individual protection equipment.

RESUMO

Justificativa e Objetivos: A COVID-19 causada pelo SARS-CoV-2 é transmitida pelo contato, por gotículas e por aerossóis. A Organização Mundial da Saúde recomenda a obrigatoriedade do uso de máscaras cirúrgicas aos profissionais da saúde e incentiva os países a aderirem ao seu uso, em massa, a fim de minimizar a transmissibilidade do vírus. Posto que a falta desse equipamento de proteção individual causa preocupação, o objetivo deste trabalho

foi avaliar as características de máscaras faciais quanto (*i*) às propriedades mecânicas alongamento, tensão de ruptura e resistência a passagem de ar e (*ii*) às propriedades morfométricas espessura, diâmetro das fibras e distribuição de poros após esterilização em autoclave. **Métodos**: As máscaras foram confeccionadas em TNT Spunbonded (100% polipropileno, 60 g/m^2), autoclavadas a 70 ºC por 5 minutos e armazendadas em filmes plásticos a temperatura ambiente. Na sequência, as propriedades mecânicas foram determinadas em máquina de teste universal Instron e densímetro automático tipo Gurley e as propriedades morfométricas em medidor de espessura semiautomático e microscópio eletrônico de varredura. **Resultados:** Observou-se que um ciclo de esterilização das máscaras faciais, por calor úmido sob pressão, promoveu o aumento da rigidez da manta, não produziu danos físicos e não diminuiu a capacidade de barreira da manta. **Conclusão**: A esterilização de máscaras faciais confeccionadas em TNT pode ser considerada uma estratégia para aumentar a segurança na sua produção e uso.

Descritores: *Prevenção de Doenças Transmissíveis. Controle de Doenças. SARS-CoV-2. Infecções por Coronavírus. Equipamento de Proteção Individual.*

RESUMEN

Antecedentes y objetivos: El COVID-19 causado por el SARS-CoV-2 se transmite por contacto, gotitas y aerosoles. La Organización Mundial de la Salud recomienda el uso obligatorio de mascarillas quirúrgicas para los profesionales de la salud y alienta a los países a adherirse a su uso, en masa, con el fin de minimizar la transmisión del virus. Dado que la falta de este equipo de protección personal es motivo de preocupación, el objetivo de este estudio fue evaluar las características de las **máscaras** faciales en cuanto a (i) las propiedades mecánicas de elongación, tensión de rotura y resistencia al paso del aire y (ii) la morfometría propiedades de espesor, diámetro de fibra y distribución de poros después de la esterilización en autoclave. **Métodos:** Las **máscaras se** fabricaron en TNT Spunbonded (100% polipropileno, 60 g / m2), se esterilizaron en autoclave a 70 ºC durante 5 minutos y se almacenaron en películas plásticas a temperatura ambiente. Posteriormente, se determinaron las propiedades mecánicas en una máquina de ensayo universal Instron y densímetro automático tipo Gurley y las propiedades morfométricas en un medidor de espesor semiautomático y microscópio electrónico escaneando.**Resultados:** Se observó que un ciclo de esterilización de mascarillas faciales, por calor húmedo a presión, incrementó la rigidez de la manta, no produjo daño **físico y no** redujo la capacidad barrera de la manta. **Conclusión:** La esterilización de mascarillas faciales fabricadas con TNT puede considerarse una estrategia para aumentar la seguridad en su producción y uso.

Palabras Clave: *Prevención de enfermedades transmisibles. Control de Enfermedades. SARS-CoV-2. Infecciones por coronavirus. Equipo de protección individual.*

INTRODUCTION

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) causes the respiratory disease COVID-19, which quickly evolved into a pandemic.[2] SARS-CoV-2 is transmitted by direct, indirect or close contact with infected people, objects or surfaces. In direct contamination from person to person, the coronavirus is transmitted to healthy individuals through breathing by droplets and aerosols produced during the speech, coughing, and sneezing of infected individuals or during medical procedures that involve the respiratory tract and generate aerosols.[3-7] In this context, health professionals are particularly vulnerable to contamination, and one of the challenges of the respiratory pandemic is their effective protection. The World Health Organization (WHO) recommends that in procedures that generate aerosols, professionals should use personal protective equipment (PPE), such as N95 respirators, isolation gowns and gloves.[3, 4] For low-risk patients without fever, patients without respiratory symptoms, and patients not requiring procedures that generate aerosols, the use of surgical masks is required to protect against droplet transmission when in close contact.[1] WHO also encourages countries to adhere to the use of face masks, en masse, in order to minimize the transmissibility of the virus.[8]

Widespread use of face masks combined with physical distancing increases the control of SARS-CoV-2.[9] However, wide availability of this personal protective equipment is a challenge, and stimulates the development of technologies in products, services and processes to control the disease, including the production of surgical masks with tissue-non-tissue (TNT).

According to the ABNT NBR-13370 standard[10], TNT is a flat, flexible and porous structure with a veil or blanket of fibers or filaments consolidated by mechanical (friction), chemical (adhesion), or thermal (cohesion) processes, or a combination of these processes. In addition, two of its main features are non-toxicity and semipermeability.[11]

Commercial TNT surgical masks have three layers of the spunbonded-meltblown-spunbonded (SMS) type, with 100% polypropylene filaments, that are thermobonded and had particle filtration efficiency ≥ 98% and bacterial filtration efficiency ≥ 95%.[12]

Autoclave sterilization is a safe, easy, rapid, and cost-effective method that does not leave toxic residues.[13] However, TNT can be thermosensitive, limiting the

use of autoclaves for sterilization. Because there are few studies on the effects of autoclave sterilization on TNT, the objective of the present study was to evaluate the characteristics of face masks made with spunbonded TNT (100% polypropylene, 60 g/m²) after autoclaving. The study evaluated the mechanical properties of elongation, rupture tension, and resistance to air passage, and the morphometric properties of thickness, fiber diameter, and pore distribution.

METHODS

Face masks

The face masks, purchased in the Brazilian market (Guarulhos, SP), were made of spunbonded TNT (60 g/m²) with bacterial filtration efficiency ≥ 99% (Assay Report 96586/2020A, Controlbio, SP, Brazil) according to Brazilian Technical Standards (ABNT NBR 14873/2002; ABNT NBR 15052/2004).[14, 15]

The masks were placed in cotton bags and sterilized in an autoclave (FABBE, 104, Brazil) at 70 °C for 5 minutes, according to the recommendations of ABNT NBR ISO 15883-1/2013.[16] Then, the masks were stored in plastic film at room temperature until the analyses.

Mechanical properties

Elongation and tensile strength were evaluated using a universal testing machine (Instron, 2712-002) using a 1 kN charge cell according to TAPPI 494 OM-06.[17] Resistance to airflow was measured by an automatic Gurley densimeter (Regmed, PAG-1000) according to TAPPI 536 OM-07.[18] The tests were carried out at 23 °C ± 1 °C and 50% ± 2% relative humidity.

Morphometry

The thickness of the masks was measured at six different points, in triplicate, using a semi-automatic thickness gauge (Regmed, ESP/SA-2/10) according to TAPPI 551 OM-06.[19]

Characterization of the polypropylene fiber was performed in triplicate. 1 cm² samples of the control and autoclaved masks were fixed on aluminum stubs with double-sided tape and gold-covered (approximately 15 nm thick) in a metallizer (Balzers, FDU 010).[20] Then the samples were analysed with a scanning electron microscope Leo 1430VP (Carl Zeiss, Jena, Alemanha) at 10 kV. The pore distribution and fiber thickness were obtained with Image ProPlus software, version 4.5.0.29.

Statistical analysis

R software, version 4.0.1, was used for descriptive statistical analysis and analysis of variance (ANOVA) of the data, at a 5% significance level.

RESULTS

The elongation and tensile strength of the masks varied between control and treatment (Table 1). The tensile strengths were 1.10 ± 0.03 N/mm and 1.35 ± 0.03 N/mm for the control and autoclaved masks, respectively. The average elongation percentage decreased from 78.21 ± 7.6% in the control to 64.38 ± 1.9% in the autoclaved samples, whereas the resistance to airflow was 0.47 ± 0.01 s/100cm³ in both control and autoclaved masks.

Table 1. P value for the variance analyses between control and treted groups.

Mechanical Properties	P-value
Tensile Strenght	0.000002446*
Elongation	0.005581*
Airflow resistance	0.1099
Morphometry	**P-valor**
Thickness	0.0003439*
Fiber diameter	0.0007964*
Pore area	0.1303

Values with (*) indicate diferences at 5 % of significance level

The morphometric characterization showed a significant difference for thickness and fiber diameter (Table 2). The resistance to airflow did not vary between the control and treatment masks. The mean thickness increased from 280 ± 10 μm in the control masks to 313 ± 4.4 μm in the autoclaved masks. The pore area in the autoclaved masks did not differ statistically from the control masks.

Scanning electron microscopy showed disordered fiber entanglement in both control and autoclaved samples, with circular fibers without fusions or aggregations (Figure 1).

The minimum, maximum and mean values of fiber diameter and pore area (Table 2) were very close with a tendency of reduction for the samples treated in autoclave when compared to the control, as observed by the distribution of the pore area showed in Figure 2.

Table 2. Descriptive statatistics to fiber diameter and pore area.

Parameters	Fiber Diameter (μm)		Pore Area (μm2)	
	Control	Treatment	Control	Treatment
Minimum	18.07	18.17	22.68	37.39
Maximum	34.18	34.44	3260.22	3142.65
Mean	25.71*	24.90*	442.30	371.11
Standard Deviation	2.24	2.18	344.24	277.81

Values with (*) indicate diferences at 5 % of significance level
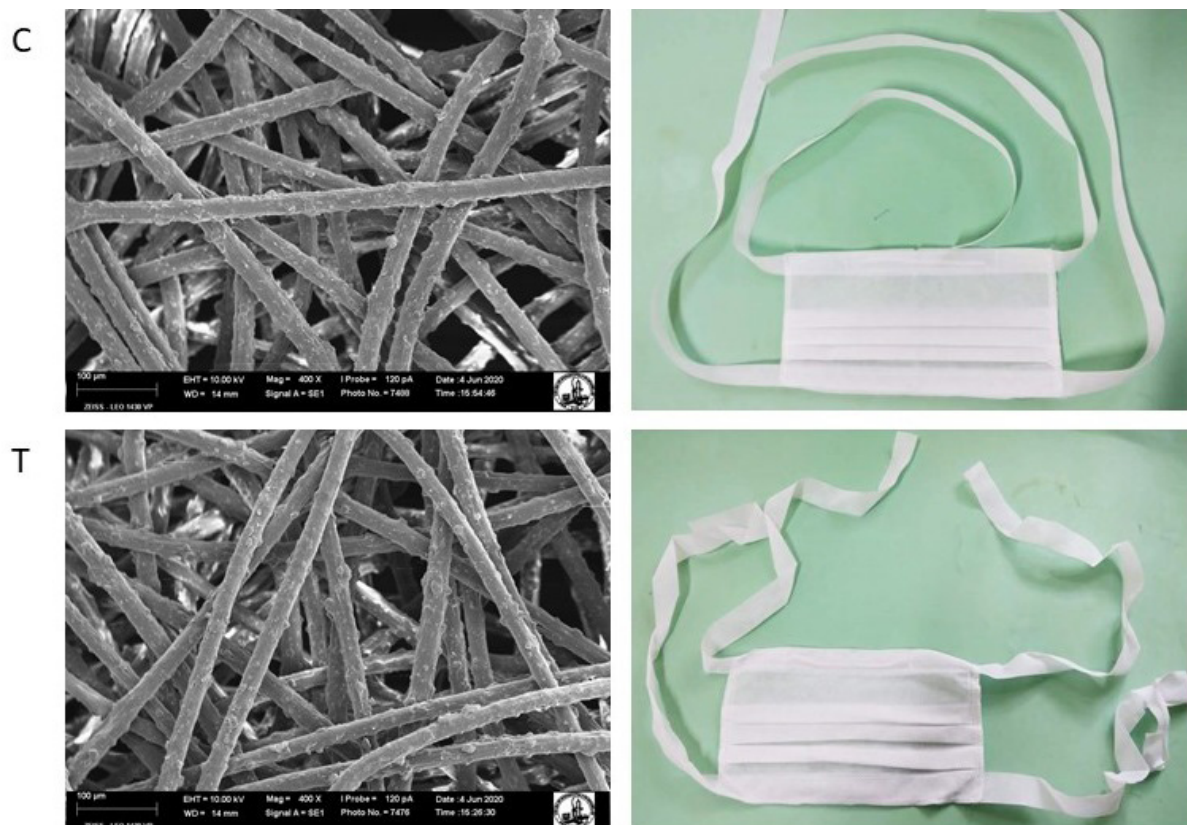
Figure 1. Scanning electron Micrographs of face masks produced in TNT (60g/m²). C) Control. T) Sterilization treatment at 70 °C for 5 minutes with autoclave. 400x magnification.
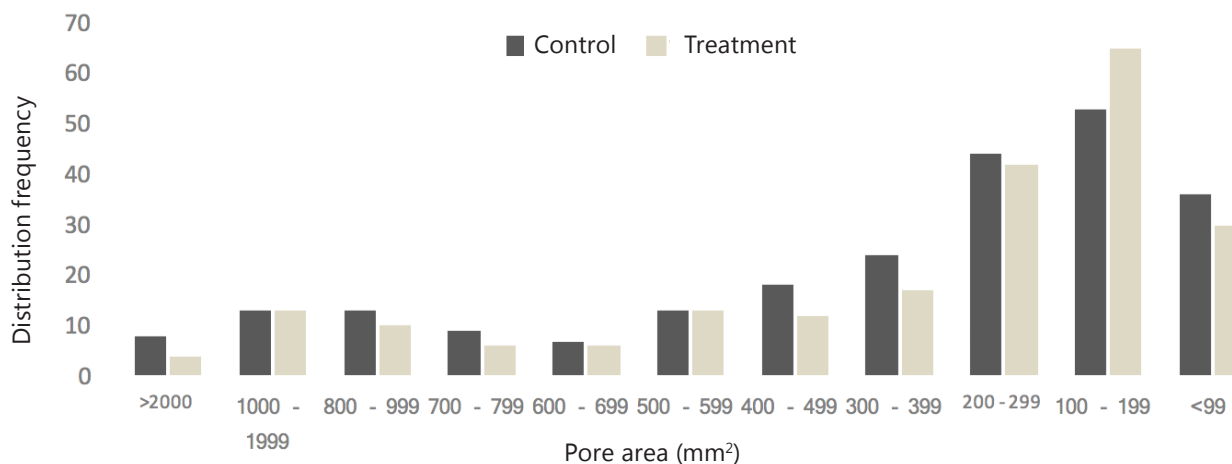
Figure 2. Pore area distribution of face masks produced in TNT (60g/m²) obtained in scanning electron microscopy. Control and Treatment by sterilization at 70 °C for 5 minutes with autoclave..

DISCUSSION

The results obtained indicate that the autoclaved face masks have uniform thickness, in addition to higher capacity of tensile strenght and lower percentage of elongation. No significant difference (p>0.05) was observed in the resistance to airflow with autoclave sterilization. Thus, sterilization provided the material with greater mechanical strength and also reduced its ability to elongate in relation to the initial length until rupture. This characteristic allows us to infer that the heat treatment increased the mask's stiffness without interfering with its droplet retention property, since the resistance to airflow did not varied significantly (p>0.05).

The results of the present studt corroborate the data from Dutch researchers[21] who evaluated the effect of reprocessing some models of FFP-2 and FFP-3 respirators. In the research, a medical autoclave with a total cycle of 34 minutes and vapor decontamination at 121 °C was used. The respirators FFP-2 and FFP-3 were used by healthcare workers during the pandemic. Most of the tested respirators maintained their shape, without visible physical damage and change in resistance to airflow with treatment, except for the FFP-3 model. A gradual reduction in the filtering capacity as a function of the number of sterilizations was observed, but this was more expressive after 3 cycles. Therefore, breathability remained adequate for the masks tested and the authors concluded that it is possible, with caution, to reuse respirators of the types evaluated after moist heat treatment.

Sterilization by heat, dry or wet, when intense, can cause degradation of polymers by oxidation and change their properties in terms of changes in molecular weight, embrittlement, breakage, color, and ductility.[22,23] Some polymers can lose structural integrity due to the high temperatures used in autoclave, causing distortion and breakage.[24] In this sense, the high crystallinity of polypropylene gives the polymer high tensile strength, rigidity and hardness. The polymer softens at temperatures above 170 °C.[23] Thus, the results of the present study indicate torsion points in the mooring loops of the heat-treated masks, however, without ruptures and conformation changes in the autoclaved fibers.

The data for the mechanical properties obtained in this study indicate that the blanket became more rigid after sterilization due to the tendency of decrease in the fiber diameter (Table 2) and pore area distribution (Figure 2).

Regarding the use of personal protective equipment for respiratory infections in health environments in low-income countries, a study revealed that PPEs were not available and were reused, in addition to non-compliance with its use.[25] It is noteworthy that protective measures for healthcare workers, which include strict adherence to basic hygiene standards and the use of face masks, protect during short periods of contact with symptomatic COVID-19 cases. Therefore, periodic replacement of PPEs is recommended.

In countries where the use of face masks was mandatory or was highly encouraged by the government during the early stages of the Covid-19 outbreak, population adherence rates were above 90%, which improved disease control. In other countries, where low adherence combined with little or no confinement may have contributed to the high number of deaths.[8] Therefore, the widespread use of face masks by the population is a measure considered prudent to prevent the spread of Covid-19.

The present study demonstrated that a cycle of sterilization of face masks made of TNT Spunbonded (60g/m²) by humid heat under pressure, at 70 °C for 5 minutes, increased the rigidity, did not produce physical damage, did not affect the resistance to airflow, and did not change the pore area of the blanket. Physical damage could decrease the mask's barrier ability, which was not observed. Thus, it is relevant to know the physical effects of sterilization on TNT used to manufacture personal protective equipment, since the demand for this equipment worldwide is high. Therefore, humid heat sterilization of TNT surgical mask to protect against the transmissibility of the virus can be considered a strategy to increase the availability of these personal protective equipment.

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CONFLICT OF INTEREST

The authors declare no conflict of interests.

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Cristiane do Carmo Cesário analysis and interpretation of data, writing of the article, guarantee of the accuracy and integrity of the work and final approval of the version to be published.

Jamile Fernanda Silva Cossolin analysis and interpretation of data, writing of the article, guarantee of the accuracy and integrity of the work and final approval of the version to be published.

Andréia Guerra Siman conception and design, relevant critical review of the intellectual content, guarantee of the accuracy and integrity of the work and final approval of the version to be published.

Flávia Batista Barbosa de Sá Diaz conception and design, relevant critical review of the intellectual content, guarantee of the accuracy and integrity of the work and final approval of the version to be published.

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José Eduardo Serrão relevant critical review of the intellectual content, guarantee of the accuracy and integrity of the work and final approval of the version to be published.

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Revista de Epidemiologia e Controle de Infecção

ORIGINAL ARTICLE

Viral hepatitis caused by occupational accidents: distribution of cases in Brazil, 2007-2014

Hepatites virais por acidentes de trabalho: distribuição dos casos no Brasil, 2007-2014

Hepatitis viral por accidentes de trabajo: distribución de casos en Brasil, 2007-2014

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ABSTRACT

Background and Objectives: to analyze the distribution of cases of viral hepatitis due to occupational accidents in Brazil from 2007 to 2014. **Methods:** this is an ecological study of a descriptive nature of notifications of viral hepatitis registered in the Information System for Notifiable Diseases. **Results:** they point out that the mean incidence of viral hepatitis due to occupational accidents in Brazil was 2 cases/1,000,000 of the economically active and employed population. There was an increasing trend in the Midwest region (p=0.02), among women (p=0.01) and those aged 38 to 49 years and 50 and older (p=0.01). The decreasing time trend was observed among those up to 37 years old and for non-black race/skin color (p=0.04). **Conclusion:** the temporal distribution was stationary in most regions and states in Brazil, increasing among female workers over 38 years old and decreasing among non-black women and under 37 years old.

Keywords: Spatio-Temporal Analysis. Hepatitis, Viral, Human. Communicable Diseases. Accidents, Occupational. Disease Notification.

RESUMO

Justificativa e Objetivos: analisar a distribuição dos casos de hepatites virais por acidentes de trabalho no Brasil de 2007 a 2014. **Métodos:** trata-se de um estudo ecológico de natureza descritiva das notificações de hepatites virais registradas no Sistema de Informação de Agravos de Notificação. **Resultados:** apontam que a incidência média de hepatites virais por acidentes de trabalho no Brasil foi de 2 casos/1.000.000 da população economicamente ativa e ocupada. Houve tendência de aumento na região Centro-Oeste (p=0,02), entre as mulheres (p=0,01) e entre 38 a 49 anos e 50 anos ou mais (p=0,01). A tendência temporal decrescente foi observada entre aqueles com até 37 anos e para raça/cor da pele não preta (p=0,04). **Conclusão:** a distribuição temporal foi estacionária na maioria das regiões e estados do Brasil, aumentando entre as trabalhadoras acima de 38 anos e diminuindo entre as mulheres não negras

e com menos de 37 anos.

Palavras-chave: *Análise Espaço-Temporal. Hepatite, Viral, Humana. Doenças Transmissíveis. Acidentes de Trabalho. Notificação de Doenças.*

RESUMEN

Justificación y Objetivos: analizar la distribución de los casos de hepatitis viral por accidentes de trabajo en Brasil de 2007 a 2014. **Métodos:** se trata de un estudio ecológico de carácter descriptivo de las notificaciones de hepatitis viral registradas en el Sistema de Información de Enfermedades de Declaración Obligatoria. **Resultados:** señalan que la incidencia media de hepatitis viral por accidente de trabajo en Brasil fue de 2 casos/1.000.000 de población económicamente activa y ocupada. Hubo una tendencia creciente en la región del Medio Oeste (p=0,02), entre las mujeres (p=0,01) y las de 38 a 49 años y 50 y más (p=0,01). La tendencia temporal decreciente se observó entre los de hasta 37 años y para raza/color de piel no negra (p=0,04). **Conclusión:** la distribución temporal fue estacionaria en la mayoría de las regiones y estados de Brasil, aumentando entre las trabajadoras mayores de 38 años y disminuyendo entre las mujeres no negras y menores de 37 años.

Palabras clave: *Análisis Espacio-Temporal. Hepatitis Viral Humana. Enfermedades contagiosas. Accidentes de Trabajo. Notificación de enfermedades.*

INTRODUCTION

Viral hepatitis are communicable infectious diseases with a variable distribution pattern among different countries and regions. Hepatitis B is more common worldwide and its chronic form affects about 250 million people.[1] Hepatitis C approaches 170 million people[2] and hepatitis A varies with age. The number of cases of hepatitis A decreases with age and increases with younger age and greater low socioeconomic and hygiene conditions.[3]

In Brazil, viral hepatitis are endemic diseases and their distribution follows the same pattern as the world: in 2019, the detection rate for hepatitis C was 10.8 per 100,000 inhabitants, and hepatitis B and A, 6.6 and 0.4/100 thousand inhabitants, respectively.[4] All types of viral hepatitis can occur in the development of work activities, being strongly related to the situation of commitment to biosafety standards and working conditions for the performance of work.

Viral hepatitis and occupational accidents are diseases and events of compulsory notification in Brazil, i.e., they must be notified by health professionals or those responsible for public and private health services that provide patient care.[5] These notifications are registered in the Notifiable Diseases Information System (SINAN - *Sistema de Informação de Agravos de Notificação*) through individual notification/investigation forms. This system needs to be operated properly and with quality data to guarantee coverage of essential data for decision-making and contribute to improving workers' health situation.[6]

Studies point to the risk of acquiring hepatitis B and C by occupational accidents with biological materials among health workers,[7,8] general services,[9] household and health waste collectors,[10,11] garbage collectors,[12] domestic workers[12] and mid-level technicians in the biological and health sciences.[13] Although the studies pay greater attention to health workers, other categories are also exposed to occupational accidents and, as a result, infectious diseases.

The justification for this study is due to the need for an investigation into viral hepatitis caused by occupational accidents, using records from SINAN notifications, and with a temporal distribution, which allows evaluating the disease occurrence over time. This is very relevant for the necessary preventive measures. In Brazil, studies of certain regions and in a specific period are observed, therefore, it strengthens the relevance of data of national scope, and these data can subsidize the actions of health surveillance of communicable diseases and workers' health in the country.

Given the above, this study aimed to analyze the distribution of cases of viral hepatitis by occupational accidents in Brazil, from 2007 to 2014.

METHODS

This is an ecological study of a descriptive nature, which allows evaluating the distributions of aggregated data in time and space. Data from viral hepatitis notifications registered in SINAN, provided by the Health Surveillance Department of the Ministry of Health, were used. Only cases in which the source of infection were occupational accidents were included, as this is a field that is understood to establish a causal link.

All cases reported in Brazil from 2007 to 2014 were evaluated, considering that there were changes in the notification forms before 2007 and 2014, as it was the last year that was available to researchers.

The variables analyzed were: year of notification (2007 to 2014); the regions (South, Southeast, North, Midwest and Northeast) and the states of residence (the 27 that make up the country); sex (female and male); age categorized by tertile (up to 37 years, 38-49 years and 50 years and over); education (up to elementary school, high school and higher education); race/skin color (black and non-black); exposure to injectable drugs, occupational accidents with biological materials (OABM), contaminated water and food, multiple sexual partners; etiological classification (Virus A, B and C); and occupa-

tion, according to the Brazilian Occupation Classification (CBO - *Classificação Brasileira de Ocupação*).

Incidence coefficients were calculated by year, sex, state and region, using viral hepatitis cases by occupational accident as the numerator, and the Economically Active and Employed Population (EAEP) per year as the denominator. Mean incidence coefficients for the period (2007-2014) were also estimated, considering in the numerator the mean of cases in the period and in the denominator, the mean of EAEP for 2010 and 2011, representing the mid-period EAEP. The EAEP was obtained by the Brazilian National Household Sample Survey (PNAD - *Pesquisa Nacional por Amostra de Domicílios*) and by the Demographic Census, both at the Brazilian Institute of Geography and Statistics (IBGE - *Instituto Brasileiro de Geografia e Estatística*).

To describe the cases by the variables analyzed, relative frequencies per year of notification were calculated. The Proportional Percentage Variation (PPV) was estimated for all incidences and relative frequencies of each variable, to verify the variation of the time series analyzed with the following formula: {[(end year-start year)/start year]*100}.

The analysis of the temporal distribution of the variables in proportions was verified by the linear chi-square test. For the incidence coefficients, Simple Linear Regression was performed, considering incidence as a dependent variable, incidence and calendar years as an independent variable (2007-2014). The temporal distribution was classified as increasing when the regression coefficients and PPV are positive, decreasing when negative, and stationary if coefficients do not show a statistically significant difference (p>0.05), when comparing the occurrence of cases from 2007 to 2014.[14]

The spatial distribution analysis was carried out together with the temporal analysis through assessment by clusters, i.e., the data grouped by the five regions and the twenty-seven states of Brazil. Incidence was stratified according to sex for the country, Brazil and its regions.

Data were processed using Microsoft Office Excel 2007 and SPSS version 17.0. This study was approved by the Institutional Research Ethics Committee with Opinion 1,249,977/2015, in compliance with Resolution 466/2012.

RESULTS

In Brazil, 1,493 cases of viral hepatitis by occupational accident were reported in the period from 2007 to 2014, with a mean incidence of 2 cases per 1,000,000 of EAEP and stationary temporal distribution. Among the regions of Brazil, there was an oscillation in the incidences from year to year with negative variation in the time series in the North (PPV= -42.3%) and Southeast (PPV= -27.8%) regions, and positive in the Northeast (PPV= 140.0%), South (PPV= 16.0%) and Central-West (PPV=133.3%), showing an increasing temporal trend in the Midwest region (p=0.02) (Table 1).

The states also showed oscillation in the distribution of viral hepatitis incidences in the period under study. Acre was the state that presented the highest incidence year by year and the mean incidence with 13.1 cases per 1,000,000 of EAEP, but with stationary trend. Tocantins (p=0.03) and Sergipe (p=0.04) followed a decreasing temporal trend (Table 1).

Regarding sex, women had higher incidences year after year in Brazil and its regions, with an increasing temporal trend only in the Midwest region (P=0.01), and men showed a stationary temporal trend in Brazil and its regions (Figure 1).

As for the characteristics of the total number of reported cases, during the study period, those up to 37 years old (36.9%), non-black race/skin color (60.1%), with high school education (47.0%), exposed to OABM (68.5%) and with hepatitis B virus (HBV) (49.2%) and hepatitis C virus (HCV) (49.4%) prevailed. There was a decreasing temporal trend for those aged up to 37 years, an increasing trend from 38 to 49 years and 50 years and over (p=0.01), and decreasing trend for non-black race/skin color (p=0.04) (Table 2).

According to occupations, mid-level technicians predominated (36.3%), service workers, salespeople in stores and markets (24.3%), maintenance and repair workers (16.0%) and science and arts professionals (12.7%). Mid-level technicians (PPV=-25.9%), service workers, salespeople in stores and markets (PPV=-13.8%) showed a negative variation in the time series, and maintenance and repair workers (PPV=69.9%) and science and arts professionals (PPV=48.8%) have a positive variation.

Table 1. Incidence coefficient (per 1,000,000) of viral hepatitis by occupational accidents in Brazil, regions and states, 2007-2014.

Regions and states	Raw Incidence								PPV	Mean incidence (2007-2014)	*p-value	TT
	2007	2008	2009	2010	2011	2012	2013	2014				
North	2.6	2.0	2.8	2.5	2.7	2.1	2.5	1.5	-42.3	2.4	0.23	S
Rondônia	3.9	2.5	7.2	3.9	4.8	4.6	7.1	2.3	-41.0	4.7	0.85	S
Acre	15.9	18.9	9.0	6.6	17.5	16.7	12.9	5.8	-63.5	13.1	0.35	S
Amazonas	0.0	0.0	2.7	3.4	0.6	1.9	1.9	2.9	290.0	1.7	0.16	S
Roraima	9.9	5.1	5.1	0.0	8.9	4.7	0.0	0.0	-100.0	4.2	0.08	S
Pará	1.5	0.6	0.9	1.3	1.4	0.6	1.7	0.3	-80.0	1.0	0.61	S
Amapá	4.0	3.7	0.0	3.4	3.8	0.0	0.0	3.0	-25.0	2.2	0.33	S
Tocantins	3.0	2.8	4.1	3.2	1.4	0.0	0.0	1.4	-53.3	2.1	0.03	D
Northeast	0.5	0.9	0.9	1.0	1.0	1.0	0.8	1.2	140.0	0.9	0.06	S
Maranhão	0.3	1.8	1.4	0.8	1.0	1.7	2.0	1.9	533.3	1.5	0.08	S
Piauí	0.6	0.0	0.0	0.0	0.6	0.0	0.7	0.0	-100.0	0.3	0.98	S
Ceará	0.3	0.5	1.0	0.5	0.5	0.8	0.5	0.5	66.7	0.6	0.80	S
Rio Grande do Norte	0.0	2.7	0.0	0.0	0.7	1.4	2.0	2.0	200.0	1.2	0.30	S
Paraíba	0.6	0.6	0.0	1.2	1.2	0.6	0.6	0.5	-16.7	0.7	0.84	S
Pernambuco	0.0	0.5	0.6	0.3	1.7	1.1	0.5	0.8	80.0	0.7	0.23	S
Alagoas	0.8	3.2	0.0	0.0	0.8	0.8	0.0	0.8	0.0	0.8	0.38	S
Sergipe	4.3	3.2	0.0	1.1	0.0	0.0	0.0	0.9	-79.1	1.2	0.04	D
Bahia	0.5	0.3	1.6	2.1	1.3	1.3	0.6	1.8	260.0	1.2	0.33	S
Southeast	1.8	1.8	2.1	1.7	2.3	2.2	1.7	1.3	-27.8	1.8	0.50	S
Minas Gerais	2.1	0.4	1.1	2.0	2.0	1.4	0.9	1.0	-52.4	1.4	0.63	S
Espírito Santo	2.3	1.6	0.5	0.5	3.2	1.5	1.6	1.0	-56.5	1.5	0.79	S
Rio de Janeiro	1.1	1.4	2.0	1.7	1.1	1.4	0.8	1.6	45.5	1.3	0.73	S
São Paulo	1.7	2.7	2.7	1.8	2.8	2.9	2.3	1.4	-17.6	2.3	0.76	S
South	2.5	3.3	3.2	3.8	3.9	4.4	3.8	2.9	16.0	3.5	0.29	S
Paraná	2.5	1.8	1.3	3.0	4.0	2.6	2.1	2.8	12.0	2.5	0.46	S
Santa Catarina	3.0	3.6	6.0	3.4	3.5	4.0	3.9	3.0	0.0	3.8	0.75	S
Rio Grande do Sul	2.3	4.4	3.2	4.8	3.9	6.3	5.5	3.1	34.8	4.2	0.29	S
Midwest	1.8	1.7	2.7	1.8	1.5	2.8	4.5	4.2	133.3	2.6	0.02	I
Mato Grosso do Sul	1.6	0.8	6.4	0.8	0.8	1.5	3.0	2.1	31.3	2.2	0.99	S
Mato Grosso	0.7	3.3	1.3	1.3	1.9	3.8	9.7	2.4	242.9	3.1	0.18	S
Goiás	2.0	1.6	1.0	2.2	1.6	1.2	2.8	5.1	155.0	2.2	0.10	S
Federal District	2.6	0.8	4.9	2.1	1.5	6.7	4.3	6.2	138.5	3.6	0.09	S
Brazil	1.6	1.8	2.0	1.9	2.2	2.3	2.1	1.8	12.5	2.0	0.19	S

Source: SINAN/Health Surveillance Department/Ministry of Health, 2015.

*Caption: PPV: Proportional Percentage Variation; TT: Temporal Trend; S: Stationary; D: Decreasing; I: Increasing. *p-value referring to Simple Linear Regression.*

Table 2. Distribution of viral hepatitis by occupational accident according to sociodemographic and clinical variables, Brazil, 2007 to 2014.

Variables	Distribution per year (%)								PPV	TOTAL	*p-value
	2007	2008	2009	2010	2011	2012	2013	2014			
Age											
Up to 37 years	42.2	43.5	32.1	30.4	38.5	33.9	35.5	33.0	-21.8	35.9	0.01
38 to 49 years	34.0	30.0	40.5	28.2	28.8	33.5	28.0	34.7	2.1	32.2	
50 years and older	23.8	26.5	27.4	32.7	32.7	32.6	36.5	32.4	36.1	31.9	
Race/skin color											
Non-black	60.6	64.6	62.2	65.6	60.1	56.5	58.2	54.7	-9.7	60.1	0.04
Black	39.4	35.4	37.8	34.4	39.9	43.5	41.8	45.3	15.0	39.9	
Education**											
Up to elementary school	46.4	38.7	41.4	35.3	32.2	39.1	34.1	33.3	-28.2	37.3	0.11
High school	38.4	45.3	42.0	52.9	51.3	41.4	53.0	50.0	30.2	47.0	
Higher education	14.3	15.3	15.9	11.8	16.4	19.5	11.6	15.9	11.1	15.2	
Exhibitions											
Injectable medication administration	34.0	35.4	33.7	38.0	40.6	40.0	41.5	35.8	5.3	37.6	0.17
Accidents with biological materials	65.7	69.2	71.8	70.8	65.1	67.1	63.9	75.5	14.9	68.5	0.78
Contaminated water and foods	8.3	5.8	7.8	4.3	8.3	4.4	8.6	6.8	-18.1	6.8	0.95
Several sexual partners	19.9	12.0	14.6	16.9	11.5	15.8	15.4	15.5	-22.1	15.1	0.78
Etiological classification											
Virus A	3.0	1.2	1.7	1.2	0.0	2.0	1.7	0.6	-80.0	1.4	0.69
Virus B	43.3	55.3	49.1	41.8	51.0	49.0	48.6	54.4	25.6	49.2	
Virus C	53.7	43.5	49.1	57.0	49.0	49.0	49.7	45.0	-16.2	49.4	
Brazilian Occupation Classification											
0	0.0	0.0	0.9	0.0	0.0	0.7	0.7	0.0	0.0	0.3	0.31
1	1.1	1.9	0.0	3.7	1.5	0.0	2.2	1.6	45.5	1.5	
2	8.0	16.5	16.2	12.1	12.3	13.2	10.9	11.9	48.8	12.7	
3	46.0	36.9	33.3	37.4	41.5	28.7	35.8	34.1	-25.9	36.3	
4	2.3	1.0	0.9	1.9	0.8	4.4	1.5	3.2	39.1	2.0	
5	27.6	16.5	28.2	18.7	21.5	29.4	27.0	23.8	-13.8	24.3	
6	1.1	1.0	0.0	1.9	1.5	2.2	1.5	1.6	45.5	1.4	
7	2.3	5.8	4.3	3.7	2.5	4.4	5.1	5.6	143.5	4.7	
8	1.1	1.9	0.9	0.0	0.8	0.7	0.7	0.8	-27.3	0.8	
9	10.3	18.4	15.4	20.6	14.6	16.2	14.6	17.5	69.9	16.0	

Source: SINAN/Health Surveillance Department/Ministry of Health, 2015.

Caption: PPV: Proportional Percentage Variation. 0: armed forces, police and firefighters; 1: senior members of the public power, directors of public interest organizations and companies and managers; 2: science and arts professionals; 3: mid-level technician; 4: administrative service workers; 5: service workers, salespeople in stores and markets; 6: agricultural, forestry, hunting and fishing workers; 7: industrial goods production and service workers I; 8: industrial goods production and service workers II; 9: maintenance and repair workers.

*p-value referring to the linear chi-square. **Illiterate: 2007 – 0.9%, 2008 – 0.7%, 2009 – 0.7%, 2013 – 1.3% and 2014 – 0.8%.
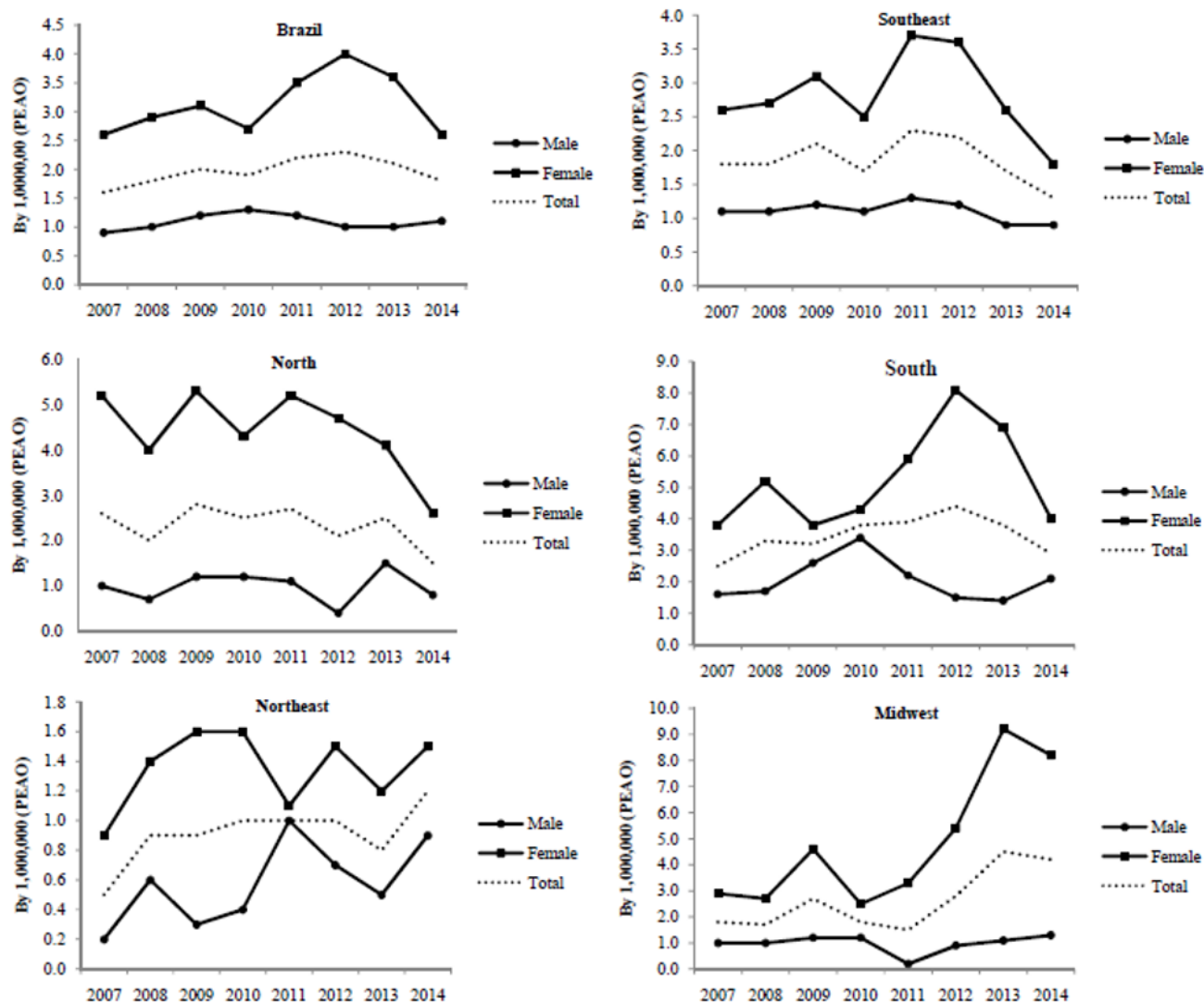
Figure 1. Incidence of viral hepatitis due to occupational accident by sex, Brazil and Regions, 2007 to 2014.

DISCUSSION

Viral hepatitis incidence by occupational accident in Brazil, regions and states were very low; however, the data can be considered underestimated due to under-reporting by several intervening factors. But, as it is an event in which the forms of prevention, in most cases, are easily accessible, it is considered a worrying information for Brazilian workers' health and also for the expenses generated by the health services with the treatment of these infections.

Viral hepatitis viruses of types A, B and C can be caused in the development of work activities, although HBV and HCV are present in greater proportions both in the general population and in workers. In the work environment, accidents with biological materials are responsible for exposure to HBV and HCV in different occupations that are exposed in daily life to blood, fluids and blood products and, mainly, contact with sharps.[8,10,11]

Viral hepatitis indicators, due to occupational accidents, varied according to the occupation in studies carried out, but frequencies were low, corroborating the present study. For HCV, in the adult population, it was 4.52%,[15] among health waste collectors, 3.3%,[11] household waste collectors, 0.9%,[11] health workers, 0.5%[8], cases reported in the state of Amapá/Brazil, 1.0%[9] and cases reported in the state of Bahia/Brazil, 0.1%.[13] For HBV, among waste collectors, it was lower than 0.05%,[11] firefighters, 6.5%,[9] cases reported in the municipality of Santa Cruz/Rio Grande do South, 0.5%,[12] health workers, 0.8%[7] and 0.6%,[8] cases reported in the state of Amapá/Brazil, 1.6%[9] and cases reported in the state of Bahia/Brazil, 0.2%.[13] Frequencies were low, as in the present study, and the proportion between occupations are similar, although some professional categories have not been studied.

There was an increase in incidence indicators in the Midwest region. When comparing the sexes, female

workers grew more in the Midwest region and by age group among those over 38 years old. The decreasing trend of incidence was observed in the states of Sergipe and Tocantins and also in the age group up to 37 years and in the group of workers of non-black skin color.

The Midwest and Northeast regions have low to moderate prevalence of hepatitis B.[16] Between 2008 and 2019, the detection rates of hepatitis type B in the population of the Midwest Region increased, hepatitis C did not change, and hepatitis A decreased. In the states of Sergipe and Tocantins, there was a slight increase in detection rates between 2008 and 2019 for HCV and a reduction for HBV and hepatitis A virus (HAV).[4] These data from the general population portray the findings in the present study as most cases are HBV and HCV. The greater the number of cases of accidents with biological materials, the greater the risk and contamination for HBV and HCV.

The state of Acre, in the present study, had the highest incidences of viral hepatitis compared to other states in the country. A study with health professionals in Rio Branco/Acre showed a high prevalence of HCV of 4.8% and was related to long-term exposure, older age and residents of the city for a longer period of time,[17] when considering the high endemicity of hepatitis B in this state.[16] Other factors related to the increase in notifications of accidents with biological materials in Acre were the implementation of a Reference Center for Occupational Health (CEREST - *Centro de Referência em Saúde do Trabalhador*), adequate physical infrastructure, training of professionals from the sentinel networks and teams compatible with demand.[18] These factors may also be related to the greater number of reported cases of viral hepatitis in the state, screening programs developed for riverside populations, continuing education for professionals, which contributes to a quality health surveillance service.

Women have been the group with the highest occurrence of OABMs that expose workers to viral hepatitis in different countries.[8,13,19] This may be linked to the occupation developed by women with greater exposure as technicians in the health sector. Age is also a major factor, the older the age, the longer the length of service, the greater the risk of OABM and, consequently, hepatitis occurrence,[11-13,15] when considering that these workers develop self-confidence and lose the discernment of precaution. The non-black skin color showed a reduction due to greater social inclusion of the black race in the labor market and, with that, greater exposure and risk for viral hepatitis.

The highest frequencies of notifications during the period under analysis were observed among workers with complete high school and high school technical occupation and service workers, with agreement between these characteristics, since OABMs are responsible for most cases of viral hepatitis occurring between mid-level and health[20] workers.[8,13,19-21] Mid-level technicians include technicians and assistants in nursing, laboratory, oral health, medical and dental equipment, clinical pathology, among others. Other occupational groups are also at risk

such as manicures and pedicures,[22] domestic workers and garbage collectors,[12] household and health waste collectors,[11] police officers[23] and maritime officers.[24]

Service workers, market and store trade vendors include those who perform laundry services, domestic servants, chamberlains/housekeepers, street sweepers, healthcare and household waste collectors, community health workers, health laboratory assistants, beautification and hygiene, caregivers, funeral services, firefighters, police officers, sex workers, among others, are related to service work, which also expose workers to biological material or sexual activity. Studies indicate the occurrence of accidents with biological materials and hepatitis B and C in household and health waste collectors,[11] garbage collectors[12], domestic workers,[12] as well as police officers[23] and maritime officers[24] are different occupations, but with risks to contact with biological materials.

In exposure to accidents with biological materials, there was a higher frequency of hepatitis. Studies indicate that contact with blood and fluids results from accidents with sharps, due to improper disposal and recapping of needles.[7,8,10,11,15,20,23] The risk of acquiring HCV from exposure to biological material is 3 to 10% and HBV is 40%.[20]

The frequency of viral hepatitis in the present study, according to type, was higher for HBV and HCV infection, considering the period. This may be related to the most frequent occupations, the forms of exposure of these occupations that contribute to the risk of transmission of these viruses, to workers who do not follow biosafety standards or are not trained to follow them, and also due to institutions' working conditions. In studies with health workers, oral health teams, household and health waste collectors and firefighters, HBV and HCV[7,8,11,15,19] were mainly assessed, which confirms the relationship between occupation, exposure and type of viral hepatitis.

The data from this study show that workers from technical activities in health care and support services were those with the highest frequency of cases of viral hepatitis, and this is because they are constantly exposed to pathogens in the development of their work activities. These data are relevant for epidemiological surveillance to expand prevention actions such as HBV vaccination that is available to all adults in health services in Brazil and anti-HBs serology testing to verify immunity, as studies indicate frequencies of non-immunized workers ranging from 14-45.3%.[8,11,19] Moreover, worker health protection should be considered by identifying the different risk situations at work for interventions to be effective.

Among the limitations of this study, we can highlight the underreporting of cases of hepatitis by professionals or public and private health services and the incompleteness of the information in the notification form, in particular the source of infection (only 45.8% of the fields were filled in) and occupation (with 63.2% of the fields filled in);[25] the seven-year period that the data were made available for analysis; the non-standardization of incidences to maintain the analysis of frequencies of other variables; trend analysis verified only by distribution in the period, with no analysis of seasonality and autocorrelation; and

scarcity of studies on the temporal trend of viral hepatitis due to occupational accidents to compare data, thus using studies of accidents with biological materials.

It is concluded that the temporal distribution of viral hepatitis due to occupational accident in Brazil was stationary in the country and in most regions and states. The Midwest region showed growth and the states of Sergipe and Tocantins decreasing incidences. Women, aged over 38 years, maintenance and repair workers and science and arts professionals showed an increase in cases in the time series.

However, these data may be underreported, requiring greater investments in training for professionals and health services both for diagnosis and establishment of the epidemiological technical nexus and for filling in all mandatory and essential fields of the notification form.

As it is an event that can be prevented in the work environment, greater investment is needed in actions to apply biosafety standards in the daily work, in addition to vaccination and guaranteeing immunity, as strategies to protect workers' health. Employers should contribute to this process by forming the Internal Commission for Accident Prevention (CIPA - *Comissão Interna de Prevenção de Acidentes*), carrying out training, checking the vaccination card of all workers in the admission and periodic evaluation and, mainly, providing the work environment with safety, through collective protection measures.

Furthermore, intervention actions are needed to monitor workers' health in different work environments such as the health sector and those of services and maintenance and repair, which differ in terms of the work process, but cases of viral hepatitis are occurring.

ACKNOWLEDGEMENTS

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AUTHORS' CONTRIBUTIONS

Técia maria Santos Carneiro e Cordeiro contributed to study conception and design, data analysis and interpretation, writing and critical review of relevant intellectual content.

Argemiro D'Oliveira Júnior contributed to data analysis and interpretation, writing and critical review of relevant intellectual content.

Tânia Maria de Araújo contributed to the writing, critical review of relevant intellectual content.

All authors have approved the final version of the manuscript and are responsible for all aspects of it, including ensuring its accuracy and integrity.

Revista de Epidemiologia e Controle de Infecção

ORIGINAL ARTICLE

Impact of alcohol gel on hand bacteria in healthcare professionals

Impacto del gel de alcohol en las bacterias de las manos en los profesionales sanitarios

Impacto do álcool gel nas bactérias das mãos de profissionais de saúde

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ABSTRACT

Background and objectives: Healthcare-Associated Infections are a problem reported by hospitals worldwide, increasing patient morbidity and mortality, prolonging hospitalization, and increasing health care costs. The hands of health professionals are still the main source of infections, making hand hygiene extremely important for spreading infection control. The objective of this study was to analyze the presence of bacteria on the hands of health professionals after hygiene with alcohol gel in a Neonatal Unit and describe the resistance of microorganisms to antimicrobials. **Methods:** Hand samples were collected using the modified glove-juice method on both occasions, before and after hand hygiene with alcohol gel. Bacteria were identified by MALDI-TOF and susceptibility tests according to Clinical and Laboratory Standards Institute document M100-E29. **Results:** A total of 214 samples were obtained, of which 104 (48.6%) showed bacterial growth before hand hygiene and 52 (24.3%) after hand hygiene with alcohol gel. There were 217 isolates from the cultures, of which coagulase-negative *Staphylococcus* was the most frequent with 41 (27.2%) and 24 (36.4%) positive cultures, respectively before and after hand hygiene. The second most frequent microorganism was *Klebsiella pneumoniae* with 32 (21.2%) and 16 (24.2%), respectively before and after hand hygiene. Multidrug resistance to antimicrobials was detected in 58.1% of gram-positive bacteria and in 34.3% of gram-negative bacteria. **Conclusion:** A decrease was observed, but not an elimination of the microbial load after hand hygiene with alcohol gel, demonstrating the need for improvements in hand hygiene.

Keywords: Hand Hygiene. Health Personnel. Neonatal Intensive Care Units. Drug Resistance, Microbial.

RESUMO

Justificativa e objetivos: As Infecções Relacionadas à Assistência à Saúde são um problema relatado por hospitais em todo o mundo, aumentando a morbimortalidade dos pacientes, prolongando a hospitalização e aumentando os custos dos cuidados de saúde. As mãos dos profissionais de saúde ainda são a principal fonte de infecções, tor-

nando a higienização das mãos extremamente importante para a disseminação do controle de infecções. O objetivo deste estudo foi analisar a presença de bactérias nas mãos de profissionais de saúde após higienização com álcool gel em uma Unidade Neonatal e descrever a resistência dos microrganismos aos antimicrobianos. **Métodos:** Amostras de mãos foram coletadas pelo método luva-suco modificado em ambas as ocasiões, antes e após a higienização das mãos com álcool gel. As bactérias foram identificadas por MALDI-TOF e testes de suscetibilidade de acordo com o documento M100-E29 do Clinical and Laboratory Standards Institute. **Resultados:** Obteve-se um total de 214 amostras, das quais 104 (48,6%) apresentaram crescimento bacteriano antes da higienização das mãos e 52 (24,3%) após a higienização das mãos com álcool gel. Foram 217 isolados das culturas, sendo Staphylococcus coagulase-negativo o mais frequente com 41 (27,2%) e 24 (36,4%) culturas positivas, respectivamente antes e após a higienização das mãos. O segundo microrganismo mais frequente foi Klebsiella pneumoniae com 32 (21,2%) e 16 (24,2%), respectivamente antes e após a higienização das mãos. A multirresistência aos antimicrobianos foi detectada em 58,1% das bactérias gram-positivas e em 34,3% das bactérias gram-negativas. **Conclusão:** Observou-se diminuição, mas não eliminação da carga microbiana após higienização das mãos com álcool gel, demonstrando a necessidade de melhorias na higienização das mãos.

Palavras-chave: Higiene das Mãos. Pessoal de Saúde. Unidades de Terapia Intensiva Neonatal. Resistência a Medicamentos, Microbiana.

RESUMEN

Justificación y objetivos: Las Infecciones Asociadas a la Atención de la Salud son un problema reportado por los hospitales a nivel mundial, aumentando la morbimortalidad de los pacientes, prolongando la hospitalización y aumentando los costos de la atención médica. Las manos de los profesionales de la salud siguen siendo la principal fuente de infecciones, por lo que la higiene de manos es extremadamente importante para el control de infecciones. El objetivo de este estudio fue analizar la presencia de bacterias en las manos de los profesionales de la salud después de la higiene con alcohol en gel en una Unidad Neonatal y describir la resistencia de los microorganismos a los antimicrobianos. **Métodos:** Se recogieron muestras de manos mediante el método guante-jugo modificado en ambas ocasiones, antes y después de la higiene de manos con alcohol en gel. Las bacterias se identificaron mediante MALDI-TOF y pruebas de susceptibilidad de acuerdo con el documento M100-E29 del Clinical and Laboratory Standards Institute. **Resultados:** Se obtuvieron un total de 214 muestras, de las cuales 104 (48,6%) presentaron crecimiento bacteriano antes de la higiene de manos y 52 (24,3%) después de la higiene de manos con alcohol en gel. Hubo 217 aislamientos de los cultivos, de los cuales el Staphylococcus coagulasa negativo fue el más frecuente con 41 (27,2%) y 24 (36,4%) cultivos positivos, respectivamente antes y después de la higiene de manos. El segundo microorganismo más frecuente fue Klebsiella pneumoniae con 32 (21,2%) y 16 (24,2%), respectivamente antes y después de la higiene de manos. Se detectó multirresistencia a los antimicrobianos en el 58,1% de las bacterias grampositivas y en el 34,3% de las bacterias gramnegativas. **Conclusión:** Se observó una disminución, pero no una eliminación de la carga microbiana después de la higiene de manos con alcohol en gel, lo que demuestra la necesidad de mejoras en la higiene de manos.

Palabras clave: Higiene de manos. Personal sanitario. Unidades de Cuidados Intensivos Neonatales. Farmacorresistencia Microbiana.

INTRODUCTION

Healthcare-associated Infections (HAI) are responsible for higher morbidity and mortality, longer length of hospital stay and greater health care costs.[1] Reducing HAI rates has become a challenge to be overcome by hospitals worldwide.

Neonatal Intensive Care Units (NICU) have had high HAI rates, especially because babies have different characteristics, with immature immune systems and low birth weight. In addition, in most cases, they depend on parenteral nutrition and often undergo invasive procedures, such as central venous catheters and orotracheal intubation, as well as broad-spectrum antimicrobial therapy.[2,3]

The reduction of the HAI rates is possible through early identification of risk factors, for instance through health surveillance, staff training, antimicrobial therapy management and especially, correct hand hygiene.[3,4] The hands of healthcare professionals are one of the main vehicles for the transmission of microorganisms between professionals and patients, especially because they are in frequent contact with the potentially contaminated surfaces.[4,5] Furthermore, a premature newborn is handled about 200 times in 24 hours, which increases the risk of infection.[6]

Bacteria present on hands include *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Enterococcus* spp., *Pseudomonas aeruginosa*, *Klebsiella* spp., *Enterobacter* spp., *Pantoea* spp. and yeast belonging to the *Candida* genus. Some of these microorganisms are resistant to antimicrobials. For example, *S. aureus* and *S. epidermidis* were found to be resistant to oxacillin/methicillin, *Enterococcus* to vancomycin and *Enterobacteriaceae* and *P. aeruginosa*, to carbapenems.[1,7]

Conventional hand hygiene (soap and water) is poorly performed among health professionals, especially those working in hospitals.[6,8,9] This is due to a gap in practice, perception and knowledge about the importance of hand hygiene and its impact on the occurrence of HAI. The difficulty in accessing places to perform this procedure or lack thereof, the prolonged time required for hand hygiene, as well as dermatological issues, such as dryness and/or hypersensitivity caused by the substances used in the cleaning process induce many professionals to not adopt the conventional appropriate cleaning processes.[8]

An alternative to conventional hand hygiene is hand hygiene with alcohol hand-rub (at concentration 60-80%, depending on the type of alcohol used),[7,8] which promotes hygiene without loss of effectiveness in removing and/or inactivating microorganisms. The use of this product is indicated when hands are not visibly dirty, it requires less time for hygiene, is easy to obtain and available, and can be arranged on the bedside, with less occurrence of hypersensitivity. Among the many products on the market for hand hygiene, alcohol gel is well accepted by health professionals.[10]

The aim of this study is to analyze the bacteria on the hands of healthcare professionals of a Neonatal Unit before and after using alcohol gel, and evaluate the susceptibility of microorganisms to antimicrobials.

METHODS

The study was carried out in the Neonatal Unit of the Hospital University of Uberlândia. The Neonatal Unit contains a total of 42 beds, 20 for intensive care, 16 for semi-intensive care and six for intermediate care in the "Kangaroo Care" model.

The Neonatal Unit has a multidisciplinary team composed of approximately 120 professionals who work directly with patients, including nurses, nursing technicians, physicians and physiotherapists.

Sample Collection

Three hand washing samples were collected during three work shifts (morning, afternoon and night), on three occasions; the first in April, the second in June and the third in September 2018, representing different seasonal periods.

Collections were performed according to the glove-juice modified technique.[11] Briefly, the research participant put both hands at the same time in a polypropylene bag containing 10 mL of BHI broth (*Brain Heart Infusion*, HIMEDIA®, India), bathing them in the broth for one minute. Then, the bag was sealed and the sample identified as "Before". Subsequently, the participant dried his/her hands with a sterile surgical dressing and performed hand hygiene with alcohol gel, according to the institution's protocol. After complete drying of the alcohol, about one minute, a second collection was performed in another bag identified as "After".

The alcohol gel brand was the same as the one available at the Neonatal Unit (Hydrated Alcohol Gel 70% v/v, Rioquímica®, Brazil).

Culture and bacterial identification

The samples (BHI in bags) were first incubated in a bacteriological incubator at 35 ± 2 °C for 18-24 hours. Subsequently, aliquots (10 µL) were taken and analyzed by Gram staining, seeded in 5% Sheep Blood Agar (HIMEDIA®, India), Mannitol-Salted Agar (HIMEDIA®, India) and Eosin-Methylene Blue Agar (HIMEDIA®, India), and incubated at 35 ± 2 °C for 18-24 hours. Microorganisms were identified by the analytical technique of mass spectrometry: Matrix Associated Laser Desorption-Ionization - Time of Flight (MALDI-TOF), which separates atoms or molecules according to their mass/charge ratio. MALDI-TOF has been recognized as a fast and reliable tool to identify bacteria, once mass spectra can be viewed as species-specific fingerprints, allowing for accurate identification of purified strains at the genus and species level.[12,13]

Antimicrobial susceptibility testing

The antibacterial susceptibility profile was determined by agar disk diffusion method, according to Clinical and Laboratory Standards Institute document M100-E29.[14]

Gram-negative bacteria were tested for the following (DME®, Brazil): amikacin (30 µg); amoxicillin and clavulanic acid (20/10 µg); ampicillin and sulbactam (10/10 µg), cefepime (30 µg), cefoxitin (30 µg), ceftriaxone (30 µg), ciprofloxacin (05 µg), gentamycin (10 µg), meropenem (10 µg), piperacillin and tazobactam (100/10 µg), sulfazotrim (25 µg), ceftazidime (30 µg), aztreonam (30 µg). Susceptibility of *Acinetobacter baumannii* and *Stenotrophomonas maltophilia* to antimicrobials was assessed by the Minimum Inhibitory Concentration (MIC), as recommended by CLSI.[14]

Gram-positive bacteria (DME®, Brazil) were tested for the following: tetracycline (30 µg), ciprofloxacin (05 µg), chloramphenicol (30 µg), erythromycin (15 µg), clindamycin (02 µg), penicillin (10 µg), gentamycin (10 µg); sulfazotrim (25 µg), cefoxitin (30 µg) (also checking resistance to oxacillin), and vancomycin (30 µg) (only for *Enterococcus* spp.).

Microorganisms resistant to three or more classes of the tested antimicrobials were considered Multidrug-Resistant (MDR).[15]

Statistical analyses

Results were tabulated and expressed as relative and absolute frequencies. McNemar's test was performed to assess the effect of alcohol on hand bacteria. The level of statistical significance was set at $P < 0.05$. The IBM SPSS Statistics for Windows, version 21.0 was used.

Study ethics

This study was approved by the Research Ethics Committee of the Federal University of Uberlândia, under no. CAAE 82191417.6.0000.5152. This research was conducted according to ethical standards required by Resolutions 466/2012 - 510/2016 - 580/2018 of the Brazilian Ministry of Health.

RESULTS

A total of 214 samples were collected, comprising before and after hand hygiene, with 48.6% (n = 104) displaying bacterial growth before hand hygiene with alcohol gel, decreasing to 24.3% after hand hygiene with alcohol gel. Table 1 displays the results in each collection period.

The study identified 217 microorganisms; 151 in the "Before" samples, and 66 in the "After" samples, as exhibited in Figures 1 and 2, respectively. Coagulase negative *Staphylococcus* (CoNS) was the most frequent, followed by *Klebsiella pneumoniae*.

Table 1. Results of the microbiological analyses of health professional hands from the Neonatal Unit, before and after hand hygiene with alcohol gel, by collection period.

| Year | Professionals n | Positive cultures for bacteria | | | | Reduction after Hand Hygiene (%) | P value |
| | | Before* | | After** | | | |
		n	%	n	%		
First Collection (April)	80	37	46.2	20	25	45.9	< 0.001
Second Collection (June)	63	37	58.7	20	31.7	45.9	< 0.001
Third Collection (September)	71	30	42.3	12	16.9	60	< 0.001
TOTAL	107	104	48.6	52	24.3	50	< 0.001

Figure 1. Frequency of microorganisms isolated from healthcare professional hands before hand hygiene in the studied Neonatal Unit. (Note: *= coagulase-negative Staphylococcus; **= Stenotrophomonas maltophilia).
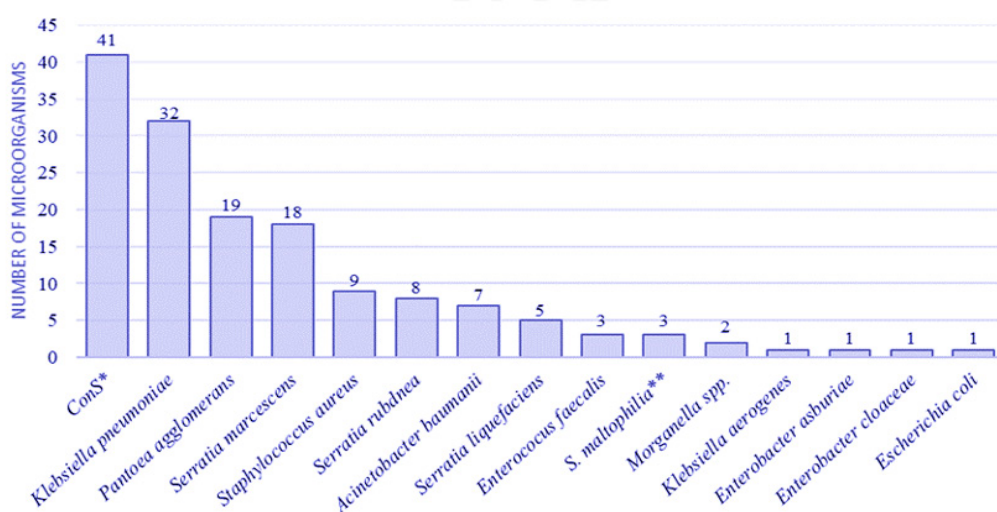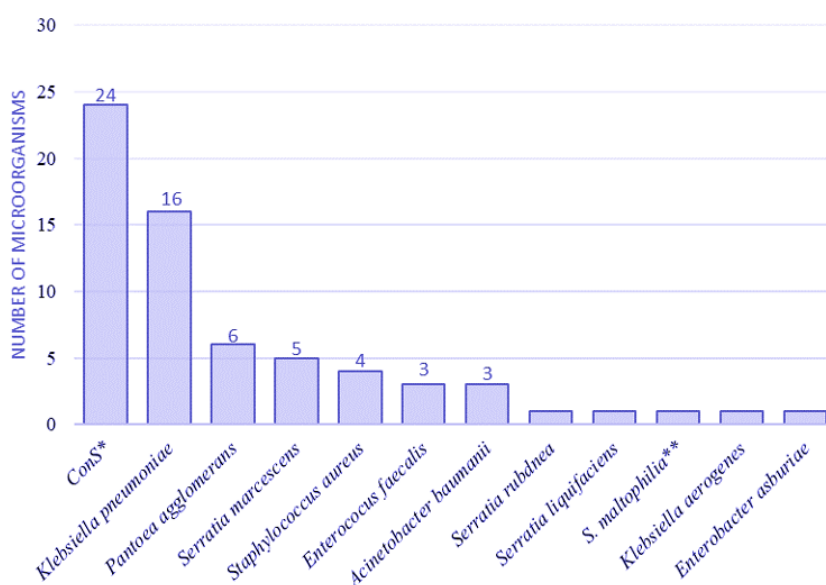

Figure 2. Frequency of microorganisms isolated from healthcare professional hands after hand hygiene in the studied Neonatal Unit (Note: *= coagulase-negative Staphylococcus; **= Stenotrophomonas maltophilia).

Tables 2 and 3 show the results obtained in the antimicrobial susceptibility testing of isolates after alcohol gel hygiene. In total, 18 (58.1%) gram-positive bacteria and 12 (34.3%) gram-negative bacteria were MDR. Furthermore, four (50%) of *Staphylococcus aureus* were MRSA (Methicillin-resistant *Staphylococcus aureus*).

Only one *A. baumanii* isolate was resistant to ampicillin and sulbactam, while one *S. maltophilia* was resistant only to ceftazidime, and one *Enterococcus* spp. to vancomycin.

Table 2. Antimicrobial resistance of gram-positive bacteria isolated from healthcare professional hands after hand hygiene in the studied Neonatal Unit.

Antimicrobial	Genus / Species					
	CoNS (n=24)		*Staphylococcus* aureus (n=4)		*Enterococcus faecalis* (n=3)	
	n	%	n	%	n	%
Ciprofloxacin	5	20.8	0	0.0	3	100.0
Clindamycin	7	29.2	2	50.0	*	*
Chloramphenicol	8	33.3	2	50.0	0	0.0
Erythromycin	12	50.0	3	75.0	3	100.0
Gentamicin	8	33.3	2	50.0	*	*
Oxacillin	9	37.5	2	50.0	*	*
Penicillin	21	87.5	3	75.0	0	0.0
Sulfazotrim	8	33.3	4	100.0	*	*
Tetracycline	7	29.2	3	75.0	1	33.3
MDR	14	58.3	3	75.0	1	33.3

*MDR= Multidrug Resistant; CoNS= coagulase negative Staphylococcus; *= cutoff points not defined by CLSI for bacterial species / genus. Oxacillin resistance determined by resistance to Cefoxitin.*

Table 3. Antimicrobial resistance of gram-negative bacteria isolated from healthcare professional hands after hand hygiene in the studied Neonatal Unit.

Antimicrobial	Genus / Species							
	P. agglomerans (n=6)		*K. pneumoniae* (n=16)		*Serratia* spp. (n=7)		*Other (n=2)*	
	n	%	n	%	n	%	n	%
Amikacin	2	33.3	1	6.3	1	14.3	0	0.0
Amox/Clav Ac.	4	66.7	5	31.3	4	57.1	2	100.0
Amp/Sulbactam	2	33.3	3	18.8	2	28.6	2	100.0
Aztreonan	3	50.0	1	6.3	1	14.3	0	0.0
Cefepime	4	66.7	1	6.3	1	14.3	0	0.0
Cefoxitin	6	100.0	15	93.8	7	100.0	2	100.0
Ceftazidime	3	50.0	1	6.3	0	0.0	0	0.0
Ceftriaxone	3	50.0	2	12.5	2	28.6	0	0.0
Ciprofloxacin	3	50.0	3	18,8	1	14.3	1	50.0
Gentamicin	3	50.0	0	0.0	1	14.3	0	0.0
Meropenem	2	33.3	1	6.3	0	0.0	0	0.0
Pipe/Tazo	0	0.0	1	6.3	0	0.0	1	50,0
Sulfazotrim	1	16.7	1	6.3	1	14.3	0	0.0
MDR	5	83.3	2	12.5	3	42.9	2	100,0

Amox/Clav Ac= Amoxicillin and Clavulanic Acid; Amp/Sulbactam = Ampicillin and Sulbactam; Pipe/Tazo = Piperacillin and Tazobactam; MDR = Multidrug Resistant; Others = Klebsiella aerogenes (1) and Enterobacter asburiae (1) P. agglomerans = Pantoea agglomerans; K. pneumoniae = Klebsiella pneumoniae

DISCUSSION

The Centers for Disease Control and Prevention (CDC) have recognized the importance of hand hygiene in reducing HAI rates since 1974.[9] Studies indicate that this practice is still underestimated by healthcare professionals worldwide, with adoption rates ranging from 30% to 60%.[8,9]

Studies assessing the presence of microorganisms on healthcare professionals' hands during their work shifts have reported different results. In India,[16] 42.7% of healthcare professionals' hands displayed bacterial growth, while in Italy,[17] only 5.41% healthcare professionals' hands showed positive culture for bacteria. In another study[18] was demonstrated that the hands of 97% of professionals in the United States exhibited bacterial growth. In Greece,[19] all professionals participating in the study displayed contaminated hands. These differences found in results of many studies may be due to the sample collection method (fingerprint, glove-juice or contact

plates), and especially, what each author considers as a positive sample. Herein, in our study all bacterial growth was considered positive, since premature newborns are extremely vulnerable to infections.[20]

In the present study, professionals were asked to clean their hands with alcohol gel to check for reduction of microbial load on hands after the hygiene process. The results indicate that 48.6% of professionals still had their hands contaminated to some degree with bacteria. Coagulase-negative *Staphylococcus* were the most frequent isolates, as described in the literature.[19,20] These microorganisms compose the skin microbiome, but are also opportunistic agents of infection in neonates, as demonstrated by Sanderson et al., in which 71% of cases of bloodstream infection in neonates were caused by CoNS.[21] In a study reporting the incidence of nosocomial infections in the same Neonatal Unit of this study, CoNS and *Staphylococcus aureus* were the most frequently causative agents of infections in neonates, representing 36.5% and 23.6% of total infections, respectively.[22]

Gram-negative bacteria are less common on hands compared to gram-positive cocci, but they are important infection agents in neonates. In the present study, *Klebsiella pneumoniae* was the most common gram-negative bacteria. Chen and colleagues reported *Klebsiella pneumoniae* as responsible for 16% of neonatal infections, followed by *Staphylococcus aureus* (12.3%).[3] In Egypt, the most frequent microorganism was also *Klebsiella pneumoniae*, present in 41.6% of infections, followed by CoNS, present in 22.8% of cases.[23]

A total of 24.3% of the samples from professional hands analyzed after hand hygiene with alcohol gel did not show any reduction in microbial load. Studies evaluating alcoholic preparations (gel, foam, liquid) demonstrate effectiveness in reducing microbial loads by up to 99.9%.[8,24]

In a study conducted in India, 35% of healthcare professionals displayed bacterial growth on their hands, becoming non-detected after hygiene with alcohol-based hand rub.[25] Similar results were reported in another study in which only 5% of hands showed bacterial growth after hand hygiene with alcohol-based handrub.[26,27]

The discrepancies between the literature and the present study may be related to the fact that in studies evaluating the effectiveness of alcoholic preparations, participants were trained so everyone could perform the proper hand hygiene technique. The effectiveness of these preparations has been proven under these conditions.[25] In this study, participants were instructed to perform hand hygiene with alcohol gel as usual, thus evidencing a possible deficiency in the way they usually perform hand hygiene, since part of participants (24.3%) exhibited bacterial growth after the hand hygiene procedure.

Concerning MDR bacteria, 58.1% of gram-positive bacteria and 34.3% of gram-negative bacteria were considered as multidrug-resistant in this study, while 50% of isolated *Staphylococcus aureus* were MRSA. Several studies have demonstrated that MDR bacteria are found on the hands of healthcare professionals, including MRSA,

ranging from 1.3% to 1.6%. However, when evaluating only *Staphylococcus* spp., in general, 39% are categorized as MDR. Regarding gram-negative bacteria, frequencies range between 3.2% to 56% concerning the presence of MDR on health professionals' hands.[16,17,19] For example, in China, 7.3% of positive samples were reported when assessing the presence of gram-negative bacilli from the hands of health professionals in an intensive care unit, among which *Klebsiella pneumoniae* was the most common, and 50% were MDR.[4]

Working in Intensive Care Units increases the risk of carrying potential microorganisms that cause HAIs in neonates, including MDR[22]. Concerning NICUs, hand hygiene habits become extremely important, as most patients are premature and extremely vulnerable to infections, remain in the hospital for long periods and receive various essential life-sustaining procedures.[20]

The presence of bacteria on hands before hand hygiene indicates which pathogens may be spreading in the unit, and a key point is noted after hygiene, since hands should be cleaned before contact with any medical devices and patients, providing safe care according to World Health Organization guidelines. Successful hand hygiene must take into account two factors, namely the quality of the product used in the process and quality/effectiveness of the performed hygiene.[10]

This study has limitations, including the technique used for collection ("modified glove-juice"), as well as hand drying with towels, which may have reduced the microbial load on hands. In addition, the non-evaluation of the hand hygiene technique performed by the assessed professionals was to ensure that professionals whose samples tested positive after the hygiene procedure resulted from inadequate technique, amount of product or even insufficient hygiene time, which may be evaluated in future studies.

The persistence of these bacteria even after hand hygiene seems to demonstrate a failure in the hygiene process, either due to the applied methodology or the alcohol gel time of action. The most frequent microorganisms found before and after hand hygiene, were Coagulase Negative *Staphylococcus*, *Klebsiella pneumoniae* and *Pantoea agglomerans*. Multidrug resistance to antimicrobials was evaluated, revealing that most of gram-positive (58.1%) and many gram-negative (34.3%) bacteria are multidrug-resistant.

This study revealed the need for improvements concerning the hand hygiene process performed by healthcare professionals in the studied unit in order to reduce the microbial load on hands. Further studies may be conducted in an attempt to better determine the most important variables involved in this process, such as the alcohol gel amount, hygiene process and product efficiency (alcohol content, composition and gel alcohol presentation, among others). Thus, efforts are required to improve both hygiene adherence and quality, which can be demonstrated and proven by epidemiological studies involving *in vitro* experiments.

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All authors have approved the final version to be published and are responsible for all aspects of the work, including ensuring its accuracy and integrity.

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ORIGINAL ARTICLE

Statistical modeling of hospital admissions for pneumonia in Campo Grande

Modelagem estatística das internações hospitalares por pneumonia em Campo Grande

Modelado estadístico de ingresos hospitalarios por neumonía en Campo Grande

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ABSTRACT

Justification and Objectives: Brazil lacks consistent epidemiological data on the respiratory morbidity of children and older adults, which makes it difficult to plan and execute effective preventive and health promotion actions. The objective of this study was to analyze the adjustments of distributions (Weibull, Normal, Gamma, Logistic) of historical series of hospitalizations for respiratory diseases (total hospitalizations), from 2011 to 2015, in Campo Grande, Mato Grosso do Sul. **Methods:** to determine the statistical models, four statistical indicators (coefficient of determination, mean root square error, mean absolute error and mean absolute percentage error) were performed from 2011 to 2015. Parameter estimates are obtained for the models adopted in the study, with and without a regression structure. **Results:** the results showed that Weibull, Gamma, Normal and Logistic distributions, applied to the series of hospitalizations for respiratory diseases in Campo Grande, were satisfactory in determining the shape and scale parameters, and the statistical indicators R^2, MAE, RSME and MAPE confirmed the data goodness-of-fit, and the graphical analysis indicated a satisfactory distribution fit. **Conclusion**: the analysis of monthly values indicates that Gamma is the best of the four distributions based on those selected. The regression model can be adjusted to the data and used as an alternative distribution that describes the hospitalization data considered in Campo Grande, Brazil.

Keywords: Environmental Statistics. Infections. Periodicity. Probability. Hospitalization.

RESUMO

Justificativa e Objetivos: o Brasil carece de dados epidemiológicos consistentes sobre a morbidade respiratória de crianças e idosos, o que dificulta o planejamento e a execução de ações efetivas de prevenção e promoção da saúde. O objetivo deste estudo foi analisar os ajustes das distribuições (Weibull, Normal, Gamma, Logística) da

série histórica de internações por doenças respiratórias (total de internações), no período de 2011 a 2015, em Campo Grande, Mato Grosso do Sul. **Métodos**: para determinar os modelos estatísticos, foram executados quatro indicadores estatísticos (coeficiente de determinação, erro quadrático médio, erro absoluto médio e erro percentual absoluto médio) de 2011 a 2015. As estimativas dos parâmetros são obtidas para os modelos adotados no estudo com e sem uma estrutura de regressão. **Resultados:** os resultados mostraram que as distribuições Weibull, Gamma, Normal e Logística, aplicadas à série de internações por doenças respiratórias em Campo Grande, foram satisfatórias na determinação dos parâmetros de forma e escala, e os indicadores estatísticos R^2, MAE, RSME e MAPE confirmaram a qualidade do ajuste dos dados, e a análise gráfica apontou um ajuste satisfatório das distribuições. **Conclusão**: a análise dos valores mensais indica que a Gamma é a melhor das quatro distribuições baseadas nos selecionados. O modelo de regressão pode ser ajustado aos dados e ser usado como uma distribuição alternativa que descreve os dados de internação considerados em Campo Grande, Brasil.

Descritores: *Estatísticas Ambientais. Infecções. Periodicidade. Probabilidade. Internação.*

RESUMEN

Justificación y Objetivos: el Brasil carece de datos epidemiológicos consistentes sobre la morbilidad respiratoria de niños y ancianos, lo que dificulta la planificación y ejecución de acciones efectivas de prevención y promoción de la salud. El objetivo de este estudio fue analizar los ajustes de las distribuciones (Weibull, Normal, Gamma, Logística) de la serie histórica de hospitalizaciones por enfermedades respiratorias (hospitalizaciones totales), de 2011 a 2015, en Campo Grande, Mato Grosso do Sul. **Métodos:** para la determinación de los modelos estadísticos, se realizaron cuatro indicadores estadísticos (coeficiente de determinación, raíz del error cuadrático medio, error medio absoluto y error porcentual absoluto medio) de 2011 a 2015. Se obtienen estimaciones de los parámetros para los modelos adoptados en el estudio, con y sin estructura de regresión. **Resultados**: los resultados mostraron que las distribuciones Weibull, Gamma, Normal y Logística, aplicadas a la serie de internaciones por enfermedades respiratorias en Campo Grande, fueron satisfactorias en la determinación de los parámetros de forma y escala, y los indicadores estadísticos R^2, MAE, RSME y MAPE confirmaron la calidad de ajuste de los datos, y el análisis gráfico indicaron un ajuste satisfactorio de las distribuciones. **Conclusión**: el análisis de los valores mensuales indica que la Gamma es la mejor de las cuatro distribuciones en base a las seleccionadas. El modelo de regresión se puede ajustar a los datos y utilizar como una distribución alternativa que describe los datos de hospitalización considerados en Campo Grande, Brasil.

Palabras clave: *Estadística Ambiental. Infecciones. Periodicidad. Probabilidad. Hospitalización.*

INTRODUCTION

Brazil has a lack of consistent epidemiological data on the respiratory morbidity of children and older adults, which makes it difficult to plan and execute effective preventive and health promotion actions. It is known that age is a risk factor proportional for respiratory diseases, i.e., the younger/older, the greater the risk for the development of these diseases.[1]

Risk factors for hospitalization for respiratory diseases include: exposure to environmental pollutants, especially smoking; household agglomeration; deficit in nutritional status; climatic seasonality; incomplete immunization schedules; low socioeconomic status; and exposure to biological agents, such as pollen. Such factors mainly affect individuals at the extremes of age, such as children under 5 years old and older adults over 65 years old.[1]

Groups that are susceptible to respiratory diseases in children are highly susceptible to exposure to air pollutants. They have greater minute ventilation due to accelerated basal metabolism and greater physical activity when compared to adults, in addition to staying longer in outdoor environments. Based on body weight, the volume of air that passes through a child's respiratory tract at rest is double that of adults in similar conditions. Irritation by pollutants that would produce a weak response in adults can potentially result in significant obstruction in childhood. Moreover, a not yet fully developed immune system increases the possibility of respiratory infections. Older adults are susceptible to the adverse effects of exposure to air pollutants, because they have a less efficient immune system (immunosenescence), a progressive decline in lung function that can lead to airway obstruction and exercise limitation. There is a reduction in chest wall compliance and pulmonary hyperinflation, causing additional energy expenditure to perform respiratory movements, in addition to a functional decrease in organic systems.[1]

Several studies involving adjustment of estimates using probabilistic/theoretical models in relation to historical data series have been developed, highlighting the benefits in planning activities that minimize risks, among which precipitation, air temperature, solar radiation, concentration of polluting gases historical seires stand out. However, there is published work (according to the authors' best knowledge) on historical series of hospitalizations for respiratory diseases based on the methodology used in this research, developed by Sousa

et al (2019)[2], which analyzed the adjustments of Burr (Bu), Inverse Gaussian 3P (IG3P), Lognormal (LN), Pert (Pe), Rayleigh 2P (Ra 2P) and Weibull 3P (W3P) distributions of series of hospitalizations for respiratory diseases (total admissions). Shape and scale parameters of distributions were determined, and, to check the observation data adjustment quality, goodness-of-fit tests (GOF) were applied, such as Kolmogorov-Smirnov (KS), Shapiro-Wilk (SW), Anderson-Darling (AD) and ($χ^2$) chi-square tests.

The objective of this study was to analyze the distribution adjustment (Weibull, Normal, Gamma, Logistic) of historical series of hospitalizations for respiratory diseases (total hospitalizations), from 2011 to 2015, in Campo Grande, Mato Grosso do Sul. The analysis was performed between people (children and adults) who contracted pneumonia. The parameter estimates related to the data set are obtained and using different models with and without a regression structure. Finally, the Gamma regression model is select using discrimination criteria, and the prediction of the mean number of admission and its respective 95% confidence intervals are obtained.

METHODS

In this study, a descriptive analysis of variables was performed. We used Weibull (W2), Gamma (G), Normal (N) and Logistic (L) functions to model hospital admission data in Campo Grande. Performance indicators are calculated by comparing observed values to predicted values. Observed values are the observation data classified values, while predicted values are the values obtained from the adjusted distribution.

Health data

The city of Campo Grande, state of Mato Grosso do Sul, (20° 27′16 "S, 54° 47′16″ W, 650 m), is located on the plateau called Maracajú-Campo Grande, 150 miles from the beginning of the world's largest flood plain, the Pantanal (a natural region encompassing the world's largest tropical wetland area, and the world's largest flooded grasslands) (139 111 km[2]), and an estimated population of 724,000 inhabitants. According to Souza et al (2019)[2], the climate in the region of Campo Grande has moderate temperatures ranging from 17.8°C, minimum, to 29.8°C, maximum, with an average of 22.7°C, with hot summer and well distributed rainfall, and average relative humidity is 72.8%.

To correlate the meteorological data with the aggravation of respiratory diseases, hospital admission data were collected, together with the SUS (Unified Health System) Department of Informatics (DATASUS).

Data available came from the SUS Hospital Information System (SIH/SUS), managed by the Ministry of Health, through the Health Care Secretariat, together with State Health Secretariats and the Municipal Health Department, and processed by DATASUS, of the Ministry of Health's Executive Secretariat.

Hospital units, SUS patients (public or private parties), send hospitalization information, provided through AIH (Hospital Admission Authorization), to municipal (full management) or state (the others) managers. This information is processed in DATASUS, generating credits related to services provided and forming a valuable database, which contains a large part of hospital admissions in Brazil.

It should be noted that SIH/SUS collects variables related to hospitalizations, such as patient identification and qualification, procedures, examinations and medical actions performed, diagnosis, reasons for discharge, amounts due, etc. Through the Internet, DATASUS provides the main information for tabulation on the SIH/SUS databases.

Study area

This is an ecological study of time series. This design is characterized by studying groups of individuals, generally affected by geographic regions. In the case of this work, the site studied is the city of Campo Grande, state of Mato Grosso do Sul.

The study population was made up of people living in Campo Grande who were hospitalized due to respiratory diseases, from 2011 to 2015. We analyzed all hospitalizations with diagnosis of respiratory diseases from all hospitals at SUS. These data are AIH records of public and private hospitals and that assist part of the population that does not have health insurance nor are private or funded patients by companies (http:/www.datasus.gov.br). The information in the database comprises: the number of the hospital's Taxpayer's Registry (CGC), the city where it is located, patient age, sex, cause of hospitalization, procedure performed, patient zip code, hospitalization, date of discharge or death, days of UTI stay, among other information. The information in the database that were selected for this study were date of hospitalization, diagnosis, and patient age (children 0-4 years and adults 4-50 years).

Probability distributions

In this study, the effectiveness of four one-component probability models was assessed, namely W2, N, G and L. The one-component parametric probability distribution functions (pdfs) were used because our data exhibit unimodal shape. These four models have been selected among other one-component models due to their successful applications according to literature.

Estimation of model parameters

Several methods can be used to estimate the considered model parameters[3]. However, the selection of effective models is more important compared to the selection of parameter estimation methods[4]. In this work, the Maximum Likelihood Estimation (MLE) method is applied. This method has shown good results in several studies. It gives the values of the parameters which maximize the probability of obtaining the observed data.

The likelihood function $L(θ)$ for a random sample x_1, $x_2,..., x_n$ and theoretical probability density function f with k parameters $θ = (θ_1, θ_2, ..., θ_k)$ is represented by:

(1)

$$L(\theta) = \prod_{i=1}^{n} f(x_i, \theta)$$

For each parameter - θ_i, MLE involves maximizing the likelihood function by solving the following:

(02)

$$\frac{d\log(L(\theta))}{d\theta_i} = 0, \; i = 1,2,...,k$$

Accuracy tests

The performance and accuracy of the tested models were assessed based on various statistical indices. The statistical indicators used in this study can be regrouped into two groups: i) dispersion indicators (error indicators); and ii) general performance indicators [4]. Mean Bias Error (MBE), Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE) are noted in the dispersion indices, while Coefficient of Determination (R^2) are regrouped in the performance indicators[4]. The equations (Eq. 3 to 7) for statistical indicators are listed below:

(03)

$$MBE = \frac{1}{n}\sum_{i=1}^{n}(P_i - O_i)$$

(04)

$$RMSE = \sqrt{\sum_{i=1}^{n}\frac{(P_i - O_i)^2}{n}}$$

(05)

$$MAPE = \sum_{i=1}^{n}\frac{|P_i - O_i|}{P_i} \cdot \frac{100}{n}$$

(6) where P_i is the predicted value, O_i is the observed value, is the mean of the predicted values, is the mean of the observed values, and n is the number of observations.

$$R^2 = \left[\frac{\sum_{i=1}^{n}(O_i - \overline{O})\cdot(P_i - \overline{P})}{\sqrt{\sum_{i=1}^{n}(O_i - \overline{O})^2 \cdot \sum_{i=1}^{n}(P_i - \overline{P})}}\right]$$

Akaike Information Criterion

An information criterion that has been widely used in model selection is the Akaike Information Criterion (*AIC*). The *AIC* is defined according to the following Eq. (8):

(8)

$$AIC = -2\ln(L(\theta)) + 2k$$

Where $L(\theta)$ is the likelihood function at the maximum point of the model, and k is the number of parameters considered from said model. The first term of the equation is a reward for the quality of fit, and the second is a penalty for increasing the number of model parameters. The preferred model will be the one with the lowest *AIC*.

RESULTS

Table 1 shows the descriptive analysis of hospitalizations (morbidity) for respiratory diseases (pneumonia) for children and adults with daily averages for the months of 2011-2015. During the study period (January 1, 2011 to December 31, 2015), the number of hospitalizations for respiratory diseases was 609 (314 children and 295 adults, with a mean of 5 daily admissions, with a minimum of 2 and a maximum of 9).

Based on the data, it is important to check if there is a pattern in the proposed data set; therefore, we present in figure 1 the data set time series.

Table 1. Hospital admissions (morbidity) due to respiratory diseases (pneumonia) in children and adults in Campo Grande, from 2011 to 2015.

Children	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2011	5	6	4	9	8	7	9	7	8	8	8	6
2012	3	4	5	6	4	5	4	5	5	4	4	6
2013	4	3	4	4	4	5	5	7	4	5	6	4
2014	5	5	5	4	4	6	5	5	5	5	5	4
2015	2	3	3	4	5	6	6	6	7	6	6	4
Average	4	4	4	5	5	6	6	6	6	6	6	5
Stdev	1	1	1	2	2	1	2	1	2	2	1	1
Adults	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2011	4	5	3	7	6	5	7	5	6	6	6	5
2012	3	5	5	7	4	5	4	5	5	5	5	7
2013	4	3	4	4	4	4	4	7	4	5	6	4
2014	5	5	5	4	5	6	6	5	5	6	5	4
2015	2	3	3	4	5	6	5	6	7	6	6	4
Average	4	4	4	5	5	5	5	6	6	6	5	5
Stdev	1	1	1	1	1	1	1	1	1	1	1	1
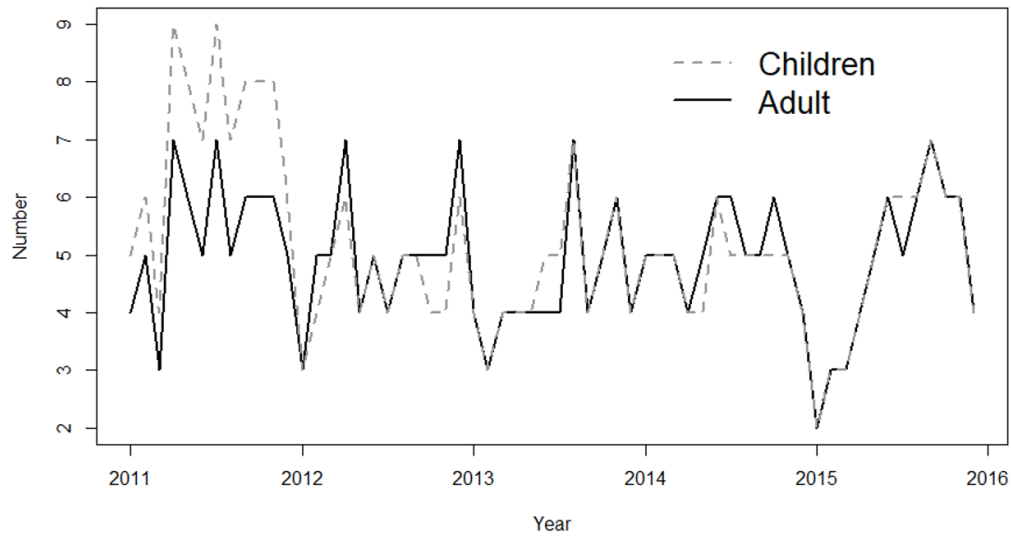
Figure 1. Time series for the monthly number of hospital admissions for 2011-2015.
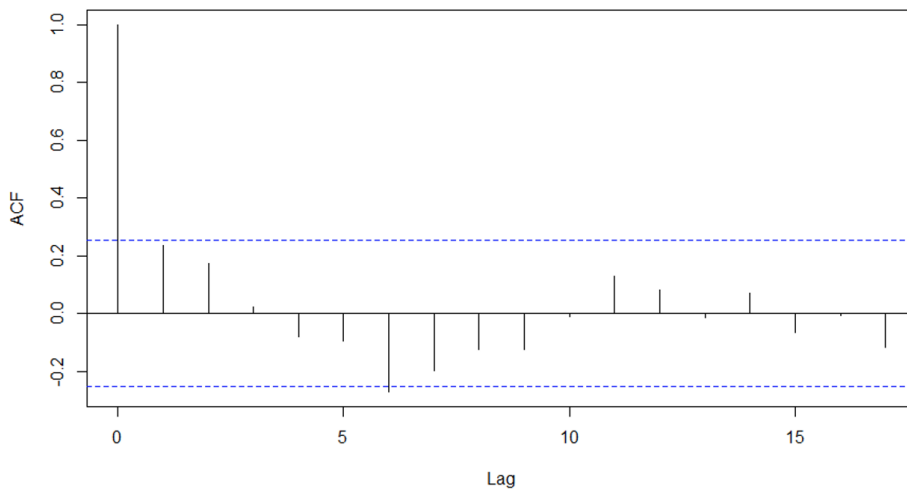
Figure 2. Autocorrelation for the monthly number of hospital admissions for the adult data.

Based on the data, a seasonal pattern was observed between rainy and dry seasons, and the transition period, especially in the quarters (April, May, June, July, August, and September), where the peak of hospitalizations corresponds to the dry season, low rainfall, relative humidity modeling minimum temperatures, and the period of highest burning rates in the state of Mato Grosso do Sul. Due to the small autocorrelation obtained from Figure 2, firstly, we will consider assumption that the data set is independent and identically distributed. Further, we will extended the analysis for using regression models where the covariates are related to dry or rainy seasons.

Model fitting with parameter estimation

The tested distributions' parameters estimates were obtained using MLE and are presented in table 1. These parameters were computed using the statistical software R.

Table 2. Parameter estimates for the distributions studied related to the children and adult data.

Children	θ	Estimates		R²	MAE	RMSE	MAPE
Weibull	a	5.740	pdf	0.5268	0.0509	0.0705	50.498
	b	3.631	cdf	0.9584	0.0646	0.0978	**17.751**
Logistic	μ	5.067	pdf	0.5803	0.0480	**0.0374**	51.330
	σ	0.839	cdf	0.9667	**0.0542**	0.0575	19.376
Gamma	a	12.132	pdf	**0.7148**	0.0397	0.0551	**48.721**
	b	0.427	cdf	**0.9754**	0.0618	0.0861	29.097
Normal	μ	5.183	pdf	0.5319	0.0480	0.0684	51.330
	σ	1.513	cdf	0.9589	0.0542	0.0848	19.376
Adult							
Weibull	a	5.385	pdf	0.6500	0.0607	0.0699	51.351
	b	4.813	cdf	0.9702	0.0832	0.1061	34.173
Logistic	μ	4.933	pdf	0.7198	0.0511	**0.0399**	35.696
	σ	0.665	cdf	0.9742	0.0817	**0.0625**	**25.676**
Gamma	a	16.781	pdf	**0.8677**	**0.0395**	0.0435	**29.351**
	b	0.294	cdf	**0.9877**	**0.0807**	0.0915	26.845
Normal	μ	4.933	pdf	0.7389	0.0528	0.0607	37.098
	σ	1.163	cdf	0.9769	0.0827	0.1010	25.892

The comparison of the four pdfs and their corresponding cdfs with the histogram of the monthly number of hospital admissions for 2011 to 2015 are illustrated in Figure 3.
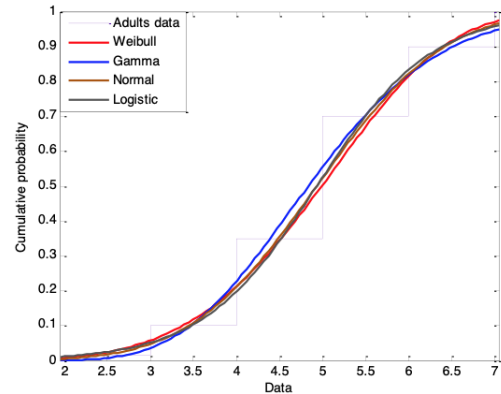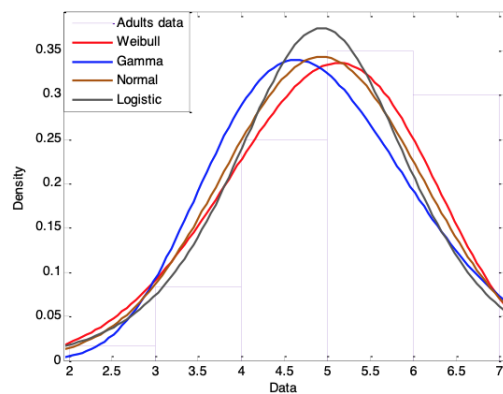
a) Adults
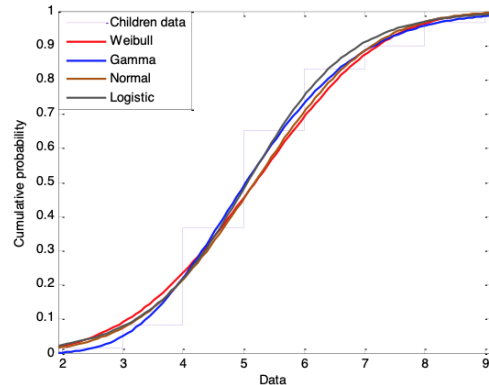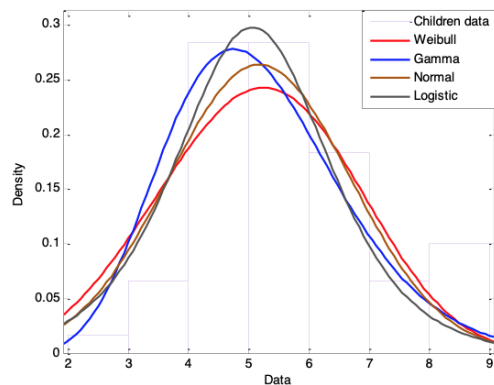
b) Children
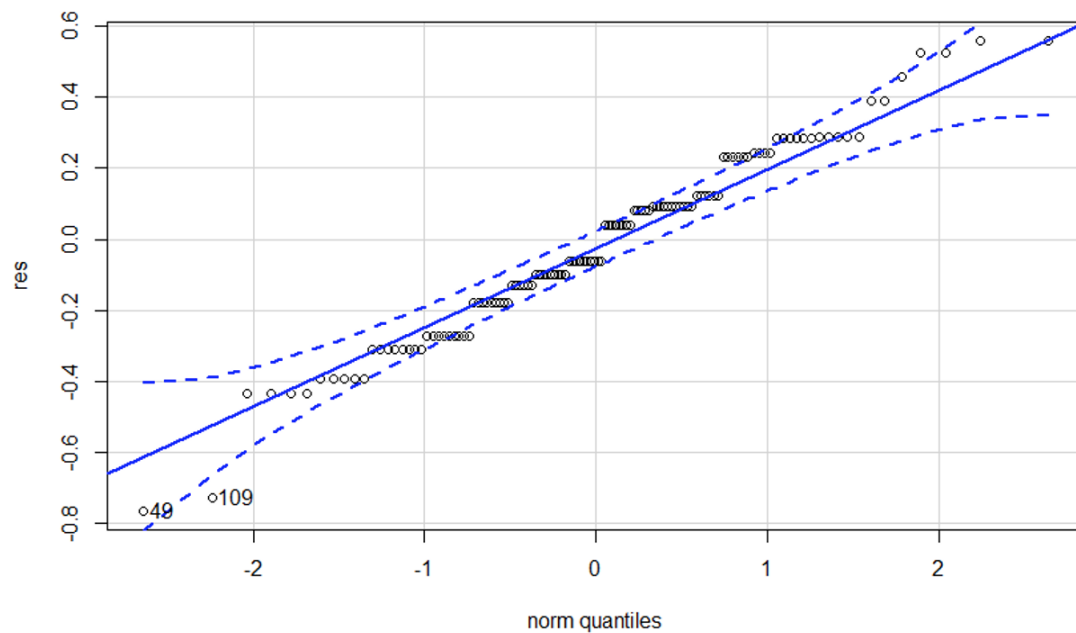
c) Normal deviation chart with distribution for respiratory hospitalizations

Figure 3. a) pdf (left) and b) cdf (right) plots of the distributions obtained for the monthly number of hospital admissions for 2011-2015, c) normal deviation chart with distribution for respiratory hospitalizations in Campo Grande, for all age groups by period.

Table 2 show the results of the tests used. When choosing the best fitting model among the considered ones according to given criteria, we selected the model with lowest values of MAPE, MAE and RMSE, with R^2 closest to 1. The best values are highlighted in bold. According to the values of the model selection criteria, from the probability distributions considered, Gamma distribution satisfactorily fits to the hospital admission data for both age groups, followed by Logistic and Normal distributions. Gamma distribution is better than other distributions with respect to R^2; on the other hand, Logistic distribution achieves better values of RMSE. This is also evident and confirmed in the plots provided in figure 3.

So far, we have considered that the data set is i.i.d; however, we believe that dry and rainy season may increase or decrease the number of admissions. Therefore, we considered the same models in the presence of regression structure; the AIC values allow us to discriminate the models and are given in table 3.

By means of the selection criteria, we verified that, among the models used, Gamma distribution also returned the best fit for the proposed data. It should be noted that the selection criteria do not help to verify how well the model was adjusted, for this, residue analysis was considered to verify the model suitability. To achieve this, we apply KS and SW tests to verify the assumption of normal values of Gamma distribution's adjusted residuals.

In this case, if p-value is greater than 0.05, residuals follow a standard normal distribution and, therefore, the analysis is being performed adequately. Such a factor can also be confirmed by visual techniques such as the quantil-quantil plot given below:

We observe that almost all points are within the confidence interval of the adjusted curve, showing a good fit of Gamma distribution with covariates to describe the model.

In this way, with the regression model, we can easily make predictions for patient admission based on the information of the period of the year and whether they are adults or children (Table 3).

Table 3. AIC for used distributions, tests of normality of Gamma distribution's adjusted residuals, adjusted parameters for the Gamma regression model and prediction of the mean number of admission and its respective 95% confidence intervals.

Distributions	AIC	p-value	Coefficient	Estimated	Std. Error	p-value	Type of patient	Period	Estimates	95%CI
							Adult	Dry	5.3	(4.9; 5.7)
Weibull	411.11	0.43	Intercept	5.316	0.213	<0.0001		Rainy	4.6	(4.2; 4.9)
Gamma	404.87	0.10	Child / Adult	0.228	0.236	0.3360	Child	Dry	5.5	(5.1; 6.0)
Logistic	411.10		Period	-0.743	0.238	0.0023		Rainy	4.8	(4.4; 5.2)
Normal	406.86									

DISCUSSION

The incidence of respiratory diseases/pneumonia in children/adults is influenced by several factors. It appears that air pollution is the main risk factor related to these diseases, followed by natural climatic conditions and, to a lesser extent, viral infections, behavioral and/or domestic factors and family history of the disease. Likewise, it appears that the most investigated pollutant, among the filtered studies, is particulate material with a diameter of less than 2.5 micrometers (μm) - ($PM_{2.5}$), a type of inhalable particles, and it is shown that it is harmful even within the ideal limits established by World Health Organization (WHO).

Studies point to the relevance of exposure to air pollution in the development of respiratory diseases.[5-7] There is important evidence that exposure to pollutants, especially $PM_{2.5}$, corresponds to a strong risk factor for respiratory diseases. Above 50 μg/m³, for each addition of 10 μg/m³ in the levels of $PM_{2.5}$ there is a 2% increase in clinical visits, while, below this concentration, each increase in the same proportions resulted in an increase of 1% in the same variable.[8] In Brazilian cities, the increase of 3 to 5 μg/m³ was associated with an increase in the risk of developing respiratory diseases/pneumonia and in hospital admissions for children/adults, which varied according to the city.[5-7]

The impacts of air pollution on respiratory, cardiovascular and metabolic health have been studied and highlighted, since it is a risk factor caused by human activities, and can be reduced. However, it should be noted that, even at levels considered safe by WHO, air pollution may have contributed to the increase in the number of hospitalizations of children/adults for respiratory problems. Children are more susceptible to the effects of air pollution and, therefore, can develop acute respiratory symptoms more easily,[6] as they have greater lung ventilation than adults.[7] Still, children spend less time outdoors and, for this reason, have less contact with air pollution. However, the brief contact with pollution can have more severe effects.[7]

Inhalation of $PM_{2.5}$, due to the reduced aerodynamic size of its particles, can damage cardiopulmonary tissues, cross the alveolar-capillary barrier and reach the blood circulation, so that it can compromise other systems besides the respiratory system.[8] At the pulmonary level, it can directly lead to the formation of reactive oxygen species (ROS), activate macrophages and increase the production of inflammatory cytokines, propagating the inflammatory response.[9]

PM_{10} is less harmful than $PM_{2.5}$, due to the greater aerodynamic size of its particles (2.5-10 μm) that restrict its reach to the upper respiratory tract.[10] One of the main sources of this pollutant is burning, which is common in the central west region, in the dry season,[8,10] where the release of PM_{10} overlaps with that of $PM_{2.5}$.[10]

The levels of NO_2 and O_3 were also correlated with the risk of pneumonia incidence in children in Campo Grande.[11] The increase of 3 μg/m³, corresponding to the interquartile difference, in NO_x concentrations, generated percentage increases in the order of 14.8%, even though the concentrations did not exceed the limits considered acceptable.[5] NO_x represents all nitrogen oxides present in the atmosphere, but as NO is rapidly oxidized to NO_2, the NO_x concentration reflects the NO_2 concentration.[12] O_3 was also correlated with respiratory problems.[5] The increase in O_3 concentration by 10 μg/m³ was associated with an increase of 3.91% in respiratory diseases in children under 5 years of age.[5]

These pollutants are capable of increasing the bronchial epithelial permeability, consequently, leukocyte infiltration and the release of inflammatory mediators.[13] Considering that the pulmonary ventilation of children is greater than that of adults,[13] they become more prone to inflammation of the upper and lower airways due to exposure to air pollution and, therefore, represent a risk group for such effects. Chronic exposure to air pollution sensitizes the respiratory tract early, which is already inflamed by other health issues. Therefore, pollution represents a source of early and continuous allergic awareness.

Unlike atmospheric pollution by industrial and automobile sources, which are characterized by chronicity, the pollution resulting from fires is seasonal,[12,13] and is also related to the increase in the number of hospitalizations for respiratory diseases.[13,14] In addition to this, exposure to pollutants resulting from fires can exceed the places where they occur, due to air masses, leading to a higher incidence of respiratory diseases in other locations.[13] Exposure to air pollutants, regardless of the source, can often boost the effects of climatic factors on hospitalizations for respiratory events, and vice versa. In the Manaus region, hospital admissions appear to be more related to meteorological variables, especially humidity, than to pollutants from biomass burning.[11] There is evidence that there is a direct relationship between meteorological variations and the population's health, especially in the impairment of lung function and in the incidence of respiratory diseases.[11-14]

Variations in temperature and humidity are also related to changes in pollutant concentrations and, consequently, hospitalizations for respiratory diseases. The increase in temperature was associated with an increase in concentrations of $PM_{2.5}$.[15] Likewise, both the increase and the sudden reduction in temperature are related to the development of respiratory diseases, as well as the reduction of humidity and thermal comfort for the population.[10]

In the South region, most complaints of respiratory problems occurred in the coldest months (July-September),[16] and in the months that foresee the arrival of this season,[10] however, they were not correlated with precipitation rates.[16] In Rio de Janeiro, most complaints of viral respiratory infections occurred between late autumn and spring.[12]

Of the included studies, three verified the relationship between viral infections and children's respiratory problems. Viruses are largely responsible for the incidence of respiratory diseases in children. About 50%

of colds are of viral origin, and culminate in economic losses in relation to medical care, and social losses due to school absences.[16]

The higher incidence of respiratory diseases caused by viral causes in children is mainly due to their immature immune and respiratory system, which makes them more prone to infections and co-infections. Also, age interferes with the environment and individual behavior. At older ages, they spend most of the time in other places, due to curricular and extracurricular activities, which involve locomotion and contact with other risk factors. Specific environments and individual behavioral patterns can influence individual exposure to pollutants and clinical respiratory patterns.[13]

Behavioral and/or domestic factors (use of a wool blanket, smoking by parents, contact with household dust, among others) seem to have little influence on the children's respiratory, compared to the others mentioned. Although there is a mild effect, children with atopic allergy, renitis or asthma respond more severely to household dust.[16,17]

In this study, we list several risk factors for respiratory diseases in children/adults, mainly exposure to air pollutants, followed by natural climatic conditions, viral causes, behavioral and/or domestic factors, and family history of the disease. It is inferred that exposure to the association of different factors can aggravate and increase the incidence of respiratory diseases, and it is highlighted that factors such as pollution originate from human activities and, therefore, can be remedied. There is also the need to expand studies on the effects of exposure to pollutants in children/adults, due to the greater susceptibility of this age group.

Still, it was found that the pollutant most investigated in the studies and that is related to a greater chance of developing respiratory diseases in children is $PM_{2.5}$, and that it can cause damage even within the limits considered ideal. Therefore, the relationship between air pollution and hospital admissions can be extrapolated to small cities, where air quality is still in line with WHO parameters.

Understanding the main risk factors associated with respiratory diseases in children/adults is essential to plan public health actions, with a view to reducing and preventing the incidence of these diseases.

In this study, parameter values for all proposed models, Weibull, Normal, Gamma, Logistic, were estimated using MLE. Four different performance indicators were used to test the accuracy of the estimated distributions. Table 3 summarizes the results related to the MLE estimation method. Through a detailed assessment of these results, it can be observed that the Gamma model based on MLE obtained the best results using all indicator tests. Based on the RMSE results, the model recorded the lowest values among the other models. MAE values corroborate the RMSE results, which confirmed the model's superiority over the others. A closer inspection of accuracy analysis results shows that the results obtained with the R^2 test indicate a high degree of consistency between

the observations and predicted pdfs, with a value of 0.9.

Souza et al.[2] adjusted the Burr (Bu), Inverse Gaussian 3P (IG3P), Lognormal (LN), Pert (Pe), Rayleigh 2P (Ra 2P) and Weibull 3P (W3P) distributions of the historical series of hospitalizations for diseases (total hospitalizations). According to the authors, the Gamma probability distribution function proved to be adequate to represent hospitalizations in all months of the year. Adjustments of probabilistic models can be seen in figures 3a and b. In general, a good fit of the models to the observed data is perceived. A proximity in the behavior of the curves of the different models with the parameters estimated by MLE obtained more indications as the most adequate pdf to represent the observed data (Table 3). These results corroborate those obtained by Souza et al.,[2] who verified compliance with the distributions to the monthly hospitalization data in Campo Grande.

To reduce uncertainties in hospital admission estimates, this study compared four candidate distributions (Weibull, Normal, Gamma, Logistic), in order to select the pdf that best matches hospital admissions dataset. The monthly data of hospital admissions, from 2011 to 2015, in Campo Grande, Brazil, were adjusted by the distributions considered. To determine the effectiveness of the statistical models, the four fit quality tests (R^2, RMSE, MAE and MAPE) were performed. The analysis of the monthly values indicates that Gamma is the best out of the four distributions based on the selected criteria.

Based on the results obtained, it can therefore be concluded that Gamma regression model fits the data and can be used as an alternative distribution that adequately describes hospital admission data considered in Campo Grande, Brazil.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

DATABASE DECLARATION/DATA AVAILABILITY

The climate database is in the public domain and is available at: https://www.cemtec.ms.gov.br/ and the hospital admissions database is available at http://www2.datasus.gov.br/DATASUS/index.php?area=02

ETHICAL CONSIDERATIONS

The present study is based on secondary, publicly available data, which do not constrain groups of popula-

tions and/or individuals in the presentation of the results found, ensuring the confidentiality of the information collected. Thus, the ethical aspects of research with human beings were respected, according to Resolution 466/2012.

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AUTHORS' PARTICIPATION

All authors participated in the article preparation, review and writing, and data collection and analysis.

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ORIGINAL ARTICLE

Efficacy and effectivity of UVC for disinfection of hospital materials of COVID-19 patients

Eficácia e efetividade do UVC para desinfecção de materiais hospitalares de pacientes com COVID-19

Eficacia y efetividad de UVC para desinfección de material hospitalario de pacientes con COVID-19

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ABSTRACT

Background and Objectives: After the beginning of the COVID-19 pandemic, more effective and efficient means were needed to disinfect hospital materials. The objective of our study is to evaluate the *in vitro* efficacy and the economic effectiveness of type C ultraviolet (UVC) irradiation for disinfection of materials used in the care of COVID-19 patients. **Methods**. Four bipartite Cled plates were inoculated with suspensions of 10,000 CFU/mL of *Escherichia coli* and *Staphylococcus aureus* strains, exposed to two 18W lamps, placed inside a laminar flow and incubated for quantitative growth assessments. The germicidal equipment was built: the "UVC box" was developed with two 18W lamps for use in materials returned to pharmacy and a "UVC closet" with two 60W lamps for surgical gowns exposure. The economic effectiveness was evaluated by comparing inventory costs with quarantine of materials versus UVC usage costs. **Results.** Microbiological inactivation in the plates started after 4 minutes with an efficiency close to 100% at 8 minutes. The "UVC box" reduced the time to release the material from 9 days to immediately, generating savings of approximately R$ 68,400, and the "UVC closet" changed the use of surgical gowns to 0.7/patient, compared to the usual of 1.5, generating savings of nearly 3,000 reais/month. The cost of installation and maintenance was R$ 1,500. **Conclusions.** The efficacy and effectiveness of the UVC system was proven, as well as the economy promoted by its installation.

Keywords: Ultraviolet Rays. Coronavirus Infection. Administration of Healthcare Services.

RESUMO

Justificativa e Objetivos: Após o início da pandemia de COVID-19, meios mais efetivos e eficazes foram necessários para desinfetar materiais hospitalares. Este trabalho visa avaliar a eficácia *in vitro* e a efetividade econômica

de luz ultravioleta tipo C (UVC) para desinfecção de materiais usados em pacientes com COVID-19. **Métodos:** Quatro placas bipartidas de Cled foram inoculadas com suspensões de 10.000 ufc/mL de cepas de *Escherichia coli e Staphylococcus aureus*, expostas a duas lâmpadas de 18W, colocadas dentro de um fluxo laminar e incubadas para avaliações quantitativas de crescimento. O equipamento germicida foi construído: uma "caixa UVC" com duas lâmpadas de 18W para materiais da farmácia e um "armário UVC" com duas lâmpadas 60W para exposição de capotes. A efetividade econômica foi avaliada comparando os custos de estoque, com quarentena de materiais versus custos de uso da UVC. **Resultados:** A inativação microbiológica nas placas se iniciou a partir de 4 minutos, com eficácia próxima a 100% aos 8 minutos. A "caixa de UVC" reduziu o tempo para liberação do material de 9 dias para imediato, gerando uma economia de aproximadamente R$ 68.400,00, e o "armário de UVC" alterou o uso de capotes para 0,7/paciente, comparado ao uso habitual de 1,5, gerando uma economia de 3.000 reais/mês. O custo de instalação e manutenção foi de R$ 1.500,00. **Conclusão:** Foi comprovada a eficácia e efetividade dos sistemas UVC, além da economia promovida por sua instalação.

Descritores: Raios Ultravioleta. Infecções por Coronavírus. Administração de Serviços de Saúde.

RESUMEN

Justificación y Objetivos. Despuésdelinicio de la pandemia de COVID-19, se necesitaronmedios más efectivos y eficientes para desinfectar losmaterialeshospitalarios. El artículo tiene como objetivo evaluarlaeficacia *in vitro* y la efectividad económica de la luz ultravioleta tipo C (UVC) para desinfección de materiales utilizados enlaatención al paciente con COVID-19. **Métodos**. Cuatro placas partidas Cledfueron inoculadas consuspensiones de 10,000 UFC/mL de cepas de *Escherichiacoli* y *Staphylococcusaureus*, expuestas a dos lámparas de 18W, colocadas dentro delflujo laminar e incubadas para evaluacionescuantitativas de crecimiento. Se construyóel equipo germicida: una "caja UVC" con dos lámparas de 18W para materiales de farmacia y un "armario UVC" con dos lámparas de 60W para exponerlas batas. La efectividad económica se evaluó comparando loscostos de inventario conlacuarentena de materiales, versus loscostos de uso de UVC. **Resultados**. La inactivación microbiológica enlas placas se inició a los 4 minutos con una eficienciacercana al 100% a los 8 minutos. La "caja UVC" redujoeltiempo de liberacióndel material de 9 días a una liberacióninmediata, economizando aproximadamente R$ 68.400 y el "armario UVC" cambióel uso de batas a 0,7/paciente, frente al uso habitual de 1,5, economizando aproximadamente 3.000 reales/mes. El costo de instalación y mantenimientofueR$1.500. **Conclusiones.** La efectividad y eficaciadel sistema UVC fuecomprobada, además de los resultados enlaeconomía por suinstalación.

Palabras clave: Rayos ultravioleta. Infecciones por coronavirus. Administración de servicios de salud.

INTRODUCTION

The emerging outbreak of COVID-19, declared a pandemic by the World Health Organization (WHO), has set up an extremely challenging scenario for health services globally. The Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2)pathogen, causing the Coronavirus Disease Discovered in 2019, emerged in Wuhan, China, and took global proportionsin 2020.

The virus has high pathogenicity and transmissibility, and can cause from asymptomatic conditions to mild systemic involvement, such as fever, cough, arthralgia, myalgia, rhinorrhea and diarrhea.[1] It is also responsible for the large increase in the number of hospitalizations for pneumonia with repercussions of the disease in multiple organs and may progress to severe disease marked by hypoxemic respiratory failure and the need for prolonged ventilatory support.[2,3]

The transmission of SARS-CoV-2 has also a challenging issue: an infected person without symptoms can also transmit COVID-19, which can occur through the air, by respiratory droplets that come out of the mouth or nose when an infected person speaks, sings, shouts or

by person-to-person contact through touch, kiss, hug or handshake, followed by mouth, nose and eye contact. It also occurs by fomites contaminated with these droplets, when these surfaces or objects are touched and the contaminated body part comes into contact with the mouth, nose or eyes.[2]

As there is still no vaccine for SARS-CoV-2 available for the entire population, it is necessary to avoid exposure to the virus for infection prevention, which can be done through nonpharmacological interventions with proven effectiveness against the other six coronaviruses throughout history.[4] Some examples are measures such as frequent hand washing up to the wrists with soap and water or 70% alcohol-based hand rub, covering the nose and mouth with a tissue or the inside of the elbow during coughing or sneezing, and the minimum distance of one meter between people in public and social spaces, in addition to the use of masks in all environments.[5]

Another aspect involves environmental considerations to reduce transmission of the virus. As the pathogen can survive for days on solid surfaces and a few hours in suspension in the air, effective disinfection is essential to reduce viral transmission.[6] Even with adequate hand

hygiene, this measure alone, especially in clinics and hospitals, may fail, as when touching contaminated surfaces close to a patient, the professional can invalidate the effect of hand washing by transferring pathogens from that patient to another, perpetuating the transmission of microorganisms.[7] In addition, studies evaluating the effectiveness of standardized cleaning interventions in healthcare facilities have reported that approximately 5–30% of surfaces remain potentially contaminated because the existing detergent and disinfectant formulations are ineffective to break biofilms.[8] However, not all objects can be treated with chemical biocidesgiven the possible risk of deterioration of the material, especially those with electronic parts.[9]

Many current studies have addressed the effectiveness of using ozone as a disinfection method, a substance that has proven effective during in vitro inactivation of a series of microorganisms, including important pathogenic bacteria and viruses in hospital infections.[10] Since its use as a preferred procedure in disinfection or sterilization of environments or hospital areas is not well establishedand due to its toxicity, it has fallen into disuse for disinfection of closed environments in many places.[11]

While the effect of daylight on viruses such as COVID-19 is still unexplored, spectrum-tuned electrical lighting is already implemented as an engineering control for indoor disinfection.[12-14] An important, growing strand of environmental considerations to reduce viral transmission for the control and prevention of COVID-19 involves more specifically the use of ultraviolet (UV) rays.[15] In this context, UV germicidal irradiation has received greater attention in the hospital environment after decades of underutilization. Used in several sectors as a germicide given its cost-effectiveness, its use in the hospital sector is on the rise for its proven high effectiveness in cleaning surfaces contaminated by hospital pathogens, being able to reduceby more than 99% the formation of bacterial-colonies on surfaces such as Intensive Care Unit (ICU) computers.[16] With renewed interest in this technology, new practical questions arise, especially with regard to efficacy and safety. Many investigations have concluded that if used correctly, UV radiation can indeed be safe and highly effective in air disinfection.[17] Some pathogens are persistent in healthcare environments and contaminate surfaces and materials in wards, operating rooms and intensive care centers, where the practice of disinfecting hospital utensils with germicidal irradiation has also been quite common.[9]

The effectiveness of UVC lamps against microorganisms on surfaces is known. At shorter wavelengths (UVC ≈ 254 nm), they are safe and have germicidal quality. For example, UVC can be effective to inactivate droplets with mycobacteria if it reaches an average irradiance of 30-50μW/cm2.[18] The effects of UVC irradiation result in cell damage by photohydration, photodissection, photodimerization and photo-induced crosslinking, thereby inhibiting the replication of microorganisms. We highlight the main advantages of using this technology: it does not require changes in the ventilation of the environment; leaves no residue after disinfection; has a broad spectrum of action at fast exposure times; and the possibility of designingportable devices of simple handling until large devices, which expands the disinfection capacity, covering procedural materials, surfaces and environments.[14]

After the beginning of the COVID-19 pandemic, an increase in hospital supplies and PPE expenses was observedin the hospital studied. When suppliesdispensed by the pharmacy are not used by patients with suspected or confirmed COVID-19, they are placed in a nine-day "quarantine", which generates an extra need/cost of stock. Regarding gowns, there was an increase in demand at the hospital as a whole and, especially, at the unit of care for COVID-19 patients. Therefore, the question on how to increase the shelf life and reuse of gowns and how to eliminate the "quarantine" of hospital suppliesarose, thus eliminating the consequent stock/extra cost safely. The use of UVC lamps is an alternative for greater economic effectiveness in hospital management in a pandemic context.

Given the variety of possibilities for using UVC, arises the question if there is a way to guarantee the germicidal efficacy of lamps available in the Brazilian market.

In this sense, the objective of the study is to evaluate the germicidal effectiveness of UVC lamps available in the Brazilian market. The aim of the study is also to evaluate the economic effectiveness of this model of disinfection of hospital supplies returned to the pharmacy and of gowns used in the care of patients with suspected or confirmed COVID-19.

METHODS

Microbiological tests were done in the microbiology laboratory of a high complexity hospital located in the city of Belo Horizonte, Minas Gerais. The aim was to demonstrate the bactericidal effect of ultraviolet light through the exposure of newly seeded plates with microorganisms used for quality control of culture media in order to infer the ability to deliver energy of UVC radiation specifically (two 18W lamps each). In this experiment, four bipartite Cled plates were inoculated with 10,000 cfu/mL suspensions of *Escherichia coli* (ATCC 25922) and *Staphylococcus aureus* (ATCC 29213) strains on each side and then placed inside a laminar flow of radiation and covered with aluminum foil in such a way that the upper half of each seeded area was protected from light exposure. The first plate was exposed to light for only 1 minute, the second for 2 minutes, the third for 4 minutes and the fourth plate for 8 minutes. Plates were incubated for quantitative growth assessments after 12, 24 and 48 hours.

In the pharmacy, a mobile box built with two UVC lamps of 18W each was positioned (Figure 1). The disinfection device had a total cost of R$ 500.00. Between March and July 2020, supplies from 128 patients were returned to the pharmacy, exposed to UVC lamps for 10 minutes and made available for immediate use by other patients (Table 1). On average, the box with UVC lamps can be used five times per hour, allowing the disinfection of approximately 1kg of material at a time.

Table 1. Quantity and percentages referring to materials returned to the pharmacy.

SUPPLIES	FREQUENCY	PERCENTAGE
40 x 20 needles	569	23%
10ml syringe	372	15%
Optiumpoc test tape	259	10%
Blood glucose lancet	255	10%
20ml syringe	149	6%
Gauze 7.5 x 7.5	126	5%
1ml syringe with device	95	4%
5ml syringe	66	3%
3ml syringe	59	2%
Surgical glove 7.5	50	2%
Jelco 20D safety	42	2%
Surgical glove 6.5	35	1%
Sterile gloves 8.0	29	1%
25 x 7 needles	26	1%
Number 11 scalpel blade	24	1%
Surgical glove 7.0	22	1%
Endo tube 8.0	22	1%
3 way faucet	21	1%
Disposable electrode	20	1%
Infusion pump LF 2001	19	1%
Closed suction system 14	17	1%
Othersupplies	242	10%
TOTAL	2,519	100%

Figure 1. "UVC box" for disinfection of supplies returned to the pharmacy: portable device at different angles (1, 2 and 3) with two 18W lamps each.

In the sector of COVID-19 patients, a "UVC closet" was built with two 60W lamps each and a motion detector device to turn them off as soon as the curtain is opened, in addition to the option of turning them on with an external switch (Figure 2). This system was evaluated for two months: in July 2020, 622 patients were hospitalized in the COVID-19 area with consumption of 434 water-proof gowns; in August, 576 patients were hospitalized in the sector, with consumption of 403 gowns. In June, the UVC system had not yet been installed, and 284 patients were hospitalized that month and 420 gowns were used. The installation of the closet meant that each patient generated the use of 0.7 gowns, on average. Without the device, 1.5 gowns are used for each patient. The savings with waterproof gowns, unit cost of R$ 7.20 (seven reais and twenty cents), was approximately R$ 3,000.00 per month. The total cost of installation and maintenance was R$ 1,000.00.

Figure 2. ""UVC closet" with motion detector device at different agles (1, 2 and 3), for disinfection of gowns in the COVID-19 area: two UVC lamps of 60W each.

In addition to microbiological analysis, the use of a radiometer is essential to measure the real power and dose of radiation generated by UVC lamps available in Brazil (Figure 3). This was the item with the highest cost (R$ 5,000.00) in the project, but it can be used for other projects and for the provision of services in other hos-

pitals. Radiometer measurements showed no leakage of radiation outside the pharmacy's "UVC box", nor outside the "UVC closet" of the COVID-19 area. In the pharmacy UVC box, the two lamps generate an average power of 1.11 mW/cm^2, well above the minimum limit required by the CDC to eliminate mycobacteria, which is 30-50 µW/cm^2.[13]

to conclusionson the low penetration capacity of UVC radiation in liquid or gelatinous media, evidenced by bacterialgrowth below the culture medium even after 8 minutes of exposure. Thus, given the good germicidal results and considering that SARS-CoV-2 is an enveloped virus hence, easier to be eliminated when structurally compared to inoculated *E. coli* and *S. aureus*, a device of UVC light emission of 36W power is 100% effective with at least 10 min of irradiation.

Figure 3. Different angles (1, 2 and 3) of the radiometer used to measure the power and radiation dose of the "UVC box": essential for full control of the use of lamps.
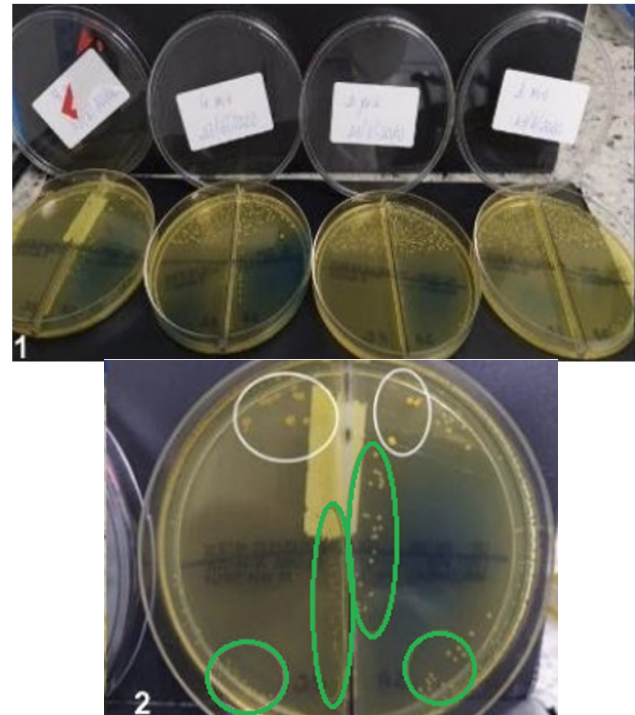
Figure 4. On the left, are the plates exposed to UVC radiation for 8, 4, 2 and 1 minute, respectively. On the right is the plate exposed for 8 minutes, indicating the colonies circled in white that grew on the surface of the shaded half and survived the indirect action of UVC. In green are microorganisms that have infiltrated under the agar at the edges of the plate and have resisted the exposure.

RESULTS

After incubation of the four bipartite Cled plates, the inactivation of bacteria in the area exposed to UVC radiation starts at 4 minutes and reaches efficiency close to 100% at 8 minutes of exposure for both strains of *E. coli* and *S. aureus*, commonly used in routine quality control of a microbiology laboratory through microbiological assays (Figure 4). In addition, it was possible to observe the elimination of colonies also in the shaded half of the plates, which shows the indirect action and may suggest irradiation of the energy delivered by UVC lamps between bacteria, or even some penetration by the aluminum foil. The presence of colonies was also observed in regions of the medial and inferior edges of the unshaded area of the plate at 8 minutes, which, at first, raised suspicions about the germicidal effectiveness of the lamps. However, when analyzing the experiment more closely, these colonies were actually found under the agar plate. A leakage of the suspension containing bacteria in these regions was observed, which can lead

With use of the "UVC box" for disinfection of materials returned to the pharmacy, there was a reduction in the time to release the material from nine days to immediate, avoiding the stock increaseby approximately R$ 68,400.00. In five months, 2,519 supplies used by the 128 suspected or confirmed COVID-19 patients were returned. The use of UVC lamps to sterilize gowns meant that each patient generated the use of 0.7 gowns, on average. Without the "UVC closet", 1.5 gowns are used for each patient. Savings only with waterproof gowns, at a unit cost of R$ 7.20 (seven reais and twenty cents), were of approximately R$ 3,000.00 per month. The total cost of installation and maintenance was R$ 1,000.00. Economic effectiveness was evaluated by comparing material quarantine inventory costs versus UVC usage costs. Thus, in addition to being effective,the system proved to be totally economically effective both for the disinfection of

hospital supplies returned to the pharmacy and for the disinfection of gowns.

DISCUSSION

The UVC lamps available in the Brazilian market are proven to be effective. The microbiological inactivation in the experiment with bipartite Cled plates starts after 4 minutes with efficiency close to 100% at 8 minutes of exposure for both strains used. Considering that SARS-CoV-2 is an enveloped virus, hence easier to eliminate, a 36W UVC device is 100% effective with at least 10 min of irradiation. Furthermore, through the experiment, the growth of microorganisms was noticed only on the surface of the plates with a low penetration capacity of UVC rays in liquid or gelatinous media, drawing attention to the care with this detail in the disinfection of gowns and materials that could possibly have been moistened prior to disinfection by UVC devices.

The construction of a low-cost and safe UVC equipment for disinfecting gowns and unused medical supplies that return to the pharmacy is possible. The two devices developed based on the UVC germicidal action were built at low cost and, as long as handled with appropriate PPE, they are completely safe for use. Measurements made by the radiometer showed no leakage of radiation out of the devices. Furthermore, the installation of an "inverted" motion detector device, which turns off the lamps in the gown "closet" in the presence of a person proved to be a fundamental safety resource.

In five months, the total cost of installing and maintaining the devices, added to the acquisition of the radiometer, was R$ 6,500.00. The total return was R$ 83,400.00; considering the extra stock at the pharmacy and expenses with gowns, after subtracting the cost of assembling the devices, a return of practically R$ 77,000.00 was generated in five months.

Data in the literature on similar sized equipment that allow disinfection of a similar volume are scarce. LUCIA is a prototype used for the disinfection of N95 masks with an initial cost of 360.00 U$D (equivalent to about R$ 1,980.00) for equipment assembling. However, its dimensions are significantly smaller and the costs of monthly maintenance of the equipment were not specified.[19]

The germicidal efficacy and economic effectiveness of systems that use UVC rays were demonstrated, adding even more value to studies of this resource and leaving as a legacy of continuity the improvement and the search for more devices, as well as different and innovative ways of using the antimicrobial action of UVC irradiation.

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AUTHOR'S CONTRIBUTION

Henrique Rietra Dias Couto, Danilo Cotta Saldanha and Silva e **Lucca G Giarola** contributed to the planning and writing of the article.

Bráulio Roberto Gonçalves Marinho Couto contributed to the analysis and interpretation of the data.

Jeruza AQ Romaniello contributed to the design and review of the article.

Davi B Rocha and **Wilson Souza Lima** contributed to the design and final approval of the article.

All authors approved the final version to be published and are responsible for all aspects of the work, including ensuring its accuracy and integrity.

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ORIGINAL ARTICLE

Epidemiological profile and factors associated with cervicalvaginal infections in quilombola women submitted to preventive examination

Perfil epidemiológico e fatores associados às infecções cérvico-vaginais em mulheres quilombolas submetidas ao exame preventivo

Perfil epidemiológico y factores asociados a infecciones cérvico-vaginales en mujeres quilombolas sometidas a examen preventivo

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ABSTRACT

Background and Objectives: reproductive tract infections are considered an important demand for women's health, due to their high prevalence in the population and the consequences they can cause, such as premature birth, infertility and cervical cancer. There are still women who do not undergo cytopathological examination, capable of preventing these infections, either due to lack of guidance or opportunity, such as *quilombola* women. This study aimed to identify factors associated with cervicovaginal infections in *quilombola* women from Feira de Santana, Bahia. **Methods**: a descriptive study, carried out in a transversal way and with a quantitative approach. Data collection was carried out from November 2019 to January 2020, with the application of an anamnesis form prepared by the team, with variables used in other studies, such as risk factors. Bivariate analysis was performed to obtain prevalence ratios (PR) between infections and the characteristics found. **Results**: a total of 82 women were studied, with an average age of 45.3 years. The main vaginal infections were caused by *Gardnerella vaginalis* (17.1%), *Trichomonas vaginalis* (8.5%), *Cocci* (8.5%), *Candida spp.* (6.2%) and *Fusobacterium spp.* (1.2%). In 88.2% of infected women, inflammation was present. **Conclusion**: the results obtained in this study showed a correlation between the inflammatory process in women and the presence of some infection. With regard to infections, there was a higher prevalence in women with low education, without a steady partner and who did not undergo regular preventive examination.

Keywords: Cervical Neoplasms. Pap Test. Vaginal Smear. Risk Factors.

RESUMO

Justificativa e Objetivos: as infecções do trato reprodutivo são consideradas uma demanda importante para a saúde da mulher, devido à sua alta prevalência na população e às consequências que podem causar, como parto

prematuro, infertilidade e câncer do colo do útero. Ainda há mulheres que não realizam exame citopatológico, capaz de prevenir essas infecções, seja por falta de orientação ou oportunidade, como as mulheres quilombolas. Este estudo teve como objetivo identificar fatores associados a infecções cervicovaginais em mulheres quilombolas de Feira de Santana, Bahia. **Métodos:** estudo descritivo, realizado de forma transversal e com abordagem quantitativa. A coleta de dados foi realizada no período de novembro de 2019 a janeiro de 2020, com a aplicação de uma ficha de anamnese elaborada pela equipe, com variáveis utilizadas em outros estudos, como fatores de risco. A análise bivariada foi realizada para obter razões de prevalência (RP) entre as infecções e as características encontradas. **Resultados:** foram estudadas 82 mulheres, com média de idade de 45,3 anos. As principais infecções vaginais foram causadas por *Gardnerella vaginalis* (17,1%), *Trichomonas vaginalis* (8,5%), *Cocci* (8,5%), *Candida spp.* (6,2%) e *Fusobacterium spp.* (1,2%). Em 88,2% das mulheres infectadas, a inflamação estava presente. **Conclusão:** os resultados obtidos neste estudo mostraram uma correlação entre o processo inflamatório em mulheres e a presença de alguma infecção. No que se refere às infecções, houve maior prevalência em mulheres com baixa escolaridade, sem companheiro fixo e que não realizavam exame preventivo regular.

Palavras-chave: Neoplasias Cervicais. Exame de Papanicolau. Esfregaço Vaginal. Fatores de risco.

RESUMEN

Justificación y Objetivos: las infecciones del aparato reproductor son consideradas una demanda importante para la salud de la mujer, por su alta prevalencia en la población y las consecuencias que pueden ocasionar, como parto prematuro, infertilidad y cáncer de cuello uterino. Todavía hay mujeres que no se hacen un examen citopatológico, capaz de prevenir estas infecciones, ya sea por falta de orientación o de oportunidad, como las mujeres quilombolas. Este estudio tuvo como objetivo identificar los factores asociados a las infecciones cervicovaginales en mujeres quilombolas de Feira de Santana, Bahia. **Métodos:** estudio descriptivo, realizado de forma transversal y con enfoque cuantitativo. La recolección de datos se realizó de noviembre de 2019 a enero de 2020, con la aplicación de un formulario de anamnesis elaborado por el equipo, con variables utilizadas en otros estudios, como los factores de riesgo. Se realizó análisis bivariado para obtener razones de prevalencia (RP) entre las infecciones y las características encontradas. **Resultados:** se estudiaron un total de 82 mujeres, con una edad promedio de 45,3 años. Las principales infecciones vaginales fueron causadas por *Gardnerella vaginalis* (17,1%), *Trichomonas vaginalis* (8,5%), *Cocci* (8,5%), *Candida spp.* (6,2%) y *Fusobacterium spp.* (1,2%). En el 88,2% de las mujeres infectadas hubo inflamación. **Conclusión:** los resultados obtenidos en este estudio mostraron una correlación entre el proceso inflamatorio en la mujer y la presencia de alguna infección. En cuanto a las infecciones, hubo mayor prevalencia en mujeres con baja escolaridad, sin pareja estable y que no realizaban examen preventivo periódico.

Palabras clave: Neoplasias Cervical. Prueba de Papanicolaou. Frotis vaginal. Factores de riesgo.

INTRODUCTION

The relationship between hormone production, environment and the presence of aerobic and anaerobic microorganisms result in the cervicovaginal microbiota. The presence of bacteria plays an important role in protecting against pathogens, living commensal with the host, such as *Lactobacillus spp*. The vaginal microbiota is directly influenced by physiological changes, such as a woman's age, menstrual cycle, pregnancy, medication use and sex life, mainly increasing the risk of reproductive tract infections (RTI).[1,2] RTIs can be asymptomatic and are considered a public health case, due to their high prevalence in the female population and the consequences they can cause, such as premature birth, infertility and cervical cancer (CC).[3]

CC is considered an important problem worldwide, and, despite having low developmental progression, benefiting early diagnosis and increasing the chances of cure, it is one of the most frequent, representing 3.2% of all cancers, with risk estimated at 15.1/100 thousand women, ranking fourth. The Brazilian National Cancer Institute (INCA - *Instituto Nacional de Câncer*) noted that CC is more incident in developing countries and estimated about 16,590 new cases for each year between 2020-2022 in Brazil, in addition to recording 6,385 cases of deaths in 2017 in the country. Excluding non-melanoma cancer, CC is the second most prevalent in northeastern Brazil, with 17.62 cases per 100,000 women.[4]

As a form of prevention, the Ministry of Health recommends performing a Pap smear for women over 25 years of age, better known as Pap smear. This test is capable of detecting cellular alterations in advance, contributing to an efficient treatment of the alterations found and, although its focus is on the identification of lesions, it is also effective in diagnosing cervicovaginal infections, such as the human papillomavirus (HPV), indicated as a necessary factor for the appearance of CC, when associated with some risk factor.[4,5]

It is considered a low-cost and easily accessible test; however, there are women who do not perform it, because they belong to population groups that do not have basic health care and monitoring, such as *quilombola* (a *quilombola* is an Afro-Brazilian resident of *quilombo*

settlements first established by escaped slaves in Brazil) communities. As a result of the historical trajectory of this group and as a response to the strong prejudice suffered over time, the descendant population of the *quilombo* became resistant and geographically isolated. Most of them are not assisted and have limited access to health care, which tends to hamper the gynecological follow-up of women, leaving them more vulnerable to cervicovaginal infections and the development of CC.[6,7]

This study aimed to identify factors associated with cervicovaginal infections in *quilombola* women from Feira de Santana, Bahia.

METHODS

This is a cross-sectional study, carried out with women from a *quilombola* community in Feira de Santana-BA, from November 2019 to January 2020.

Prior to data collection, meetings were held with the community and their respective leaders to present the project, explain the importance of the research and clarify doubts. At the end of the meetings, the leaders signed a Participation Term, consenting to carry out the research in the community. Before the collection of materials, a questionnaire, prepared by the research team, was applied to individuals who agreed to participate in this investigation. The community has 573 inhabitants; of these, 301 (52.5%) are women. Sexually active women were included and pregnant women were excluded. For the research, 95 women were included, who were willing to participate in the study, making it necessary to sign the Informed Consent Form (ICF) for women aged 18 years and older. For underage and sexually active girls who expressed interest, the Assent Form was sent for signature, and those responsible signed the specific consent form for them.

Cervicovaginal samples were collected between November 2019 and January 2020, at the Family Health Unit of the community, and were performed by team nurses. The slides were stained using the Papanicolaou technique. The reports were issued and classified according to Bethesda System's latest update and according to the Ministry of Health recommendations, both steps performed by biomedical staff. Soon after, the results were delivered to the patients, accompanied by the necessary guidelines from the team to seek medical help.

Of the total sample, nine participants were excluded, due to the fact that the cervicovaginal sample was considered unsatisfactory by the biomedical doctor, and another four, for not having completed the questionnaire. The following were considered as independent variables: alcohol consumption (yes and no); vaginal complaints (yes and no); smoking (yes and no); age (≤ 45 years and ≥ 46 years); education (elementary and high school); skin color (white and non-white); number of lifetime sexual partners (≤ 3 partners and ≥ 4 partners); fixed partner (yes and no); use of contraceptive methods (yes and no); age at first intercourse (≤ 17 years and ≥ 18 years); and frequent use of preventive measures (yes and no). The variable vaginal infection (yes and no) was considered as the main outcome.

Initially, data were analyzed using descriptive statistics, and as the study did not present continuous quantitative variables, it was decided to perform a bivariate analysis, estimating the raw Prevalence Ratio (PR) and its respective confidence intervals (CI) and p-values by Pearson's chi-square test, with a significance level of 5%, using STATA, version 15.0, StataCorp LLP, 2017.

This study is part of a research entitled *Prevalência da Infecção pelo Papilomavírus humano (HPV) em Mulheres Quilombolas do Recôncavo Baiano*, in partnership with *Faculdade Maria Milza* (FAMAM) and *Universidade Federal do Recôncavo da Bahia* (UFRB). The project was submitted and approved by the Research Ethics Committee of FAMAM-BA, with Opinion 3,648,330 and CAAE (*Certificado de Apresentação para Apreciação Ética* - Certificate of Presentation for Ethical Consideration) 87619618.1.0000.5025, in compliance with Resolution 466/2012 of the Brazilian National Health Council (*Conselho Nacional de Saúde*).

RESULTS

The study was carried out with 82 women from the community, whose average age was 45.3 years. Most women had the preventive examination diagnosis within the limits of normality (without vaginal infection) in the material collected (58.5%); however, there were benign cellular alterations with the presence of microorganisms, mainly *Gardnerella vaginalis* (17.1%) (Table 1).

Table 1. Frequency of cervicovaginal infections in quilombola women, Feira de Santana-BA, November 2019 to January 2020.

Microorganisms		%
Gardnerella vaginalis	4	17.1
Gardnerella vaginalis +		8.5
Trichomonas vaginalis		8.5
Cocos		6.2
Candida spp		1.2
Fusobacte-rium spp		58.5
No vaginal infection	8	100
Total	2	

As a result of reactive cellular changes, it was observed that 36.6% of all women had inflammation, with a mean age of 40.33 years, whose main agent was *Gardnerella vaginalis* (73.3%).

Women who had access only to elementary school had a higher prevalence of infections (61.8%), non-white (100%), without a steady partner (52.9%), did not undergo preventive measures regularly (64.7 %) (Table 2).

Table 2. Distribution of characteristics and prevalence ratios of cervicalvaginal results of quilombola women, Feira de Santana-BA, November 2019 to January 2020.

Variables	Infected n (%)	Non Infected n (%)	TOTAL N (%)	PR (95% CI)	(p)
Alcoholism					
Yes	11 (32.4)	17 (35.4)	28 (34.1)	0.92 (0.52-1.60)	0.773
No	23 (67.6)	31 (64.6)	54 (65.9)	1.00	
Vaginal complaints					
Yes	10 (29.4)	19 (39.6)	29 (35.4)	0.76 (0.42-1.36)	0.349
No	24 (70.6)	29 (60.4)	53 (64.6)	1.00	
Age					
≤ 45 years	17 (50)	25 (52.1)	42 (51.2)	1.00	
≥ 46 years	17 (50)	23 (47.9)	40 (48.8)	1.05 (0.62-1.75)	0.852
Education					
Access to ele-mentary school	21 (61.8)	31 (64.6)	52 (63.4)	0.93 (0.55-1.57)	0.794
Access to high school	13 (38.2)	17 (35.4)	30 (36.6)	1.00	
Skin color					
White	0 (0)	3 (6.3)	3 (3.7)	-	-
Non-white	34 (100)	45 (93.7)	79 (96.3)	-	-
Sexual partners					
≤ 3 partners	26 (76.5)	40 (83.3)	66 (80.4)	1.00	
≥ 4 partners	8 (23.5)	8 (16.7)	16 (19.6)	1.26 (0.71-2.25)	0.439
Fixed partner					
Yes	16 (47.1)	27 (56.3)	43 (52.4)	1.00	
No	18 (52.9)	21 (43.7)	39 (47.6)	1.24 (0.74-2.07)	0.411
Contraceptive methods					
Yes	17 (50)	18 (37.5)	35 (42.7)	1.34 (0.80-2.23)	0.259
No	17 (50)	30 (62.5)	47 (57.3)	1.00	
First intercourse					
≤ 17 years	17 (50)	15 (31.3)	32 (39)	1.56 (0.94-2.58)	0.086
≥ 18 years	17 (50)	33 (68.7)	50 (61)	1.00	
Preventive					
Yes	12 (35.3)	19 (39.6)	31 (37.8)	0.89 (0.52-1.54)	0.693
No	22 (64.7)	29 (60.4)	51 (62.2)	1.00	
Smoker					
Yes	1 (2.9)	1 (2.1)	2 (2.4)	1.21 (0.29-4.96)	0.8041
No	33 (97.1)	47 (97.9)	80 (97.6)	1.00	

Caption: PR - Prevalence Ratio; CI - confidence interval.

DISCUSSION

A correlation between the factors associated with infections caused by agents capable of injuring cervico-vaginal cells, especially anaerobic bacteria, is necessary, given the importance of prevention and incidence control worldwide. These agents act in the transformation zone, stimulating the replacement of glandular epithelium by squamous epithelium, characterizing squamous meta-plasia. In this process, there is greater susceptibility to CC, because these cells are more permissive to HPV infection.[6]

Among the 82 patients studied, 34 (41.5%) had cases of vaginal infections, being 21 (25.6%) positive for *Gardnerella vaginalis,* with a mean age corresponding to 42.4 years, a higher value than that found in Rio Grande do Sul,[9] in women treated at Basic Health Units, with 5.1% cases of *Gardnerella vaginalis*. A study carried out with *quilombola* women assisted by the Unified Health System (*Sistema Único de Saúde*) of municipalities in Maranhão[6]

found 27.7% of cases of infection by *Gardnerella vaginalis*, however, with a higher prevalence in women <30 years. *Gardnerella vaginalis* is identified as the main cause of bacterial vaginosis, due to its high power of pathoge-nicity, such as the ability to adhere to vaginal epithelial cells, biofilm formation (favoring the adhesion of other anaerobic microorganisms), and the production of the toxins vaginolysin (cytolysin that induces vaginal epithelial cell lysis) and sialidase (an enzyme capable of degrading cervical mucus).[10] In 50% of infected women, bacterial vag-inosis (BV) is asymptomatic and facilitates the transmission of sexually transmitted infections (STIs).[11]

In the present study, of these 21 women, 7 (8.5%) had co-infection with *Trichomonas vaginalis,* similar data to the study carried out in women from southern Brazil [12], with 9% of the cases represented. The value found in this study was higher than that found in a prenatal care clinic in Ghana,[3] with 1.4%. *Trichomonas vaginalis* is the pro-

tozoan responsible for causing trichomoniasis, the most prevalent non-viral STI worldwide, where the population most in need of guidance and basic health care is more susceptible to infection, which is caused by changes in the cervicalvaginal balance, since the diagnostic method is inaccessible to some health professionals and public laboratories in the country.[12]

Among the infected women, 7 (8.5%) had in their results the presence of *cocci*, with an average age of 39.7 years, values below the studies carried out in women from the semiarid region of Paraíba,[13] with 40.12% and 32% in women assisted at a health unit in Barreiras, Bahia.[14] The presence of *cocci* on cervicovaginal cytology may appear without being associated with any alteration, as they are part of the normal female microbiota. However, with imbalance, it can cause inflammation and infection, and, in some cases, asymptomatically.[15]

Of the cases found, *Candida spp.* was represented with 5 (6.2%) cases, with an average age of 45.5 years, which is lower than the study carried out with pregnant women,[3] which found 36.5%. Women treated at basic health units[9] had a result below that found in this study, with 5.1% of cases of infection by *Candida spp.* The yeast *Candida spp.* is a fungus that can live in the vaginal microbiota commensally and without causing symptoms in 50% of women. When balance is affected, strains of *Candida spp.* multiply excessively, accounting for 85% to 90% of cases of vulvovaginal candidiasis.[16]

Only one patient (1.2%), aged 58 years, was diagnosed with *Fusobacterium spp.*, prevalence similar to that found in a hospital in Curitiba,[17] accounting for 1.17% of cases. *Fusobacterium spp.* is a gram-negative, anaerobic bacillus found in the normal microbiota of the mouth and intestinal mucosa. However, the correlation between *Fusobacterium spp.* and colorectal and CC due to the production of FadA is mentioned, a virulence factor capable of resulting in the proliferation of carcinogenic cells.[18]

In general, in women's vaginal microbiota, *Lactobacillus spp.*, accounting for 47.6% of cases, was found to be more prevalent. *Lactobacillus* are found in healthy women and maintain the cervicovaginal balance by producing lactic acid (making the pH of the vagina acidic), hydrogen peroxide and bacteriocins, preventing infection by other pathogenic microorganisms.[6] The reduction of *Lactobacillus* contributes to STIs and can cause BV. On the other hand, the disordered increase implies the exacerbated production of lactic acid and consequent decrease in pH, which can cause cytolytic vaginosis.[1,2]

Given the high rate of infection in cases of inflammation, the importance of its identification during examination is emphasized. The main pathogens identified capable of causing this type of benign alteration are *Gardnerella vaginalis*, *Trichomonas vaginalis* and *Candida spp.* These microorganisms were also cited as causing inflammation in a study carried out in a city in Rio Grande do Sul.[5] The results corroborate this study, since the 30 women diagnosed with inflammation were infected with one of these pathogens, in addition to from infection by *Fusobacterium spp.* Early diagnosis of these

microorganisms is extremely important, as inflammation can camouflage the presence of malignant changes in the smear and facilitate infection by other microorganisms.[15]

The risk factors associated with the infections found were not statistically significant in this study.

In this study, 32.4% of infected women reported consuming alcohol. Alcohol consumption generates oxidative stress, through the p450 2E1 enzyme, and is linked to the development of CC, due to the relationship of antioxidant enzymes and detoxifying pathways to cells transformed by HPV.[19] Moreover, alcohol consumed before sexual intercourse increases libido and decreases reasoning.[20] Thus, the chance of having sex without using condoms increases and, consequently, the risk of acquiring STIs.[21]

Among infected women, 29.4% had some type of vaginal complaint. This data may be related to the fact that infection by *G. vaginalis*, *T. vaginalis* and *Candida spp.* can be asymptomatic in most cases, reinforcing the importance of performing a preventive examination and gynecological follow-up, and not just a diagnosis based on the presence of symptoms, since the lack of them does not exclude the presence of infection.[11,15] The results found in a city in Rio Grande do Sul[5] brought the average age among women to 45.76 years, a value similar to that of this study, which had a mean age of 45.3 years.

It was observed in a survey carried out with women with CC that patients with higher levels of education tend to seek health care and have more information.[22] A study carried out on STIs in women deprived of liberty[21] points to a higher prevalence of vaginal infection in women with incomplete primary education (34.5%), a result that is similar to that found in this study, which found most infections (61.8%) in women with access only to elementary education. There was no infection in self-declared white women, so 100% of the infection cases affected non-white women. This high prevalence may have been due to the small sample of white women registered in this study. On the other hand, another study found a higher prevalence of infections in non-white women and associated this data with historical factors, in which the black population and their descendants are socioeconomically less supported and without assistance, contributing as a risk factor for vaginal infections.[23]

Regarding the number of sexual partners, the highest prevalence of infections was among women who reported having less than 3 sexual partners in their lifetime (76.5%), although other studies found a higher prevalence in women with four or more sexual partners, as in exchange students in Portugal,[24] associating infections with high exposure and a greater chance of sexual intercourse with an infected partner, which can increase the spread of infections. The higher prevalence of infections in women who reported not having a steady partner (52.9%) is consistent with the results found in exchange students in Portugal, since women with a steady partner are less likely to have contact with infected individuals.

A study on STIs in women deprived of their liberty found a prevalence of 53.1% of cases in patients who said they never used condoms.[21] In the present study, the

percentage was the same for both women who claimed to use it and for those who did not, accounting for 50%. The use of contraceptive methods does not prevent infections and, therefore, the WHO suggests using condoms, because it provides a physical barrier preventing the passage of bacteria and viruses. The average age of the first intercourse of women with some infection is 14.2 years, lower than a study carried out with exchange students in Portugal,[24] which found 17.6 years, but that emphasizes the importance of the age at the first sexual intercourse, since it has been decreasing over the years, and the rate of adolescents under the age of 16 who are sexually active has been increasing, as shown in this study. The younger the adolescent, the less likely it is to contain information and the greater the risk of risky sexual behavior and, consequently, the risk of STIs.

Most women with infection reported not having a preventive examination frequently (64.7%). This finding reinforces the need for gynecological follow-up and preventive examinations, at least once a year, for better assistance, prevention and treatment of cervical infections.[4,14] In this study, 97.1% of women who had an infection said they were not smokers, however its relationship as a risk factor for cervical infections has been proven in some studies, due to the presence of carcinogenic substances with transformational action on the cervix, leading to immunosuppression and favoring infection by pathological agents.[19]

As a result of the racism suffered since the time of slavery, the black population is a victim of cultural devaluation and faces daily challenges in all social spheres, such as education, poverty and health. This situation worsens when it comes to *quilombola* communities, especially women, highlighting the difficulty of medical consultation, carrying out preventive examination and the association with CC, nutritional risks, among other problems. Black women have lower life expectancy when compared to white women, evidencing the complications of access to health.[5,25]

The limitations inherent to this study are characterized by the sample studied, as there is resistance from the *quilombola* population and low demand for preventive examinations. Thus, these results should not be extended to the general population. It is also necessary to mention that some information may have been omitted by the women interviewed, depending on the particularity of the topic, in addition to the possibility of indecision to answer questions such as the age of the first intercourse and the number of sexual partners. It is worth mentioning the need for further research in this community to prove the results and investigate the main cause of infections.

Considering the results analyzed and discussed in this study, *G. vaginalis* was the most prevalent infectious agent in women in this *quilombola* community. Although there are no statistically significant results among the analyzed characteristics, in this study, there was a higher prevalence of infections in women with low education, without steady partners and without frequent Pap smears. Thus, it becomes evident the need for guidance and ways to rescue these women for better monitoring and carrying out preventive examination.

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Revista de Epidemiologia e Controle de Infecção

REVIEW ARTICLE

Patient participation in compliance with hand hygiene by health professionals: an integrative review

Participação do paciente na adesão à higiene das mãos pelos profissionais de saúde: revisão integrativa

Participación de los pacientes en la adherencia a la higiene de manos por parte de los profesionales sanitarios: una revisión integradora

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ABSTRACT

Background and objectives: Healthcare-associated Infections are a global health concern. Although the best strategy for its prevention is hand hygiene (HH), there is still low compliance by health professionals in the execution of the correct technique. In order to improve compliance with HH, the World Health Organization (WHO) implemented the multimodal strategy, which emphasizes patient participation in health services, in order to encourage professionals to wash their hands. With this, we sought to verify the impact of the implementation of educational strategies with patient involvement and participation in compliance with hand hygiene by health professionals. **Methods:** An integrative literature review in the CINAHL, LILACS, PubMed, Scopus and WOS databases. **Results:** The present sample comprised eight international studies that empowered patient participation with intervention strategies on HH and studies in which patients provided feedback on compliance assessment, which reflected in greater compliance with HH by health professionals. **Conclusion:** Educational interventions with patient participation and involvement proved to be effective for health professionals to comply with HH, especially when all components of the multimodal strategy were adequately addressed.

Keywords: Health Education. Hand Hygiene. Patient Participation. Continuing Education. Power.

RESUMO

Justificativa e objetivos: As infecções relacionadas à assistência à saúde são um problema de saúde mundial. Embora a melhor estratégia para sua prevenção seja a higiene das mãos (HM), nota-se ainda baixa adesão dos profissionais de saúde na execução da técnica correta. Com o propósito de melhorar a adesão a HM, a Organização Mundial de Saúde (OMS) implementou a estratégia multimodal, que ressalta a participação do paciente nos serviços

de saúde, a fim de incentivarem os profissionais a higienizar as mãos. Com isso, buscamos verificar o impacto da implementação de estratégias educativas com o envolvimento e participação do paciente na adesão à higienize das mãos por profissionais de saúde. **Métodos:** Revisão integrativa da literatura nas bases de dados CINAHL, LILACS, PubMed, Scopus e WOS. **Resultados:** Compuseram a presente amostra oito estudos internacionais, que empoderaram a participação do paciente com estratégias de intervenção sobre HM e estudos no qual o paciente foi provedor de *feedback* de avaliação da adesão, o que refletiu em maior adesão à HM pelos profissionais de saúde. **Conclusão:** Intervenções educativas com a participação e envolvimento do paciente se mostraram eficazes para adesão à HM pelos profissionais de saúde, em especial, quando todos os componentes da estratégia multimodal foram adequadamente contemplados.

Descritores: Educação em Saúde. Higiene das Mãos. Participação do Paciente. Educação Continuada. Poder.

RESUMEN

Justificación y objetivos: Las infecciones relacionadas con la asistencia sanitaria son un problema de salud mundial. Aunque la mejor estrategia para su prevención es la higiene de manos (HM), aún existe una baja adherencia por parte de los profesionales sanitarios en la ejecución de la técnica correcta. Para mejorar la adherencia a la HM, la Organización Mundial de la Salud (OMS) implementó la estrategia multimodal, que enfatiza la participación del paciente en los servicios de salud, con el fin de incentivar a los profesionales a lavarse las manos. Con esto, buscamos verificar el impacto de la implementación de estrategias educativas con la implicación y participación del paciente en la adherencia a la higiene de manos por parte de los profesionales sanitarios. **Métodos:** Revisión integradora de la literatura en las bases de datos CINAHL, LILACS, PubMed, Scopus y WOS. **Resultados:** La presente muestra estuvo conformada por ocho estudios internacionales que empoderaron la participación del paciente con estrategias de intervención en HM y estudios en los que el paciente brindó retroalimentación sobre la evaluación de la adherencia, lo que se reflejó en una mayor adherencia a la HM por parte de los profesionales de salud. **Conclusión:** Las intervenciones educativas con participación e involucramiento del paciente demostraron ser efectivas para que los profesionales de la salud se adhieran a la HM, especialmente cuando todos los componentes de la estrategia multimodal se abordaron adecuadamente.

Palabras clave: Educación en Salud. Higiene de Manos. Participación del Paciente. Educación Continuada. Poder.

INTRODUCTION

Healthcare-associated Infections (HAIs) are a worldwide public health concern and are defined by Ordinance 2616 of the Brazilian Ministry of Health as any infection acquired after patient admission to a health facility, manifested after forty-eight (48) hours after admission or after discharge, when associated with surgeries or invasive procedures.[1,2]

In the United States of America (USA), in 2016 it was estimated that about 10% of hospitalized patients had HAI. The Brazilian Ministry of Health considers that incident reaches a proportion of 15% or more on this country. The Latin American Sepsis Institute (LASI) points out that annually 400,000 new cases are diagnosed and about 240,000 people die from HAIs.[3]

Aiming at the prevention of this problem, the Brazilian Health Regulatory Agency (ANVISA - *Agência Nacional de Vigilância Sanitária*) recommends the mandatory notification of the four types of HAI: primary bloodstream infection (BSI) associated with central venous catheter (CVC), ventilator-associated pneumonia (VAP), urinary tract infection (UTI) and surgical site infections (SSI).[4]

The simplest and most used strategy for HAI prevention is hand hygiene (HH), which consists of performing the procedure using appropriate technique and time, using water and soap or 70% alcoholic solution, in order to remove dirt and microorganisms.[5] Studies have shown that 99.9% of transitory colonization of the hands of health professionals was eliminated with the correct HH technique, following the steps recommended by the World Health Organization (WHO) guidelines.[6]

However, the world literature reports a low compliance of health professionals with HH. A study in Switzerland that aimed to improve HH compliance by professionals through performance feedback and patient participation found that less than 66% of professionals comply with the five moments of HH,[7] namely: 1) before touching a patient; 2) before a procedure; 3) after a procedure or body fluid exposure risk; 4) after touching a patient; 5) after touching a patient's surroundings.[8]

In developing countries, the situation worsens. Research carried out in southern Brazil found that the compliance rate with the five (5) moments of HH was only 54.5% by health professionals working at a teaching and research hospital.[9] In southeastern Brazil, a study conducted in an Intensive Care Unit demonstrated that less than 43% of professionals performed HH adequately.[10]

Aiming at encouraging compliance with HH practices, the WHO implemented, in 2009, the multimodal strategy (MS), which is composed of five complementary and interdependent components of intervention, which have been proven to help in compliance with HH, both medium and short term, namely: 1) system change; 2)

training & education; 3) monitoring & feedback; 4) reminders & communication; and 5) culture change.[8,11]

It is worth noting that the components monitoring & feedback and culture change emphasize the importance of patient participation, which should be strongly encouraged in educational interventions based on the aforementioned MS. For this to occur, it is necessary to empower the user about the importance of HH by health professionals during the care provided. The WHO states that patient empowerment is a process in which they understand their role when receiving knowledge and skills from their health care provider, in order to understand the care process and ensure subsidies to intervene in the actions received.[8]

Given the proven effectiveness of HH to reduce HAI, low compliance of health professionals with this technique and the relevance of patient participation in actions that promote HH in health care environments, it was necessary to know: What is the impact of implementing educational strategies with patient involvement and participation in compliance with HH by health professionals?

The objective of this study was to verify the impact of implementing educational strategies with patient involvement and participation in compliance with HH by health professionals.

METHODS

Study design

This study is an integrative literature review, which provides the introduction of experimental and non-experimental studies, in order to obtain a greater compression of the phenomenon. This type of study articulates information from theoretical and empirical literature, in addition to integrating several purposes, such as definition of concepts, review of theories and investigation of methodological problems of a specific topic.[12, 13, 14]

The integrative review analyzes the current knowledge on a specific topic, being designed to identify, analyze and synthesize results of different studies on the same topic, aiming at the quality of care provided to patients.[15] This study design is composed of six phases: 1) selection of research hypothesis or question ; 2) search strategy (establishment of inclusion and exclusion criteria, database and selection of studies); 3) categorization of studies (extraction, organization and summarization of data); 4) assessment of studies included in the review; 5) interpretation of results; and 6) synthesis of knowledge.[12,16,17,18]

Inclusion and exclusion criteria

Experimental, quasi-experimental or "before/after" scientific articles, which used an educational intervention to improve compliance with HH by health professionals, including patient participation, published in English, Spanish or Portuguese, from 2009 to 2019, were included. This period of time is justified by the year of dissemination of MS for HH by the WHO.

Theses, dissertations, studies in which the method was not adequately described, carried out only with health professionals, or which were not fully available were excluded.

Search strategies and data organization

Literature searches were conducted from April to July 2019. Primary studies were searched in the following databases: Medical Literature Analysis and Retrieval System Online (MEDLINE), Latin American and Caribbean Literature in Health Sciences (LILACS), Current Nursing and Allied Health Literature (CINAHL), SCOPUS and Web of Science (WOS).

To guide the study, the PICO strategy (Participant, Intervention, Comparison and Outcomes)[15] was used in order to identify in the texts the answer to the following question: What is the impact of implementing educational strategies with patient involvement and participation in compliance with HH by health professionals?

To ensure a thorough search, the Health Science Descriptors (DeCS), Medical Subject Headings (MeSH), uncontrolled descriptors (keywords) and the CINAHL Subject Headings were defined. The following DeCS, MeSH and CINAHL Subject Headings used were: health education, hand hygiene, patient participation, handwashing. The keywords used were: multimodal strategy, in addition to synonyms found on the DeCS and MeSH websites. Boolean operators AND and OR were used, in order to allow intersection and union between descriptors and keywords.

A total of 4857 articles were identified in the databases, as shown in figure 1. These articles were initially organized using Clarivate EndNote Online, whose program facilitated the process of removing duplicates and articles that did not correspond to the period adopted for this study. This resulted in 1,988 duplicate articles and 894 that did not fit into the period adopted for this review.

Data were systematized using a guide called Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) for the categorization of studies. figure 1 outlines the main steps taken, whose outcome met the inclusion of eight studies.
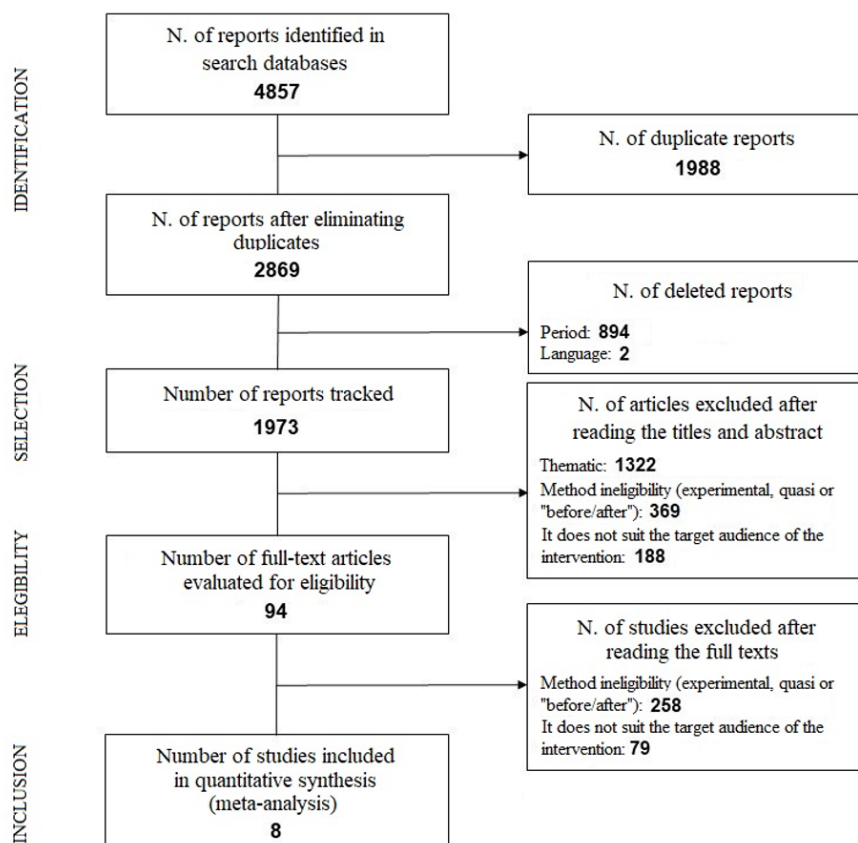
Figure 1. PRISMA flowchart for included studies.

CONTENT AND DISCUSSION

After search refinement using the PRISMA tool, the final sample consisted of eight (8) articles. The selected studies resulted in four (4) WOS studies, two (2) MEDLINE database studies, and two (2) Scopus studies. Data regarding educational interventions and study results are presented in Chart 1.

Participants in the interventions were composed of nursing, medical and other health professionals who worked predominantly in adult Intensive Care Unit (ICU), medical clinic, emergency, pediatric clinic and surgical clinic sectors. The studies also involved patients admitted to tertiary care clinics who stayed at least three days in the health facility, as well as their caregivers or family members, when applicable.

In 62.5% of the studies, MS was used contemplating its five (5) components and patient participation stands out as a member of the fifth component "culture change". In 25% of the articles, patient participation was included in the proposed interventions, and in 12.5% of the articles, patient participation was the only intervention performed.

As shown in Chart 1, the most used strategy was continuing education with patients, giving them the autonomy to question health professionals about HH in the moments before touching them, handling care equipment (e.g., infusion pumps, catheters and probes, me-

chanical ventilator, among others) and before touching objects placed in patients' vicinity.

In all studies included in this sample, both patients and their caregivers and family members were trained to perform the correct HH, highlighting its importance due to the high rates of infections in the selected institutions, aiming to reduce HAIs, making them protagonists of their security process.

Three of these studies pointed out that patients are intimidated by questioning the health team, reporting that they are not comfortable in questioning their caregivers about their work tasks.[7, 21, 25] In these studies, health professionals were composed of a multidisciplinary team, with the largest presence of physicians, nurses and nursing technicians.

However, the articles showed an increase in the HH rate by health professionals after the intervention was carried out using patients as part of the educational strategy.

HAIs represent a major global health problem, and their control is relevant both in developed and underdeveloped countries, as they generate a high cost for health institutions, since treatment is costly and can often be ineffective. Moreover, it causes harm to both the patient and the health professional, as both are susceptible to contamination by pathogenic microorganisms.[26]

The steps that comprise MS to achieve HH actions are done through the change in the system, which concerns the institution's infrastructure changes to ensure

Chart 1. Synthesis of key information from the eight (8) articles included in this integrative review, Brazil, 2019.

AUTHOR	YEAR	PLACE	PERIOD	POPULATION	INTERVENTIONS USED	RESULTS BEFORE THE INTER-VENTION	RESULTS AFTER THE INTER-VENTION	CONCLUSION
BITTLE, et al.[19]	2009	The Johns Hop - University Hospital lo-cated in Bal-timore – USA.	2008 to 2009	The intervention was carried out with fifty (50) patients and professionals who were in the otolaryngology, plastic surgery and medical clinics.	In 2008, direct observation of compliance with HH by pro-fessionals was carried out, collecting their self-reports and the number of antiseptic prod-ucts used. Patients were edu-cated to assess professionals' HH, taking responsibility for the role of observer. Patients performed formal reports about HH opportunities they wit-nessed.	The rate of health professio-nals who performed HH was 40% in July 2008.	The compliance rate to HH in 2009 was 80%.	It was found that patient participation as an observer increased the levels of com--pliance with HH.
AL-TAWFIQ, et al.[20]	2013	Saudi Aramco Medical Ser-vices (SAM-SO) Public Hospital in Saudi Arabia.	Jan. 2007 to Jan. 2011	The intervention was carried out with patients and profession-als from cardi-ology, surgery, medical, neona-tal and pediatric clinics, which totaled three hundred and fifty (350) beds.	In 2007, the program started the intervention with educa-tional presentations on the importance of HH, and, after that, opportunity observations were carried out. In the follow-ing years, targets for compli-ance with the five (5) mo-ments of HH were defined for 85% and the inclusion of MS components in the program. In 2011, the second stage of interventions started through monthly monitoring, frequent or immediate feedback, on-site observation campaigns, read-justment of materials for HH and distribution of alcohol gel for professionals and patients. Patients were educated by the interventional team to ques-tion the professional before contact, with phrases such as "Have you sanitized your hands?".	The rate of health professionals performing HH was 38% in 2007.	The compliance rate in 2011 was 85%, (p=0.005).	The study found a positive improvement in the change in professionals' behavior in relation to HH, reaching the proposed com-pliance goal.
ALVAREZ et al.[21]	2015	Tertiary care hospital in Spain.	2014 to 2015	The intervention was carried out in the one hun-dred and twenty-five (125) beds of the hospital, distributed in oncology, hema-tology, surgical endocrinology, ICU and resusci-tation unit wards, and had seven hundred and thirty-seven (737) health professionals working in these units.	The educational program used MS in its entirety in conjunc-tion with patient and family empowerment. The study used the five (5) components of the aforementioned strategy and raised awareness and training on the importance of HH, distributed informational leaf-lets and held training work-shops on the World HH Day for patients and families. Pa-tients were also included as observers and feedback provid-ers, as they were encouraged to question practitioners about HH.	The rate of health professionals who perform HH was 44.8% in 2014.	The compliance rate in 2015 was 69.9% (p<0.05).	The study con-cludes that MS with patient participation resulted in a significant increase in the rates of compli-ance with HH by profession-als. The study also highlights the need for constant moni-toring and train-ing of those involved.
CAINE, et al.[22]	2015	Hospital in the state of New Hamp-shire in the USA.	2008 to 2014	The study was carried out with one hundred and sixty-six (166) patients from inpatient clinics and health pro-fessionals who worked in these units.	The intervention was carried out through educational lec-tures on HH with patients and health professionals, availabil-ity of alcohol gel, paper tow-els and soap, in addition to reminders in the workplace. Patients were encouraged to act as observers of HH oppor-tunities by health profession-als and to question the con-duct when deemed necessary.	Before the inter-vention, the com-pliance rates of professionals to HH were 82%.	After the interven-tion, compliance rates rose to 93% (p<0.0001).	The interven-tion adopted had a signifi-cant result, as the rates of compliance with HH in-creased signifi-cantly. Fur-thermore, pro-fessional-patient interaction was strengthened with the inter-vention.
CHEN, et al.[23]	2015	Kaohsiung Taiwan Veter-ans General Hospital.	2003 to 2014	The study in-volved the one thousand four hundred and eight (1,408) hospital beds and two thou-sand four hun-dred and sixty-three (2,463) health profes-sionals, includ-ing physicians, nurses, techni-cians and nurs-ing assistants.	The five (5) components of MS were used in full, with the addition of patient participa-tion as an evaluator of the HH of professionals, encouraging them to question professionals about compliance with HH before touching them. Patients who agreed to participate re-ceived badges to identify their participation in the study.	The compliance rate of HH of the professionals was 62.3%.	The compliance rate was 73.3% (p<0.001).	The study con-cluded the in-tervention was successful, as there was an improvement in the change in the profession-als behavior in relation to HH.

FONGUH et al.[24]	2016	Held in Bel-gium in ter-tiary care institutions.	2005 to 2015	The study was carried out with professionals and patients from Intensive Care Units.	The program used six national campaigns to reduce HAI rates, namely: "Hand hygiene with alcohol-gel;" "Hand hy-giene: do it correctly;" "Hand hygiene: unadorned and proper use of gloves;" "Doctor, don't forget, it works and you're a model;" "Hand hygiene, do it correctly before any contact with patient" and "Hand hy-giene together with patient." It is important to highlight that in the last campaign patients were encouraged about HH and instructed to ask about the technique by a professional before the first contact with their body, equipment or be-longings. During the interven-tion, the trained teams ob-served HH opportunities of professionals three (3) months before and three (3) months after the launch of the cam-paign.	The compliance rate with HH by health profession-als was only 19%.	The post interven-tion rate was 69% (p<0.05).	The study found that HH compliance rates increased significantly with cam-paigns, but makes it clear that it is neces-sary to repeat them periodical-ly to achieve and sustain the compliance rate.
STEWAR DSON, et al.[7]	2016	Switzerland, Geneva Uni-versity Hospi-tals.	2010 to 2014	The study in-volved health professionals and patients from the two hundred (200) beds of medical and surgical clinics.	Control group: applied to MS; Performance feedback group: HH observation sessions. At the end, verbal feedback was provided and, when feasible, a card informing about the steps of HH with individual coun-seling on how to improve the technique was given. This card illustrated the steps and five (5) ideal moments to perform the technique, with a view to reaching 80% compliance goal. Improved feedback group with patient participation: the same activity as the previous group was carried out, with the addi-tion of patient participation, the distribution of encouraging pins to health care profession-als and setting reminders in the workplace. Such participa-tion was made by involving patients to receive, on admis-sion to service, an information leaflet about HH and a bottle of alcohol gel. Patients were instructed to interact with health professio-nals, in order to encourage HH focusing on moment one: before touching patients.	Control group: 66%. Performance feed-back group: 65%. Improved feed-back group + patient participa-tion: 66%.	Control group: 73%. Performance feed-back group: 75% (p=0.19). Improved feed-back group + patient participa-tion: 77% (p=0.048). Compliance with Moment One of HH by WHO: p=0.03 in the control group and p<0,0001 in the other two groups.	It was observed that there was an improvement in the change in professionals' behavior in relation to HH, but it did not reach the rec-ommended goal of 80% compli-ance.
CHENG, et al.[25]	2017	Held in two units of the Hong Kong West Healthcare Region Hos-pital.	2016	Intervention performed in the nine hundred and thirty (930) beds of the two hospital units and the seven inpatient wards, with the partici--pation of one hundred and sixty-seven (167) patients and one hundred and fourteen (114) profes-sionals from the aforementioned wards.	Focus groups were held to delineate the intervention for patients and health profession-als. The intervention was carried out through educational lectures and bedside guidance encouraging patients to ask "Have you ever cleaned your hands?" to health care profes-sionals before the first contact. Patients who were unable to question verbally were given an elucidating sign with this question.	The compliance rate of profession-als with HH was 87.2%.	The compliance rate increased to 87.9% (p=0.891).	It describes the importance of patient partici-pation, but says that the percent-age of increased compliance of health profes-sionals with HH was not high, justified by the short intervention time.

Note: MS: multimodal strategy; HH: hand hygiene.

that health professionals can sanitize their hands and an organizational culture of installed safety, transversal to professionals, patients, direct supervisors and superiors. The favorable institutional safety climate is guided by the management responsibility to create an environment that facilitates professionals' awareness and promotes positive perceptions of patient safety, ensuring HH improvement as a priority at all levels of health care.[27,12]

In that regard, an essential part of this process is professionals' education and training, through training and regular and permanent training on the implementation of the proper HH technique, contemplating the five (5) moments proposed by the WHO.[27] Through health education activities, the multidisciplinary team motivation also becomes viable, making them perform local actions that reinforce HH as a fundamental measure for HAI prevention and control and feel that they are protagonists in this process.[28]

Thus, it is necessary that professionals and patients have technical knowledge about the correct mode of HH so that they can excellently comply with practice aimed at reducing HAIs. Note the importance beyond a health education activity, but as an artifact to optimize new practices and search for quality of care by both.[28]

Based on the above, it is necessary to implement this theme in the training process of health professionals, as there is a need for technical and scientific development of this theme through the use of active methodologies, in order to emphasize the importance of HH.[29]

The assessment and feedback component comprises monitoring the changes that have occurred, from monitoring HH practices to infrastructure, verifying whether educational interventions were effective in improving compliance. On the other hand, reminders in the workplace are instruments used to highlight the indications and importance of HH, performance of the appropriate technique and procedures, in places with greater circulation of professionals.[30]

The aforementioned studies that make up the sample of this review showed the importance of patient participation as part of safe care and a favorable institutional safety climate, since compliance with HH was significantly improved with interventions that included patient empowerment.

Observational research in a specialized pediatric hospital in the Brazilian Midwest showed a considerable increase in HH by health professionals after the implementation of the five (5) components of MS after the implementation of the five (5) components of MS together with patient participation".[31]

In the same way, a study carried out in Switzerland with health care professionals from a hospital in Geneva, aiming at improving compliance with HH by these health professionals, showed that patient involvement was effective in compliance with HH, proving to be statistically significant (p<0.04), increasing compliance with HH from 66% to 77% after the implementation of the educational strategy.[7]

Exploratory qualitative study, carried out in Porto Alegre to understand the perception of family members and caregivers in relation to patient safety, reinforced the need and relevance of training professionals to include the family, in order to promote safe care.[32]

Educational strategies aimed at patient safety require effective communication between professionals and health services. Communication failures can affect the quality of services, resulting in incidents, errors and damages, such as medication administration errors that can be avoided with efficient communication between work team memebrs.[33, 34, 35]

Institutions and health professionals need to ethically commit to improving communication, to ensure and preserve safety, integrity and respect for patients, coworkers and their own rights as professionals and citizens.[36]

It is noteworthy that, in Brazil, the Resolution of the Collegiate Board of Directors (RDC) 63/2011 was established in 2011, which provides for the Requirements for Good Operating Practices for Health Services. In Article 8 of this RDC, it is established that a health service must institute strategies and actions aimed at patient safety, including "guidelines to encourage patient participation in the care provided".[37]

Based on the above, it was observed in this study that patient participation has a positive influence on compliance with HH by health professionals, although many patients are still intimidated by questioning the health team about performing the technique. The results showed that the main obstacle to this effective communication between patients and caregivers is the fact that users believe that this questioning or assessment of professionals' practice can interfere with their care process.[20,21,25]

In the same way, it is necessary to involve patients as active subjects in promoting improved compliance with HH of health professionals, as this is a useful and promising educational strategy, which should be part of the safety culture of health institutions.

Patient participation as a unique form of intervention is not an effective and long-lasting strategy for compliance with HH. WHO recommends that it is necessary to use several actions to address institutional obstacles and established behavioral cultures.[37,38] Cultural changes do not occur quickly and spontaneously, so they need to be permanent and always re-assessed.[8]

The present review showed that health education with patient participation has been shown to be effective in raising and maintaining the compliance rates with HH. Innovative methods with the inclusion of patients should replace conservative behaviors, in order to empower the subjects and keep them active in their care process.

CONCLUSION

Educational strategies that used patient participation and involvement in HH promotion by health professionals proved to be effective for greater compliance of health professionals with this essential technique. Thus, the interventionist strategies described here can support patient involvement in future actions aimed at improving HH in health facilities.

However, the lack of studies carried out in the Brazilian territory is highlighted, demonstrating the need for further discussion and application of MS components in health establishments, since compliance with HH is considerably lower than recommended and infection rates related to health care show worrying rates.

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All authors have approved the final version to be published and are responsible for all aspects of the work, including ensuring its accuracy and integrity.

LETTER TO THE EDITOR

Operationalization of vaccination against covid-19 in the city of Vitória - ES, a successful experience

Operacionalização da vacinação contra a covid-19, no município de Vitória - ES, uma experiência de sucesso

Operacionalización de la vacunación contra covid-19 en la ciudad de Vitória - ES, una experiencia exitosa

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Given the epidemiological scenario resulting from the pandemic caused by SARS-CoV-2, the municipality of Vitória created, in March 2020, the Municipal Contingency Plan for Human Infection by the New Coronavirus (*Plano de Contingência Municipal para Infecção Humana pelo Novo Coronavírus*).[1]

The first cases of covid-19 were identified in the city of Wuhan, China, in December 2019, quickly spreading worldwide due to its virus' high transmissibility.[2,3] In the municipality of Vitória, the first case was reported on March 13, 2020; given the worldwide pandemic, the capital of the state of Espírito Santo declared a state of public health emergency via Decree No. 18,037. The declaration allowed for of a set of measures to be adopted, restricting the circulation of people and inducing social isolation as a way to contain the disease's growing rate of cases.[1,4]

The organization of Vitória's Municipal Operational Plan for the Vaccination Strategy Against covid-19 (*Plano Operacional de Estratégia de Vacinação contra a Covid-19)* began in November 2020, being published (in the municipality's official website) on January 2021, and constantly updated.[5] Vitória's municipal immunization program followed the recommendations of the Ministry of Health (MS) and, according to the availability of vaccine doses, optimized the immunization of the population.[6]

The main objective of the Municipal Operational Plan is to organize the actions and strategies for the vaccination against covid-19, addressing the pre-campaign, campaign, and post-campaign phases; in addition to providing for all the storage and distribution logistics of the municipal network to contain the dissemination of SARS-CoV-2, especially in groups eligible for vaccination, reaching high and homogeneous vaccination coverage. Furthermore, the plan also anticipates the promotion of media strategies related to the dissemination of the vaccine, to the fight against fake news, and to the population's acceptance of the vaccination.[5]

Vitória's health network has 100% coverage by Primary Care and 28 vaccination rooms in operation during the opening hours of health units, from 7 AM to 6 PM. Each vaccine room has a higher-level nursing professional, auxiliaries and nursing technicians. The technical team

responsible for the municipal immunization program is composed of nurses, nursing technicians, physicians, pharmacists and administrative assistants, who lead local teams from application, storage, logistics, record information system, and monitoring of post-vaccine adverse events.

In the pre-campaign stages, in addition to adjustments of physical structures and acquisition of equipment and supplies, continuous training and updates were offered on good practices of vaccine application (conservation, dilution and application, consistent records, adverse effects, among others) to the vaccination teams, composed of municipal employees and with partnerships with higher education institutions and the private sector.[5]

In Vitória, the technological capacity available in the vaccine rooms (computerization and connectivity) was essential, since it is the first national campaign with nominal registration in the Information System of the National Immunization Program (SI-PNI), with the purpose of identifying vaccinated people, ensuring the traceability of the immunobiological materials used and monitoring vaccination coverage.[6] In the first few weeks, it was a challenge to start the campaign; with the national system not yet enabled, data had to be registered after the actual start of the vaccine application.

Since the first priority groups of the national immunization plan are older adults in long-term institutions, people with disabilities living in inclusive homes, and frontline health workers of hospitals and emergency care, and also due to the (un)availability of vaccine for dose escalation, the choice to start vaccination actions outside health units. Vaccination began on January 19, 2021, with rotating teams within institutions and services, taking the appropriate precautionary measures and care with vaccines and other supplies to minimize vaccine losses, since the available immunobiological materials were mainly in multi-dose vials and with bottle opening time ranging from 6 to 8 hours, depending on the laboratory.[5,7]

Vaccination for the population in the subsequent groups was through online scheduling, available on the municipal city service portal, or through the *Vitória online* app, already used for other vaccines and which, although not new to the population, was fundamental for the current epidemiological moment.

Online scheduling allowed the system to provide doses in vaccination rooms and other environments such as parks, gymnasiums, churches, and schools, promoting an agile vaccination program and providing a greater supply of doses, applied in open and well-ventilated places. Moreover, to ensure the reception of people who did not have access or had difficulties with the technological tool, scheduling in the health units was also available, with the Family Health teams, who assist in scheduling and vaccine application processes in the homes of older adults with mobility restrictions or bedridden.

Vitória was the first capital of the country to reach 50% of its population vaccinated and continues to maintain high rates of immunization.[8] From January 1st to September 20, 2021, the municipality applied 528,009 doses of covid-19 vaccine, comprising 100% of the population immunized with the first dose and 78.64 % with the second dose and/or single dose, considering the population over 18 years of age.[7]

In such a current high complexity scenario at global scale, in which vaccinating is the best solution to prevent covid-19, the combination of vaccination with the maintenance of prevention and control measures— such as mask use, hand hygiene, physical distancing, respiratory etiquette, diagnostic tests, contact screening, quarantine, and social isolation—becomes a great challenge when seeking to stop the spread of SARS-CoV-2 and its new variants.[9,10]

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AUTHORS' CONTRIBUTION

Tatiane Comerio, Priscila Carminati Siqueira e Ethel Leonor Noia Maciel contributed to the conception, design, analysis, and writing of the article.

Thiago Nascimento do Prado e Carolina Maia Martins Sales contributed to the planning, design, review, and final approval of the article. All authors have approved the final version to be published and are responsible for all the aspects of the work, including ensuring its accuracy and integrity.