Review Article

Disinfection of incubators used in Neonatal Intensive Care Units: an integrative review

Desinfecção de incubadoras usadas em Unidades de Cuidados Intensivos Neonatais: revisão integrativa

Desinfección de incubadoras usadas en Unidades de Cuidados Intensivos Neonatales: revisión integradora

Eva Anny Wélly de Souza Brito[1] https://orcid.org/0000-0003-2532-0126
Mariana Cavalcante Martins[1] https://orcid.org/0000-0001-8234-8980
Nirla Gomes Guedes[1] https://orcid.org/0000-0003-0405-7517
Mônica Oliveira Batista Oriá[1] https://orcid.org/0000-0002-1483-6656
Régia Christina Moura Barbosa Castro[1] https://orcid.org/0000-0002-0673-9442
Weslley Monteiro Amora Sousa[1] https://orcid.org/0000-0001-6310-1210
Leonardo Alexandrino da Silva[1] https://orcid.org/0000-0002-1812-6459
Thais Aquino Carneiro. Enfermeira[1] https://orcid.org/0000-0002-0546-6139

How to cite:
Brito EA, Martins MC, Guedes NG, Oriá MO, Castro RC, Sousa WM, et al. Disinfection of incubators used in Neonatal Intensive Care Units: an integrative review. Acta Paul Enferm. 2022;35:eAPE03397.

DOI
http://dx.doi.org/10.37689/acta-ape/2022AR0033977

Abstract

Objective: To analyze the scientific evidence of incubator disinfection practices used in Neonatal Intensive Care Units.

Methods: This is an integrative literature review, conducted from June to July 2020, in the LILACS, SciELO, CINAHL, Scopus, Web of Science and MEDLINE databases. The findings were organized according to the PRISMA flowchart and discussed according to pertinent literature.

Results: Of the 780 articles found, only five met the inclusion criteria. The sanitizers used were: didecyldimethylammonium chloride, PHMB and vaporized hydrogen peroxide (VHP); didecyldimethylammonium chloride; N-(3-aminopropyl)-N-dodecylpropane-1,3-diamine; didecyldimethylammonium chloride and steam cleaning; water with detergent for cleaning in the bucket and bleach (200 mg/L) and 2.5% Umonium38® disinfectant. There is a diversity of options for disinfection of incubators, with variation of methods and frequency of cleaning. The sanitants used were effective, pointing to reduction of microbial load.

Conclusion:A variety of procedures and products were observed that can be used for cleaning and disinfection of incubators. Disinfection procedures favored the reduction of surface contamination. However, the presence of microorganisms, even if reduced, alerts about the risk to patient safety.

Resumo

Objetivo: Analisar as evidências científicas de práticas de desinfecção de incubadoras usadas em Unidades de Cuidados Intensivos Neonatais.

Métodos: Revisão integrativa de literatura, realizada de junho a julho de 2020, nas bases de dados: LILACS, SciELO, CINAHL, SCOPUS, *Web of Science* e MEDLINE. Os achados foram organizados conforme o fluxograma PRISMA e discutidos de acordo com a literatura pertinente.

Resultados: Dos 780 artigos encontrados, apenas cinco contemplaram os critérios de inclusão. Os saneantes utilizados foram: cloreto de didecildimetilamônio, polihexametilenobiguanida e Peróxido de Hidrogênio (VHP); cloreto de didecildimetilamônio; N-(3-aminopropyl)-N-dodécylpropane-1,3-diamine; cloreto de didecildimetilamônio e limpeza a vapor; água com detergente para limpeza no balde e água sanitária (200mg/L) e desinfectante Umonium38® a 2,5%. Há diversidade de opções para desinfecção das incubadoras, com variação de métodos e frequência de limpeza. Os saneantes utilizados foram eficazes, apontando para redução da carga microbiana.

Conclusão: Observou-se uma variedade de procedimentos e produtos que podem ser utilizados para limpeza e desinfecção das incubadoras. Os procedimentos de desinfecção favoreceram a redução da contaminação da superfície. No entanto, a presença de micro-organismos, mesmo que reduzida, alerta sobre o risco à segurança do paciente.

Keywords
Incubators; Infant, newborn; Intensive care units, neonatal; Disinfection; Cross infection

Descritores
Incubadoras; Recém-nascido; Terapia intensiva neonatal; Desinfecção; Infecção hospitalar

Descriptores
Incubadoras; Recién nacido; Cuidado intensivo neonatal; Desinfección; Infección hospitalaria

Submitted
November 13, 2020

Accepted
April 11, 2022

Corresponding author
Mariana Cavalcante Martins
E-mail: marianaenfermagem@hotmail.com

Associate Editor (Peer review process):
Monica Taminato (https://orcid.org/0000-0003-4075-2496)
Escola Paulista de Enfermagem, Universidade Federal de São Paulo, SP, Brasil

[1]Universidade Federal do Ceará, Fortaleza, CE, Brazil.
Conflicts of interest: nothing to declare.

Resumen

Objetivo: Analizar las evidencias científicas de prácticas de desinfección de incubadoras usadas en Unidades de Cuidados Intensivos Neonatales.

Métodos: Revisión integradora de literatura, realizada de junio a julio de 2020, en las bases de datos: LILACS, SciELO, CINAHL, SCOPUS, *Web of Science* y MEDLINE. Los resultados fueron organizados de acuerdo con el diagrama de flujo PRISMA y discutidos de acuerdo con la literatura pertinente.

Resultados: De los 780 artículos encontrados, solamente cinco contemplaron los criterios de inclusión. Los desinfectantes utilizados fueron: cloruro de didecildimetilamonio, polihexametilen biguanida y peróxido de hidrógeno (VHP); cloruro de didecildimetilamonio; N-(3-aminopropil)-N-dodecilpropano-1,3-diamina; cloruro de didecildimetilamonio y limpieza a vapor; agua con detergente para limpieza en el balde y cloro (200mg/L) y desinfectante Umonium38® al 2,5 %. Existe una diversidad de opciones para la desinfección de las incubadoras, con variación de métodos y frecuencia de limpieza. Los desinfectantes utilizados fueron eficaces, lo que indica una reducción de la carga microbiana.

Conclusión: Se observó una variedad de procedimientos y de productos que se pueden utilizar para la limpieza y la desinfección de las incubadoras. Los procedimientos de desinfección favorecieron la reducción de la contaminación de la superficie. Sin embargo, la presencia de microorganismos, aunque reducida, alerta respecto al riesgo a la seguridad del paciente.

Introduction

Healthcare-associated infections (HAI) contribute to high levels of morbidity and mortality, the appearance of multidrug-resistant bacteria, increased hospital stay, and high costs for public health, directly affecting patient safety and the quality of services provided. Among all the populations affected by HAI, we highlight those hospitalized in Neonatal Intensive Care Units.[1]

Newborns (NB) are more susceptible to hospital infections by multidrug-resistant infectious agents and their complications, since they have an immune system still expanding, with skin barriers and inefficient mucous membranes, in addition to great exposure, in some cases, to hospital therapeutic interventions, such as the use of invasive devices and broad-spectrum antimicrobials.[2]

The addition to technologies in health services facilitates the work process and intensifies the quality of care provided. However, in situations of lack of training for the proper handling and maintenance of equipment, the incorporation of technological equipment can, on the contrary, hinder professionals' work during the routine in the unit and cause losses.[3]

In this context, medical-hospital equipment has become increasingly sophisticated and important in the aid of diagnoses and life support. Among these, we highlight the neonatal incubator, Medical Care Equipment (MCE) capable of keeping Premature Newborns (PTNB) in a thermoneutral environment similar to the uterus. The incubator, in addition to preventing hypothermia, provides humidified environment, isolating from contaminants, allowing complete visualization and access to NBs. However, when handled erroneously, it can pose risks to the safety of NBs.[4]

It is undeniable that environmental contamination represents a risk of transmission between patients and professionals. In this sense, the cleaning and/or disinfection of environmental surfaces contributes to the prevention of surface contamination and reduces contamination, contributing to a reduction in the occurrence of infections. Thus, the cleaning of a health unit is within the activities performed in a hospital routine, making patients biologically less susceptible to pathogenic microorganisms.[5]

When considering the safety of PTNB in the hospital environment, it is necessary that hygiene in incubators used in Neonatal Intensive Care Units (NICU) be performed every time an NB is removed from the incubator, whenever the equipment is received, when it is in disuse or is disconnected,[5] as well as within the deadlines established in the protocols of each institution.

The lack of knowledge of nursing professionals regarding the role of environmental surfaces as the main reservoirs for the spread of bacteria resistant to multiple drugs is alarming, implying the possibility of exposure to such factors without proper precautions and, consequently, the risk of contamination and dissemination of these multidrug-resistant bacteria.[6]

In a study conducted in a neonatal ICU in Botucatu, it was identified that 75% of nursing technicians/auxiliaries and 79% of nurses reported having some doubt/difficulty to handle and maintain incubators.[7]

Thus, the need for the nursing team to know the practices related to cleaning and disinfection of incubators is evident, contributing to the reduction of the risk of infections and the development of actions that qualify the health care provided to NBs.

Considering the above, this study aimed to analyze the scientific evidence of incubator disinfection practices used in NICUs.

Methods

This is an integrative literature review,[8] conducted between June and July 2020. Research development took place in five stages.

Step 1 - Theme identification or guiding question formulation: The PICO strategy[9] (P: incubator-dependent NBs; I: incubator cleaning and disinfection processing; Co: scientific evidence of cleaning and disinfection practices carried out in incubators). The following question originated: what does scientific production describe in relation to the procedures used in the disinfection of incubators used in NICUs?

Step 2 - Definition of search terms: the basis was in the Descriptors in Health Science (DeCS) and Medical Subject Headings (MeSH). The descriptors were used in English and Portuguese in the remaining databases. "Cross Infection (*Infecção Hospitalar*)"; "Incubators (*Incubadoras*)"; "Disinfection (*Desinfecção*)"; "Intensive Care Units, Neonatal (*Unidades de Terapia Intensiva Neonatal*)". Crossings were carried out in English and Portuguese: Cross Infection AND Incubators AND Disinfection; *infecção hospitalar* AND *incubadoras* AND *desinfecção*; Cross Infection AND Disinfection AND Intensive Care Units, neonatal; *infecção hospitalar* AND *desinfecção* AND *unidade de cuidados intensivos neonatais*; Cross Infection AND Intensive Care Units, neonatal AND Incubators; *infecção hospitalar* AND *unidade de cuidados intensivos* AND *incubadoras*.

Step 3 - Inclusion criteria: primary articles that addressed the guiding question. There was no limit on the language and period of publication, as the purpose was to cover the largest number of articles and follow the progression of evidence over time. Guidelines, manuals and editorials, articles that did not identify the practices adopted in disinfection, studies not available in full, duplicated publications in more than one database were excluded.

Step 4 - Selection of databases and search for scientific productions. The studies came from journals indexed in the following databases: Latin American and Caribbean Literature in Health Sciences (LILACS); Scientific Electronic Library Online (SciELO); Cumulative Index to Nursing and Allied Health Literature (CINAHL); SciVerse Scopus (Scopus); Web of Science; and Medical Literature Analysis and Retrieval System Online (MEDLINE). The search was matched by two independent and consensual evaluators. Initially, the titles and abstracts were read, followed by the full reading of those who remained in the sample.

Step 5 - Article eligibility assessment according to Preferred Reporting Items for Systematic Reviews and Meta Analysis (PRISMA).[10] Later, the extraction, analysis, presentation and discussion of results were carried out. It is emphasized that the categorization of the results was not carried out, as all articles used different cleaning strategies/steps/materials. The information was extracted and arranged in a spreadsheet in Microsoft Word and grouped into the variables author, year, country of publication, objective, procedures used for cleaning the incubators, results/conclusions and level of evidence, being identified in chronological order (A1 – A5).

Figure 1 exposes the steps of selecting and including the articles in this review.

To assess the articles, the level of evidence determined according to their methodological characteristics was considered.[11] Level I of evidence considers that the recommendations from the findings of articles in this classification have a greater possibility of applicability in practice, when compared to level VI.[11]

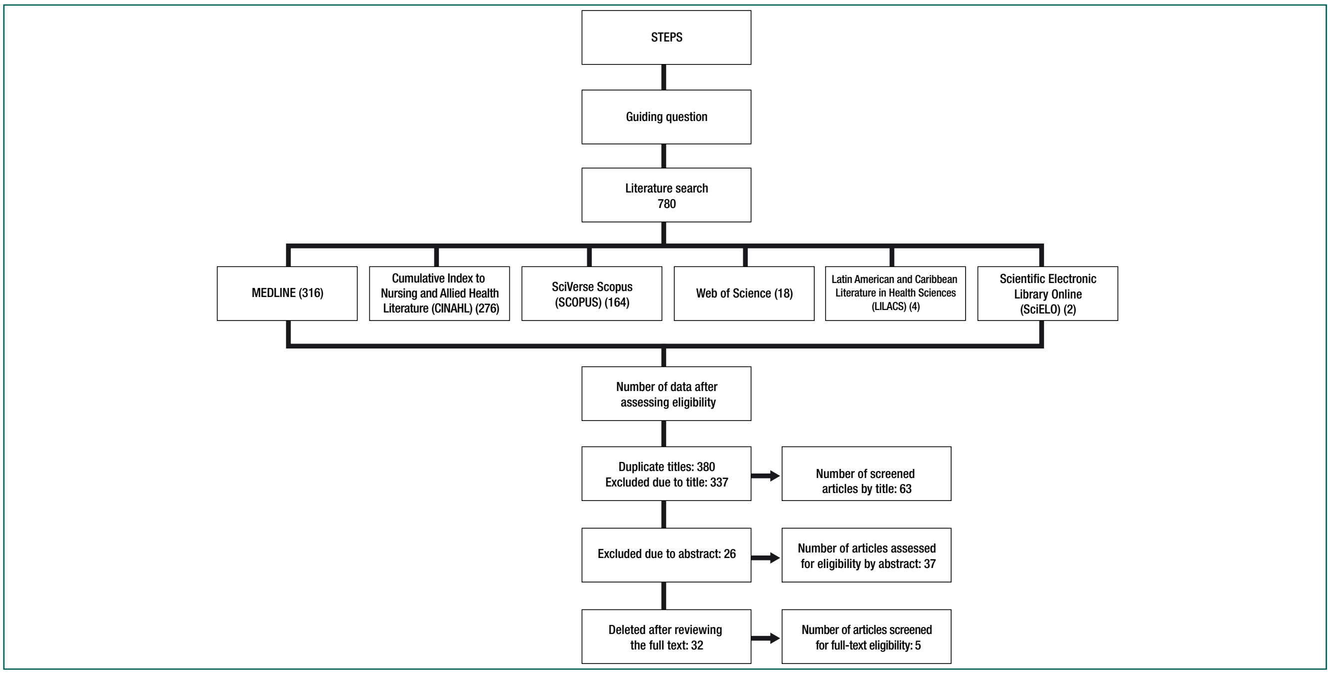

Figure 1. Flowchart of article selection and inclusion

Results

The search in the databases resulted in 780 studies (Figure 1), of which 716 were excluded by title and by repetition, with 64 being used. After reading these, 26 were excluded for not answering the guiding question. The remaining 38 articles were read in full, independently, by two evaluators, 33 of whom were excluded because they did not answer the research question. Exclusions were made in an equal and consensual manner by the two reviewers. Thus, the final sample consisted of five articles. Chart 1 presents products used, disinfection frequency and results obtained in the selected studies.

Article characterization is described in Chart 2.

Discussion

The results showed recent interest in research in this area, since the production found is less than five years old.

The incubators represent an important technological advance in the maintenance of NBs' health status, especially those who are hospitalized in the NICU. Due to the functionality of promoting a controlled environment, they contribute to maintaining body temperature, adequate humidity in the environment and appropriate air flow. The process of cleaning the incubators is a fundamental aspect in ensuring safe practices in the use of this equipment.[17]

Chart 1. Description of products used, disinfection frequency and results obtained per article

Authors, year, country	Products used	Disinfection frequency	Result
Li *et al.* 2017. China. (A1)	Cloths soaked with disinfectant (substance not informed), after cleaning the environment with bleach.	Daily	HAI reduction
Fattorini *et al.* 2018. Italy. (A2)	Umonium38® Neutralis disinfectant.	<6 days of hospitalization: Upon discharge/transfer >7 days of hospitalization: weekly	Colony Forming Unit reduction
Chiguer *et al.*; 2019; Morocco (A3)	Disposable wipes moistened with PHMB-associated didecyldimethylammonium chloride, followed by the use of hydrogen peroxide.	One-off intervention	Colony Forming Unit reduction
Cadot *et al.*, 2019. France. (A4)	Didecyldimethylammonium chloride (1), associated with Surfanios® (2), in addition to steam cleaning (2).	Daily (1) and weekly (2)	Contamination reduction
Ory *et al.*, 2019. France. (A5)	Water vapor disinfection (Sanivap SV2900).	Not specified	*S. capitis* case incidence reduction

A1 – Article 1; A2 – Article 2; A3 – Article 3; A4 – Article 4; A5 – Article 5

Chart 2. Presentation of selected studies according to variables of interest

Study	Objectives	Hygiene/material (steps followed)	Results/conclusions	Levels of evidence
A1	Assess the scope of the impact of relocating the ward to a new facility and changing environmental cleanup practices to reduce MRSA[a] on inanimate surfaces and HAI incident rate over the five-year period.	1. Change of reusable cotton cloths for all surfaces of the unit, including the NB's spaces, once a day to use individual cloths soaked with disinfectant substance, after cleaning the environment with bleach (200mg/L) twice a day. P.S.: Disinfectant substance not specified.	There was a significant reduction in HAI incidence after the intervention (P<0.001); however, there was an increase in the incidence of infections related to PICC[b] (P=0.019).	VI
A2	Assess the effectiveness of a protocol for disinfecting neonatal incubators in a clinical environment for different microorganisms potentially involved in the spread of HAI.	1. Cleaning protocol, consisting of five phases: a) machine is disconnected and removed from the energy source; b) removal of removable parts; c) disinfection of removable parts; d) disinfection of fixed parts; e) assembly of removable parts. 2. Every seven days, the NB was transferred to a new incubator. 3. Umonium38® Neutralis[c] disinfectant was used with manufacturer's recommendation of 2.5% and contact time for 10 minutes.	Decrease of at least 91.2% of CFU[d], presenting lower rates of bacterial growth in the samples referring to the internal surfaces after disinfection.	VI
A3	Assess the effectiveness of enhanced cleaning process to reduce bacterial contamination in the NICU environment.	1st day: standard cleaning routine of the unit with didecyldimethylammonium chloride in reusable plain cloths. 2nd day: disinfection routine implementation with disposable wipes moistened with didecyldimethylammonium chloride associated with PHMB[e]. 3rd day: use of VHP[f] for the entire wing.	There was a statistically significant decrease in CFU[d], after applying the changes only from moment 1 to 2 (P<0.0001), decreasing from 24 CFU to 2. From moment 2 to 3, there was a drop from 2 to 0 CFU[d].	VI
A4	Present the investigation process and hygiene practices adopted with a focus on the incubator to control an outbreak of K. pneumoniae producing beta-lactamase.	1st moment: assessment of standard precautionary practices, contact and disinfection. 2nd moment: Surfanios®[h], after steam cleaning (daily cleaning of the incubator with Anios DE® 7.85 II[g]; weekly, the NBs are transferred from the incubator, being disinfected with Surfanios®[h], and steam cleaning [SV 4000A, Sanivap, France] of the incubator and the mattress), was added to pre-established protocol. 3rd moment: exchange of all mattresses due to cracks (reassessment after 1 month). Steam cleaning for the acrylic of the incubators and chemicals for the mattresses. 4th moment: reassessment after seven months.	After applying the interventions, there was a reduction in the level of contamination of incubators, decreasing from 35.6% to 4.9% and mattresses from 61.2% to 9.8% of positive samples.	VI
A5	Assess the impact of infection control interventions to reduce the number of cases of *S. capitis* NRCS-A during a five-year period in a NICU.	1. Replacement of disinfection with molecular detergents for disinfection with water vapor (Sanivap SV2900[i]). 2. Protocol followed four periods: P1) steam cleaner pre-purchase; P2) cleaner use; P3) machinery malfunction; P4) cleaner repair and reuse.	The incidence of cases of infection by S. capitis, during the periods of use (P2 and P4), was lower than those of non-use (P1 and P3), with a statistically significant difference (P<0.001), with zero infections in P4.	VI

A1 – Article 1; A2 – Article 2; A3 – Article 3; A4 – Article 4; A5 – Article 5; a - Methicillin-resistant S. aureus; b – Peripherally inserted central catheter; c – N-benzy-N-dodecyl-N,N-dimethyl-ammonium chloride/ N-benzyl-N,N-dimethyl-N-tetradecyl-ammonium chloride; d - Colony Forming Units; e – polyhexamethylene biguanide; f – hydrogen peroxide vapor; g - didecyldimethylammonium chloride; h – N-(3-aminopropyl)-N-dodécylpropane-1,3-diamine + Didecyldimethylammonium chloride; i - machinery used to carry out water vapor disinfection.

The studies that composed the sample showed that the incubator plays the role of reservoir for microorganisms and that it presents a significant reduction in colonization, after implementing surface disinfection practices, despite the variety of procedures and products used in the disinfection of incubators described in the articles assessed.

In 2012, the Brazilian National Health Regulatory Agency (ANVISA - *Agência Nacional de Vigilância Sanitária*) recommended that the process of sanitizing incubators in NICUs be carried out first with cleaning using soap and water, followed by a quaternary ammonium solution.[18] Brazilian studies using or assessing such practices were not found in the sample.

Regarding the ammonium quaternaries, mentioned in A3 and A4, in the incubator cleaning process, more specifically the fourth and fifth generation, studies show that screens with touch commands, LCD, incubators and benches of nutrition services can be used for fixed surfaces, due to the effectiveness for microbiological control, low human and environmental toxicity, reduced volatility and corrosivity, odorless, easy handling, foam formulation, bactericidal, virucidal, tuberculocidal and action in the presence of organic matter. On the other hand, it presents as disadvantages the possibility of causing dermal irritation, being able to damage synthetic rubbers, cement and aluminum.[19-21]

Regarding A1, a Chinese study, although it did not specify the substance used for disinfecting the incubator, the use of sodium hypochlorite in the environment around the incubator, such as floor and other surfaces, was reported. With bactericidal, virucidal, fungicidal, tuberclicidal and sporicidal characteristics, depending on the concentration of use, it has a fast- and low-cost action, being indicated for disinfection of fixed surfaces (floor and wall) in bathrooms. Its disadvantage is instability at temperatures above 25°C and when in contact with acidic pH, in addition to being inactivated in the presence of organic matter, corrosive to metals, unpleasant odor and can cause irritability in eyes and mucous membranes. It presents as a particularity to be used for disinfection, at a concentration of 1,000ppm, of environments colonized by Clostridium difficile.[22]

Also, hydrogen peroxide vapor (A3) was found to be effective in cases of patients with Clostridium difficile infection, being optional to use 0.5% sodium hypochlorite, since disinfection with 70% alcohol is not effective in the sporulated form of the bacillus.[17] Hydrogen peroxide is believed to be used as a supplement to the main routine cleaning and disinfection process for amplification of microbiological control.[23]

Another procedure used in microbiological control is the physical disinfection with water vapor on the incubator's acrylic surface, associated with the chemical disinfection of the incubator mattresses.[16] Steam use against microorganisms, at 140ºC pressurized, showed a satisfactory improvement in the colonization of wards.[24] On the other hand, the increase in moisture in the mattresses may facilitate the promotion of incubation of microorganisms.[15]

Water vapor use obtained positive results in relation to contamination by the microorganism *S. capitis*, known for its resistance to antimicrobials or certain disinfecting agents and/or capacity to form biofilms.[25] In other scenarios, a reduction in contamination levels was also detected when using water vapor.[26-28]

As for the frequency of cleaning and disinfection of incubators and equipment in the vicinity, considered as the patients' environment, it is recommended that it be daily in nurseries and NICUs.[29]Another study highlighted that the exchange of incubators should always be done between one client and another and every five or seven days after continuous use, when clinical conditions allow it; however, this practice, despite being widely used, has not yet been validated.[30]

Based on the results of the studies analyzed, it is evident that cleaning and disinfection procedures favored microbiological control, considering the reduction of infections in NBs and the colonization of the environment, defined through biological analyzes that allowed detecting the presence and/or concentration of pathogens (quantification of CFU, pulse field gel electrophoresis), to verify bacterial strains, bacterial growth in culture media, ionization and matrix-assisted laser desorption.

Thus, it is important to implement other strategies, in addition to cleaning/disinfection, as a way of mitigating the risk of HAI in infants, such as the use of bundles, qualification of the teams responsible for cleaning the incubators and the environment.

Although the concept of enhanced terminal room disinfection does not work directly,[31] the articles used mixed techniques/products, in order to assist and enhance the process of cleaning incubators and the NICU environment.

It is noteworthy that it was not the focus of this study to analyze the most effective method or the one that produces the best cost-benefit for NBs and the health institution. However, it is noteworthy that studies with these objectives are still necessary to increase the quality of care for NBs.

Conclusion

A variety of procedures and products have been observed that can be used for cleaning and disinfecting incubators. The sanitizers used were: didecyldimethylammonium chloride, PHMB and vaporized hydrogen peroxide (VHP); didecyldimethylammonium chloride; N-(3-aminopropyl)-N-dodecylpropane-1,3-diamine; didecyldimethylammonium chloride and steam cleaning; water with detergent for cleaning in the bucket and bleach (200 mg/L) and 2.5% Umonium38® disinfectant. Disinfection procedures favored the reduction of surface contamination. However, the presence of microorganisms, even if reduced, warns about patient safety risk and about the importance of training health professionals regarding the processing and certification of the techniques and products used. Nursing plays an important role in relation to these processes, since it acts directly in developing the procedure protocols and recommendations. Moreover, it is pertinent to prepare new studies in order to generate evidence that facilitates or assists in hygiene practice standardization of incubators.

Acknowledgments

We thank the Coordination for the Improvement of Higher Education Personnel (CAPES - *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior*) for the valuable contribution with the financial resources destined to the scholarship holders who carried out this research of relevant contribution to science.

References

1. Vila ME, Gomes MF. Perfil microbiológico e de sensibilidade em uma uti neonatal de referência no estado do Pará de janeiro de 2016 a julho de 2017 [monografia]. Belém (PA): Universidade Federal do Pará; 2017 [citado 2020 Jul 10]. Disponível em: https://bdm.ufpa.br:8443/jspui/bitstream/prefix/434/1/TCC_PerfilMicrobiologicoSensibilidade.pdf
2. Gonçalves LR, Luz PC, Azevedo AL. Avaliação microbiológica de incubadoras: antes e depois da limpeza em uma maternidade de Teresina – PI. Rev Interdisciplinar. 2016;9(2):57-64.
3. Tavares KF, Torres PA, Souza NV, Pereira SR, Santos DM. Hard technology in the intensive care unit and the subjectivity of nursing workers. J Res Fundam Care Online. 2013;5(4):681-8.
4. Coutinho ES. Desenvolvimento de um procedimento operacional padrão para manutenção preventiva para incubadoras Fanem Vision 2286 do Hospital de Clínicas de Uberlândia da Universidade Federal de Uberlândia [monografia]. Uberlândia (MG): Universidade Federal de Uberlândia; 2019 [citado 2020 Jul 13]. Disponível em: https://repositorio.ufu.br/bitstream/123456789/25281/3/DesenvolvimentoProcedimentoOperacional.pdf
5. Ferreira AM, Andrade D, Rigotti MA, Almeida MT, Guerra OG, Santos Júnior AG. Assessment of disinfection of hospital surfaces using different monitoring methods. Rev Lat Am Enfermagem. 2015;23(3):466-74.
6. Sales VM, Oliveira E, Célia R, Gonçalves FR, Melo CC. Microbiological analysis of inanimate surfaces in an Intensive Care Unit and patient safety. Rev Enfermagem Refeferência. 2014;4(3):45-53.
7. Costa CC. Avaliação de incubadoras neonatais e práticas de manuseio pela equipe de enfermagem [dissertação]. Botucatu (SP): Faculdade de Medicina, Universidade Estadual Paulista; 2016 [citado 2020 Jul 19]. Disponível em: https://repositorio.unesp.br/bitstream/handle/11449/137905/costa_cc_me_bot.pdf?sequence=3&isAllowed=y
8. Mendes KD, Silveira RC, Galvão CM. Revisão integrativa: método de pesquisa para a incorporação de evidências na saúde e na enfermagem. Texto Contexto Enferm. 2008;17(4):758-64. Review.
9. Grupo Ânima Educação. Manual Revisão bibliográfica sistemática integrativa: a pesquisa baseada em evidências. Belo Horizonte (MG): Grupo Ânima Educação; 2014 [citado 2020 Jul 21]. Disponível em: http://biblioteca.cofen.gov.br/wp-content/uploads/2019/06/manual_revisao_bibliografica-sistematica-integrativa.pdf
10. Souza MT, Silva MD, Carvalho R. Integrative review: what is it? How to do it? einstein (São Paulo). 2010;8(1):102-6. Review.
11. Melnyk BM, Fineout-Overholt E. Evidence based practice in nursing & healthcare: a guide to best practice. 3rd ed. Philadelphia: Lippincot Williams & Wilkins; 2014. p. 656.
12. Li QF, Xu H, Ni XP, Lin R, Jin H, Wei LY, et al. Impact of relocation and environmental cleaning on reducing the incidence of healthcare-associated infection in NICU. World J Pediatr. 2017;13(3):217-21.
13. Fattorini M, Buonocore G, Lenzi D, Burgassi S, Cardaci RM, Biermann KP, et al. Public Health since the beginning: neonatal incubators safety in a clinical setting. J Infect Public Health. 2018;11(6):788-92.
14. Chiguer M, Maleb A, Amrani R, Abda N, Alami Z. Assessment of surface cleaning and disinfection in neonatal intensive care unit. Heliyon. 2019;5(12):e02966.
15. Cadot L, Bruguière H, Jumas-Bilak E, Didelot MN, Masnou A, de Barry G, et al. Extended spectrum beta-lactamase-producing Klebsiella pneumoniae outbreak reveals incubators as pathogen reservoir in neonatal care center. Eur J Pediatr. 2019;178(4):505-13.
16. Ory J, Cazaban M, Richaud-Morel B, Di Maio M, Dunyach-Remy C, Pantel A, et al. Successful implementation of infection control measure in a neonatal intensive care unit to combat the spread of pathogenic multidrug resistant Staphylococcus capitis. Antimicrob Resist Infect Control. 2019;8:57.
17. Deguines C, Décima P, Pelletier A, Dégrugilliers L, Ghyselen L, Tourneux P. Variations in incubator temperature and humidity management: a survey of current practice. Acta Paediatr. 2012;101(3):230-5.
18. Agência Nacional de Vigilância Sanitária (ANVISA). Segurança do paciente em serviços de saúde: limpeza e desinfecção de superfícies. Brasília (DF): ANVISA; 2012 [citado 2020 Ago 2]. Disponível em: https://www.gov.br/anvisa/pt-br/centraisdeconteudo/publicacoes/servicosdesaude/publicacoes/manual-de-limpeza-e-desinfeccao-de-superficies.pdf
19. Campos JL, Jesus OA. Higiene hospitalar: a importância da limpeza na prevenção de infecções [monografia]. Jacareí (SP): Faculdade Inesp; 2015 [citado 2020 Ago 2]. Disponível em: https://www.ccih.med.br/higiene-hospitalar-a-importancia-da-limpeza-na-prevencao-de-infeccoes/
20. European Chemicals Agency (ECHA). N-(3-aminopropyl)-N-dodecylpropane-1,3-diamine. Finland: European Chemicals Agency [cited 2020 Aug 20]. Available from: https://echa.europa.eu/pt/substance-information/-/substanceinfo/100.017.406
21. Barbosa AS, Carneiro GS, Repullio LL, Silveira M, Silva SM, Vilani-Moreno FR. Eficácia do álcool etílico e quaternário de amônio na desinfecção de equipamentos médicos hospitalares. Rev Epidemiol Controle Infecção. 2018;8(4):409-14.
22. Empresa Brasileira de Serviços Hospitalares (EBSH). Protocolo/Limpeza e desinfecção de superfícies - Unidade de Vigilância Sanitária e de Qualidade Hospitalar do HC-UFTM. Uberaba (MG): EBSERH; 2017 [citado 2020 Ago 22]. Disponível em: http://www2.ebserh.gov.br/documents/147715/0/Limpeza+e+desinfec%252B%25C2%25BA%252B%25C3%25BAo+de+superf%252B%25C2%25A1cies+4.pdf/9801ccd7-6118-466b-a34c-bfa37b73b640
23. Dancer SJ. Controlling hospital-acquired infection: focus on the role of the environment and new technologies for decontamination. Clin Microbiol Rev. 2014;27(4):665-90. Review.
24. Gillespie E, Wilson J, Lovegrove A, Scott C, Abernethy M, Kotsanas D, et al. Environment cleaning without chemicals in clinical settings. Am J Infect Control. 2013;41(5):461-3.

25. Cui B, Smooker PM, Rouch DA, Daley AJ, Deighton MA. Differences between two clinical Staphylococcus capitis subspecies as revealed by biofilm, antibiotic resistance, and pulsed-field gel electrophoresis profiling. J Clin Microbiol. 2013;51(1):9-14.

26. Brown E, Dhanireddy K, Waldron C, Teska P, Eifert J, Boyer R. Evaluation of disinfectants and wiping substrates combinations to inactivate Staphylococcus aureus on Formica coupons. Am J Infect Control. 2019;47(4):465-7.

27. Martin EK, Salsgiver EL, Bernstein DA, Simon MS, Greendyke WG, Gramstad JM, et al. Sustained improvement in hospital cleaning associated with a novel education and culture change program for environmental services workers. Infect Control Hosp Epidemiol. 2019;40(9):1024-9.

28. Gillespie E, Brown R, Treagus D, James A, Jackson C. Improving operating room cleaning results with microfiber and steam technology. Am J Infect Control. 2016;44(1):120-2.

29. Public Health Ontario. Best Practices for Environmental Cleaning for Prevention and Control of Infections in All Health Care Settings. 3rd Edition. Ontario: Public Health Ontario; 2018 [cited 2020 Oct 01]. p. 95-106. Available from: https://www.publichealthontario.ca/-/media/documents/B/2018/bp-environmental-cleaning.pdf

30. Agência Nacional de Vigilância Sanitária (ANVISA). Pediatria: prevenção e controle de infecção hospitalar. Brasília (DF): ANVISA; 2006 [citado 2020 Out 1]. Disponível em: http://anvisa.gov.br/servicosaude/manuais/manual_definicao_criterios_nacionais_infec%E7%F5es_relacionadas_assistencia_saude_neonatologia.pdf

31. Anderson DJ, Chen LF, Weber DJ, Moehring RW, Lewis SS, Triplett PF, et al. Enhanced terminal room disinfection and acquisition and infection caused by multidrug-resistant organisms and Clostridium difficile (the Benefits of Enhanced Terminal Room Disinfection study): a cluster-randomised, multicentre, crossover study. Lancet. 2017;389(10071):805-14.