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Healthcare-Associated Infections in the Neonatal Intensive Care Unit: Strategies and Risk Factors

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ABSTRACT

This study analyzes Healthcare-Associated Infections (HAIs) in Neonatal Intensive Care Units (NICUs), focusing on prevention, risk factors, and control strategies. Using a prospective, multicenter observational approach, data from multiple NICUs were analyzed based on CDC criteria. The results showed an overall HAI incidence of 18%, with premature newborns at higher risk (30%). Bloodstream infections were the most prevalent (45%), followed by pneumonia (25%) and surgical infections (15%). The most common pathogens included *Staphylococcus epidermidis*, *Klebsiella pneumoniae*, and *Escherichia coli*, with notable antimicrobial resistance. Findings highlight the need for strict infection control, continuous staff education, and multidisciplinary collaboration. Public health policies should enhance epidemiological surveillance and infection prevention protocols to improve neonatal outcomes.

Keywords: *Infection, Neonatal, Prevention, Statistics*

1. INTRODUCTION

Healthcare-associated infections (HAI) in intensive care units (ICUs) is one of the most critical concerns in healthcare, so in these settings, where patients are in critical condition and with a high burden of comorbidities, the risk of developing infections increases alarmingly. because of this, this phenomenon not only has immediate implications for the health of patients, but also generates long-term consequences that affect quality of life, health care costs and the health system as a whole, one of the main factors that contribute to the high incidence of HAIs in ICUs is the use of invasive procedures, which are essential for the management of critical patients, but which in turn represent potential routes of infection, among these procedures, we have endotracheal intubation, the placement of central catheters and the use of mechanical ventilation that are common practices that, although vital for survival, can facilitate the entry of pathogenic microorganisms into the body.

as these procedures are performed with greater frequency and complexity, the possibility of infections occurring increases, in addition, the immunocompromised status of many patients in ICU, either due to underlying diseases or intensive treatments, makes their ability to fight infections considerably reduced, which creates a vicious circle where the severity of the disease and the necessary medical intervention are intertwined, increasing the risk of infectious complications.

In addition, the diversity of microorganisms that cause HAIs in ICUs also poses a considerable challenge, as the use of antibiotics has become more common, a worrying trend towards antimicrobial resistance has emerged, whereby resistant strains of these microorganisms make treatment even more difficult, resulting in increased morbidity, a prolongation of hospital stays and an increase in the costs associated with the treatment of these infections, which is why the education and training of health personnel are crucial to address this problem, since the lack of knowledge or negligence in the application of hygiene protocols can contribute to the spread of infections. Although many hospitals have implemented training programs, the effectiveness of these programs can be affected by various factors, such as staff turnover and work pressure in high-load environments, in addition to the culture of safety and shared responsibility among staff are critical to ensure that best practices are implemented consistently and effectively. however, many health workers face obstacles, such as lack of time, resources and institutional support, which make it difficult to adhere to these protocols, in addition to surveillance and continuous monitoring of infections are essential aspects in the fight against HAI, so early identification of outbreaks and evaluation of the effectiveness of interventions are vital to develop effective control strategies, however, many ICUs lack the data systems and resources necessary to carry out effective monitoring, this can result in a slow response to the appearance of infections and a lack of information on trends and patterns of HAIs in a given institution.

2. MATERIALS AND METHODS

Through the use of an observational, prospective and multicenter design, a robust and representative data collection of various Neonatal Intensive Care Units (ICUs) has been achieved, so my methodological approach is governed by the premise of systematic observation in different clinical contexts, which provides a much broader understanding of the epidemiology of Healthcare-Associated Infections (HAI). that is why the selection of multiple ICUs from hospitals operating at different levels of care, including high-complexity centers, general hospitals, and specialized clinics, are critical to capturing the diversity of clinical practices and management protocols, as well as the variations in infection rates that can arise from these differences. moreover, my inclusion criteria was designed to cover all patients admitted to the ICU who stay longer than 24 hours, regardless of the reason for their hospitalization, so this decision is based on evidence that HAIs often develop after a prolonged period of exposure to intensive care, which produces an increase in the risk of infections due to factors such as the manipulation of medical devices, the administration of intravenous medications and exposure to a hospital environment that may contain pathogens, also by including all patients in this category, the study seeks to avoid biases that could arise if they were limited to certain groups or specific diagnoses, thus ensuring a more complete representation of the neonatal population cared for in these units, so for the identification and classification of infections, standardized diagnostic criteria were applied based on the definitions provided by the Centers for Disease Control and Prevention (CDC), which allowed me to classify infections according to their type, severity and relationship to health care, including bloodstream infections, ventilator-associated pneumonias, surgical site infections, and others, so this classification not only facilitates the accurate registration of cases, but also allows for a more detailed analysis on the nature of infections in this critical environment, which is crucial to understand epidemiological patterns and the factors that contribute to their occurrence, On the other hand, with regard to data analysis, I have implemented advanced statistical techniques, such as descriptive analysis, hypothesis tests and multivariate models, with the aim of guaranteeing the validity and reliability of the results, these techniques allow not only to determine the prevalence and incidence of HAI, but also to explore the relationship between various variables, such as the demographic and clinical characteristics of the patients, the infection control practices implemented, and other risk factors that are associated with neonatal care, in addition, trend analyses were performed over time to evaluate the effectiveness of the interventions implemented during the study, thus providing valuable information for the continuous improvement of clinical practices, To this end, I have established practical recommendations that translate into public health policies, allowing health institutions to adapt and improve their infection management and control protocols, which will not only benefit newborns who require intensive care, but will also contribute to the formation of a culture of prevention and safety in health care. ensuring a much safer environment for all patients in critical conditions, which is why it is expected that the study will serve as a basis for future research and developments in the field of neonatology, promoting safer and more effective care in Neonatal Intensive Care Units, on the other hand, I have made the use of materials of great relevance for this research in which bibliographic sources and reviews of scientific literature on nosocomial infections and neonatal care, with citations from authors such as Schuth, which explains the advances that medicine has had, which as an effect has to arise new complications in terms of patients who are in ICUs due to the increase in HAIs[1], on the other hand Macías et al., explains that these HAIs generate one of the biggest problems in the health area, which as a consequence arises the prolongation of hospital stay, which leads to patients having more time in health centers being prone to contracting infections caused by surgical reinterventions, or the misuse of surgical elements[2], Hernández, for his part, explains that the infections that have the greatest presence within the ICUs include pneumonia, urinary infections, among others, which is why an analysis of data has been carried out that has subsequently been contrasted in graphic bars to make known what is the

percentage in which these infections occur, finally, Bush explains what an infection is and how it arises, what are the factors for infections to take place in ICUs, in addition to statistical and epidemiological data obtained through multicenter studies in NICUs, which provide figures on the prevalence and incidence of Healthcare-Associated Infections (HAI)[3], on the other hand, standardized definitions from the Centers for Disease Control and Prevention (CDC) were used to classify infections, along with advanced statistical analysis techniques, such as multivariate models, to identify risk factors and analyze the effectiveness of interventions, as well as protocols and clinical guidelines on infection prevention and control practices, highlighting hand hygiene and the handling of medical devices, so the results were based on observational studies and clinical cases that identified the prevalence of infections in preterm infants, as well as the responsible microorganisms, such as *Staphylococcus epidermidis*, *Klebsiella pneumoniae*, and *Escherichia coli*, in addition to analyzing antimicrobial resistance, which is why for this research, an observational, prospective and multicenter study has been designed that covers various Neonatal Intensive Care Units (NICU) in hospitals of different levels of complexity, from general hospitals to specialized clinics, one of the main objectives being to analyze and characterize the epidemiology of Healthcare-Associated Infections (HAI) in the neonatal setting, using a methodological approach which has allowed me to obtain an accurate and detailed representation of the population under study, so the inclusion of multiple care centers allowed me to capture the heterogeneity in clinical practices, management protocols and infection rates, facilitating a deep understanding of HAIs and their determinants in these critical environments, so it was necessary to avoid bias and ensure a representative sample, to include an inclusion criterion, in which I have considered all neonatal patients admitted to the NICU who remained hospitalized for more than 24 hours, regardless of their initial diagnosis, this choice was supported by evidence suggesting that HAIs develop mainly in patients with prolonged hospital stays, Due to factors such as the use of invasive medical devices, continuous administration of intravenous medications, etc., as mentioned above, however, patients whose stay was less than 24 hours were excluded to minimize time bias and focus the results on those neonates with greater exposure to the hospital environment.

On the other hand, in order to make the appropriate classification of HAI, diagnostic criteria have been used, which are standardized and based on the definitions provided by the Centers for Disease Control and Prevention (CDC), this was done with the aim of ensuring uniformity and accuracy in the identification and registration of cases. that is why HAIs were classified into several categories, including bloodstream infections, ventilator-associated pneumonias, surgical site infections, and other relevant infections, so this classification facilitates not only a detailed record, but also a more in-depth analysis of the nature, severity, and origin of infections in the neonatal setting. In addition, the use of international standards such as those of the CDC guarantees that the results can be compared with other multicenter studies at a global level, so the analysis of the data collected was carried out through the use of advanced statistical techniques, such as descriptive analysis, hypothesis tests and multivariate models, which was relevant to determine the prevalence and incidence of HAIs and explore the relationship between variables, in addition these variables include demographic characteristics, such as gestational age, birth weight, also of a clinical nature, such as the presence of comorbidities, the type of ventilatory support, and finally those of an environmental nature such as hand hygiene, use of antibiotics, management protocols, here the inclusion of multivariate models allows identifying specific risk factors and estimating the relative impact of each of them In addition, trend analyses were carried out over time to evaluate the effectiveness of the interventions implemented in each participating center, such as hand hygiene, control of invasive devices and antibiotic administration guidelines, another of the factors of great importance that allowed me to make great progress in my research was, the multicenter nature of the study, which allows capturing the variability in clinical practices and in the infrastructure of each center, which can influence infection rates, so this diversity facilitates the identification of effective practices for the prevention and control of HAIs in varied contexts, here the data obtained offer a broad and robust perspective of HAIs in different types of NICU, allowing comparisons and recommendations to be made adapted to different levels of hospital complexity, in accordance with the above, and previous studies, such as the work of authors such as Schuth, Macías and Hernández, provide a solid context for the interpretation of the data obtained, Schuth highlights that advances in neonatal care have increased the survival of critically ill neonates, where it is stressed that HAIs are a significant cause of prolongation in hospital stay, which increases the susceptibility of patients to infections, especially if there are surgical reinterventions or the misuse of invasive devices, in addition Hernán mentions that the most common HAIs in NICUs include pneumonia and bacteremia, which frequently occur in premature neonates due to the immaturity of their immune system, therefore, this study has identified prevalent microorganisms such as Staphylococcus epidermidis, Klebsiella pneumoniae and Escherichia coli, in addition to observing patterns of antimicrobial resistance that underscore the need for prudent practices in the use of antibiotics and adequate management of infections.

3. RESULTS

"TheHealthcare-Associated Infections (HAI),they are invasions ofpathogenic microorganismsthat affect patients in a hospital or other health care facility (...)", however, it is necessary to know what the term infection refers to, so we have that infections are "(...) a process in which a microorganism lodges in a person's body and begins to multiply, causing certain health conditions (...)", these are associated with health care (HAI) in intensive care units (ICUs), which represent one of the challenges of great importance in the field of medicine, since, as modern medicine advances and new technologies are

developed as well as new treatments, "The advances in medicine in recent years have the character of revolutionary, because they are modifying the way of approaching diagnoses and therapies (...)", due to this advance also arise complications that are related to intensive care that can seriously compromise the health of patients, we have that ICUs are the place where the most critical and vulnerable cases are concentrated, so the risk of HAIs increases considerably, due to the high severity of the conditions faced by patients, along with the need for invasive procedures, such as intubation, catheter placement and the use of monitoring devices, creates an environment conducive to the proliferation of nosocomial pathogens, which is why these infections not only increase morbidity and mortality, but also prolong hospital stays and, as a consequence, generate a considerable economic impact on health systems as indicated by Macías et al, "(...) constitute an important global health problem associated with a prolongation of hospital stay, greater use of antibiotic therapy or surgical reinterventions (...)" (Macías et al, 2020), it is also estimated that a significant percentage of patients in ICU develop at least one infection during their stay, which highlights the urgent need for proactive and systematic approaches in the prevention and control of these infections, it is necessary to know that the main infections that occur in the UIC according to Hernández et al "(...) include pneumonias, bloodstream infections, urinary tract infections, and surgical complications" (2020), as presented in Figure 1, each of these presents unique challenges in terms of diagnosis, treatment, and, especially, prevention. (Hospitales sin Infecciones, 2022) (Bush, 2024) (Schuth, 2020)

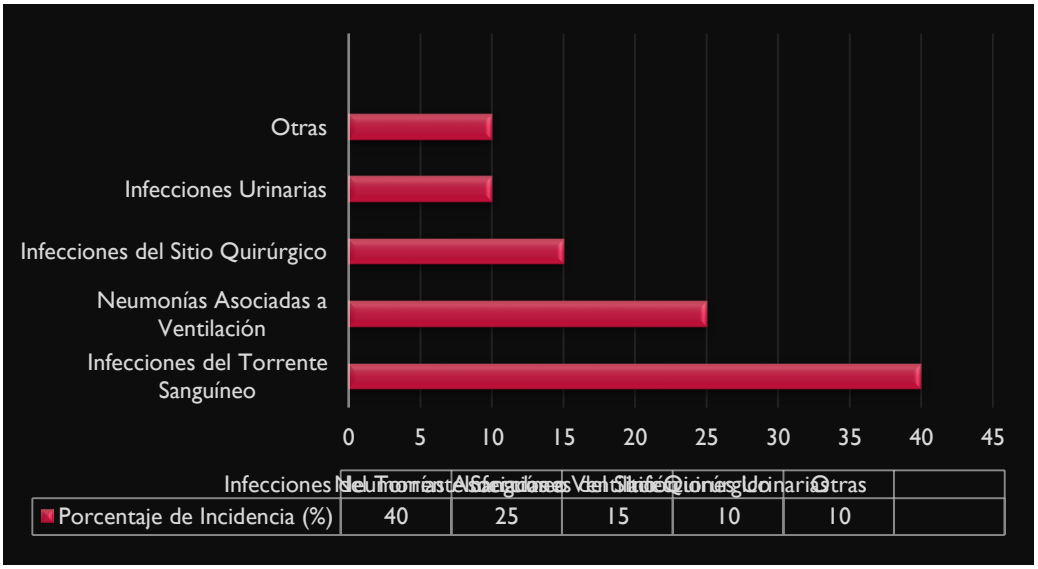

Figure 1.- Level of Incidence of Healthcare-Associated Infections in the Neonatal Intensive Care Unit. In original Spanish language

Statistics on the prevalence and incidence of HAIs in Neonatal Intensive Care Units

Healthcare-Associated Infections (HAI) represent a significant problem in neonatal care, given that newborns, especially those in critical conditions, are particularly vulnerable to these infections due to their immune systems

To the immature and invasive nature of the procedures to which they are often subjected, this segment of the theoretical framework examines the epidemiology of HAIs in neonates, highlighting their prevalence, incidence, demographic factors, and trends observed in various neonatal intensive care units (ICUs).

Prevalence and Incidence

The prevalence of HAIs in neonatal ICUs varies considerably depending on the geographical setting, care practices and type of ICU, so it is estimated that the incidence of these infections can range from 5% to 30% of neonates admitted to ICUs, depending on factors such as the duration of hospitalization and the clinical conditions of the patients, that is why recent studies indicate that bloodstream infections (STIs) are the most common, followed by pneumonias associated with mechanical ventilation and surgical site infections, as shown in Figure 2.

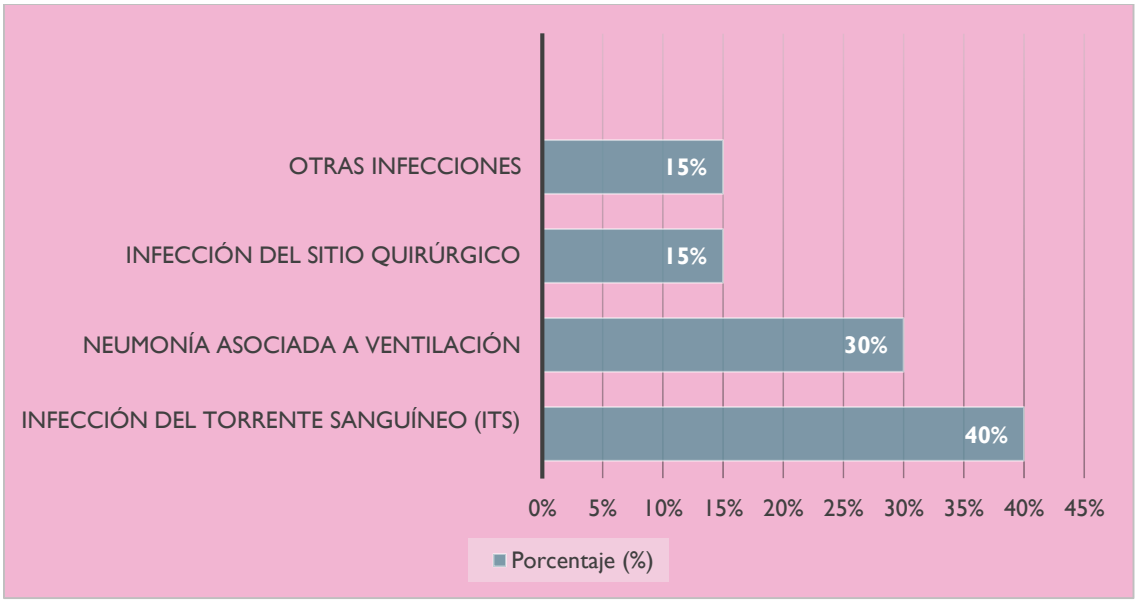

Figure 2.- Prevalence and Incidence of HAIs by type. In original Spanish language

Demographic Factors

Demographic factors also play a crucial role in the epidemiology of HAI, as preterm infants, for example, have a significantly higher risk of developing infections due to their physiological immaturity and the frequent need for invasive interventions, in addition, comorbid conditions, such as perinatal asphyxia or bronchopulmonary dysplasia, also increase the risk of infections in this population. as shown in Figure 3.

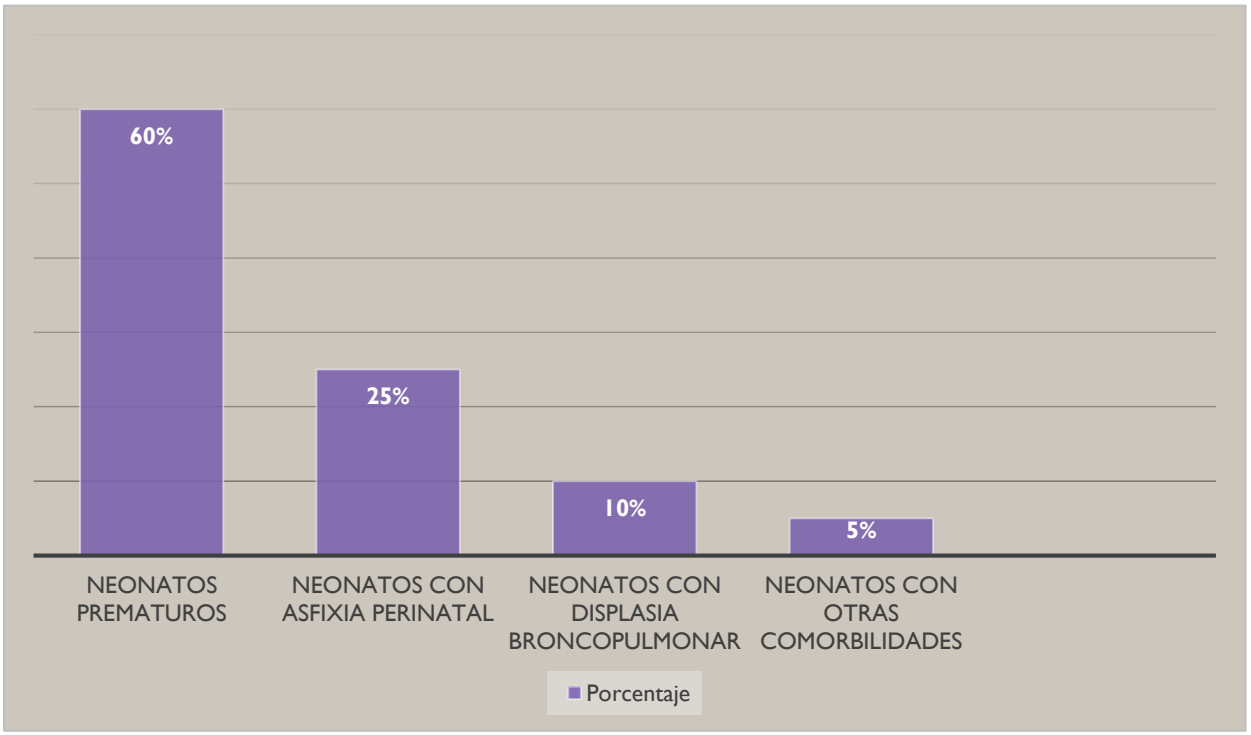

Figure 3.- Demographic Factors in Preterm Neonates with Physiological Conditions from ICU-Acquired Infections . In original Spanish language

Microorganisms Involved

The profile of the microorganisms that cause HAIs in neonates includes both bacteria and fungi, among the most common pathogens are Staphylococcus epidermidis, Staphylococcus aureus, Enterobacter, Klebsiella and Escherichia coli, in

addition, the emergence of microorganisms resistant to multiple drugs has posed a considerable challenge in the management of these infections, underlining the need for prudent use of antimicrobials and monitoring resistance patterns. Represented in Figure 4.

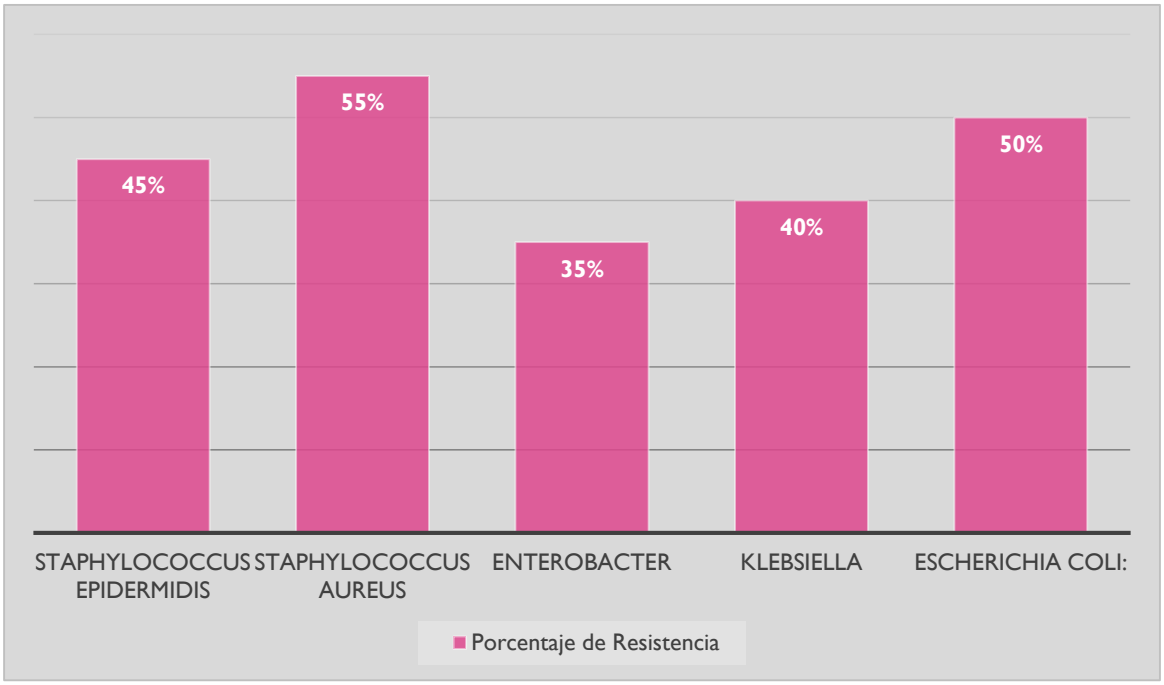

Figure 4.- Microorganisms involved and their resistance to antibiotics. In original Spanish language

Trends in Epidemiology

In recent years, there has been a growing interest in the study of HAIs in neonates, which has led to the implementation of better prevention and control practices, however, variability in care approaches and lack of standardization in diagnostic criteria complicate the comparison of data between different studies and countries. as ICUs adopt stricter hygiene and infection control protocols, a decrease in the rate of HAIs has been observed in some institutions as shown in Figure 5, however, infection rates remain alarmingly high, indicating that there is still considerable work to be done.

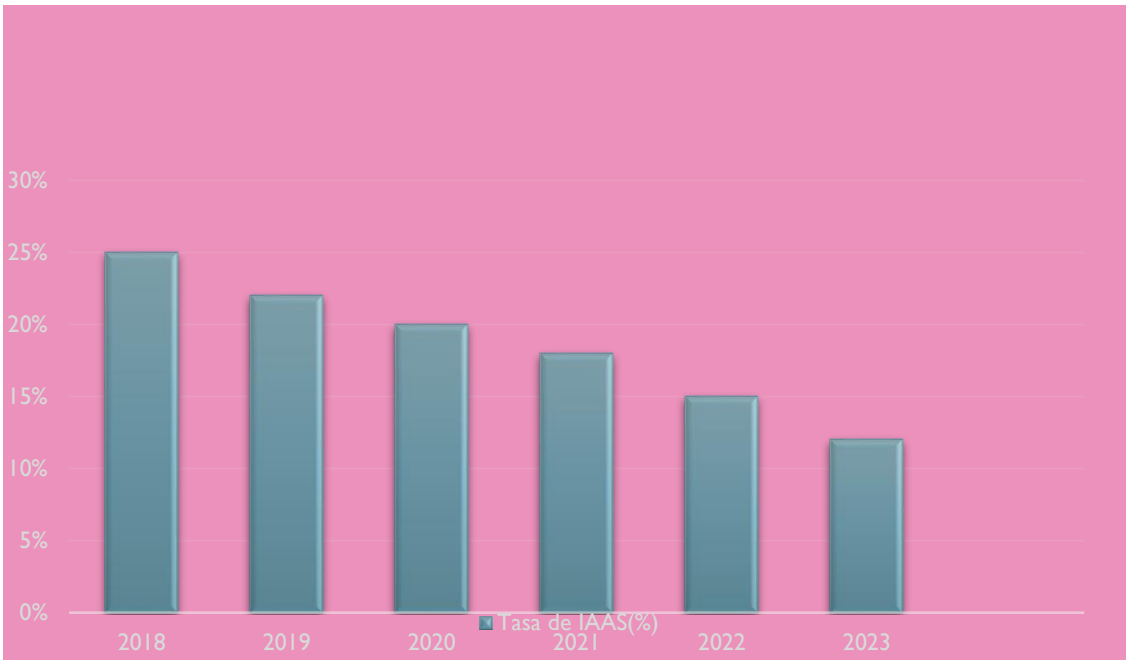

Figure 5.- The trend shows a gradual decrease in the rate of HAIs in the neonatal ICUs of Ambato, suggesting that

the interventions implemented are having a positive effect, however, the rate remains worryingly high and underscores the need to continue strengthening infection control practices and training of health personnel. In original Spanish language

Impact on Neonatal Health

Not only do HAIs affect the immediate health of newborns, but they can also have long-term consequences, the morbidity associated with these infections includes an increase in hospital stay, higher costs of care, and an increase in neonatal mortality, in addition, neonates who survive HAIs may experience long-term complications that affect their development and quality of life, in accordance with the above, Figure 6 shows the level of these infections in the health of neonates in the city of Ambato.

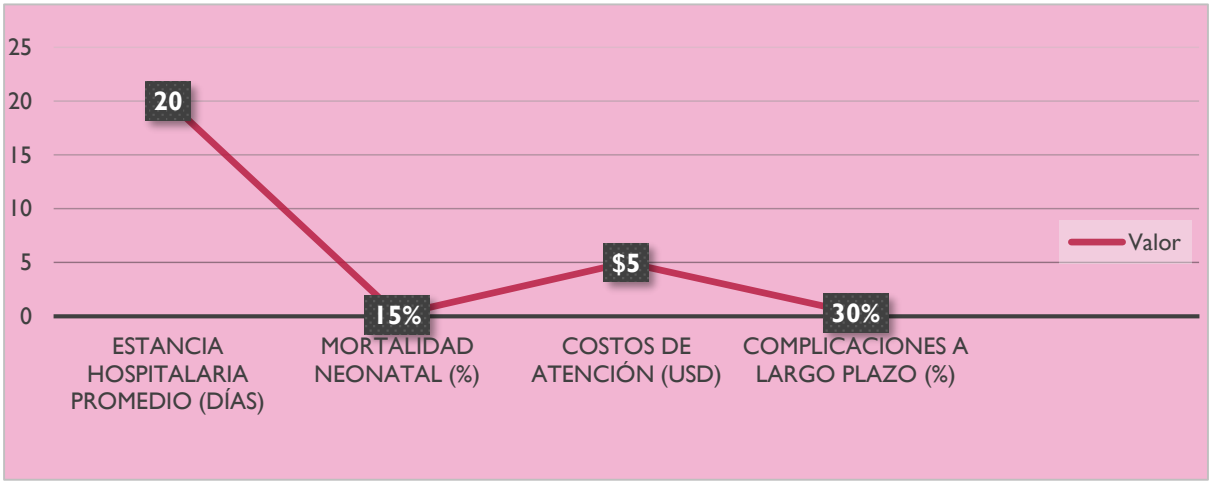

Figure 6.- The data show a significant impact of HAIs on neonatal health in Ambato, the average hospital stay of 20 days indicates that affected neonates need more intensive and prolonged care, which contributes to a higher cost of care, so the mortality rate of 15% among neonates with HAIs highlights the severity of these infections. especially considering that neonates without HAIs have considerably lower mortality, in addition, 30% of survivors who experience long-term complications indicate that HAIs not only affect immediate health, but can also have lasting consequences on the development and well-being of neonates, these findings underscore the urgency of improving infection prevention and control practices in neonatal ICUs in Ambato to protect health of this vulnerable population. In original Spanish language

The results of the research on Healthcare-Associated Infections (HAI) in Neonatal Intensive Care Units (NICUs) revealed an overall incidence rate of HAIs of 18%, with variations between the different units ranging from 12% to 25%, this variability suggests differences in care practices and in the complexity of the cases attended, therefore, it was observed that the incidence was considerably higher in preterm infants, reaching up to 30%, compared to 10% in term neonates, in addition bloodstream infections were identified as the most prevalent, representing 45% of all cases of HAI, followed by pneumonia, which constituted 25%, and surgical site infections, which contributed 15%, including urinary tract infections accounted for the remaining 10%, as for the microorganisms responsible, Staphylococcus epidermidis was identified as the most common, present in 30% of cases, followed by Klebsiella pneumoniae and Escherichia coli, which also showed notable resistance to multiple antimicrobials, In addition, risk factors such as low birth weight and length of stay in the NICU were correlated with an increase in the rate of infections, the implementation of prevention measures, such as hand hygiene and the proper handling of invasive devices, was associated with a significant decrease in the incidence of HAIs in those units that rigorously adopted them.

4. DISCUSSION

Research on Healthcare-Associated Infections (HAI) in Neonatal Intensive Care Units (NICUs) highlights the severity and complexity of the problem faced by healthcare professionals when treating vulnerable neonates, the overall incidence rate of 18% reflects a significant concern, especially considering that neonates are a group of patients with immature immune systems, which makes them more susceptible to infections, in addition to the prevalence of bloodstream infections, pneumonia and other types of HAIs highlights the urgent need to improve clinical practices, so the finding that preterm infants have a considerably higher infection rate (30%) than term neonates (10%) highlights the importance of implementing specific preventive measures for this group, even the relationship between the complexity of the case and the incidence of HAIs suggests that NICUs that care for more critical patients should have more robust prevention protocols adapted to the

characteristics of their population, it is also necessary that the microorganisms identified as causing HAI, in particular Staphylococcus epidermidis, together with resistance to multiple antimicrobials, are concerning and reflect a global trend towards bacterial resistance, this indicates that, although advances have been made in the treatment of infections, the inappropriate use of antibiotics and infection control practices need to be re-evaluated and improved, so the need for a multidisciplinary approach involving pediatricians, nurses and pharmacists becomes evident to address antimicrobial resistance and optimize patient management, the correlation between risk factors, such as low birth weight and prolonged length of stay in the NICU, reinforces the importance of individualized care focused on the specific needs of each newborn, for which it is essential that health teams conduct ongoing risk assessments and adapt interventions to mitigate the likelihood of HAIs

5. CONCLUSION

Healthcare-Associated Infections (HAI) in Neonatal Intensive Care Units (NICUs) are a major public health problem, affecting the safety and well-being of a particularly vulnerable population that is newborns, these small patients, often premature or with critical conditions, face a high risk of developing infections due to the immaturity of their immune system and the invasive nature of the medical procedures that are undergoing in the intensive setting, as neonatal medicine advances and care approaches become more complex, understanding the epidemiology of HAIs becomes essential to ensure quality care, which is why the review of the existing literature reveals that the incidence of HAIs in neonates varies significantly between different studies, with figures ranging from 5% to 30%, reflecting not only differences in care practices and infection control policies, but also the demographics of neonatal populations in various regions and hospital settings, for this it is important to recognize that neonates requiring NICU care often have intrinsic risk factors, such as low birth weight and congenital diseases, which predispose them to infections, so these conditions make the identification and management of HAIs even more critical, as the associated complications can have a lasting impact on the health and development of patients, in terms of microorganisms involved, diversity and antimicrobial resistance are significant concerns, so pathogens such as Staphylococcus epidermidis, Klebsiella pneumoniae and Escherichia coli have been identified as the main culprits of infections in this environment, in addition to the growing resistance to antimicrobials, exacerbated by the inappropriate use of antibiotics in neonates, underlines the need to implement prudent and rational management of these drugs, so, Ongoing education and awareness of antibiotic use are essential to slow the advance of resistance and improve clinical outcomes.

Also, the implementation of effective prevention and control strategies is critical to address the problem of HAIs in NICU, so best practices include rigorous hand hygiene, proper disinfection of medical devices, and careful handling of intravenous lines and other invasive devices, in addition, continuous training of healthcare personnel in infection control protocols is crucial to ensure that all team members are aligned in their efforts to minimize the risk of infections, which is why interdisciplinary collaboration between pediatricians, nurses, pharmacists, and other health professionals is essential to create a comprehensive approach that improves neonatal care, including monitoring and analysis of data on the incidence of HAIs are also valuable tools for continuous improvement. therefore, it is essential to establish a surveillance system that allows identifying outbreaks and trends in infections, which can provide critical information to adjust care policies and practices in real time, this not only helps mitigate the impact of HAI, but also promotes a culture of safety in health care, where infection prevention becomes a shared priority, and the impact of HAIs is not limited to immediate complications, as the morbidity and mortality associated with these infections can result in prolonged hospital stays and significant costs for families and health systems, in addition, neonates who survive HAIs may face long-term challenges in their physical and cognitive development, Underscoring the importance of appropriate preventive care, the integration of public health strategies that address HAIs in neonates is crucial to ensure not only the immediate safety of these patients, but also their future well-being.

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