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Evaluation of the effectiveness of the Neodisc in neonatal emergency situations. Assessing the efficacy of a support system during emergency scenarios in Neonatology: a clinical simulation study

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Abstract

Introduction: Emergency situations are frequent and unpredictable in neonatal units, with moments of high stress for the staff in charge. Dosage calculations are usually done mentally, adjusted based on the patient's weight, producing significant variability. These medications require multiple dilutions and a variety of material sizes for the airway management. In order to reduce errors in these cases, we developed the Neodisc tool.

Methods: A research project for the design of the tool and subsequently, carrying out a quasi-experimental study with post-intervention measures, for the evaluation of the effectiveness of the Neodisc.

Results: In 76,7% of cases, errors in the procedure were observed when Neodisc was not used. In contrast, employing the designed tool reduced errors to 10%, a statistically significant discovery with a great clinical relevance. Additionally, preparation time for materials was reduced 142 seconds using Neodisc. Without the tool, the participants admitted not to feel secure, the 93.3% when preparing airway equipment and the 63.3% when preparing medication. The Neodisc provided them with a sense of safety and reduced the possibility of making errors.

Conclusions: The implementation of the Neodisc would bring standardization and significantly reduce the risk of making mistakes in emergency situations. It would reduce the time spent and improve the perception of safety and trust of staff, reducing stress and increasing patient safety.

EVALUACIÓN DE LA EFICACIA DEL NEODISC EN SITUACIONES DE URGENCIA DEL NEONATO. EFICACIA DEL EMPLEO DE UN SISTEMA DE SOPORTE EN LAS SITUACIONES DE EMERGENCIA EN NEONATOLOGÍA: EVALUACIÓN EN SIMULACIÓN CLÍNICA

Resumen

Introducción: *Las situaciones de emergencia son comunes e inesperadas en las unidades neonatales, siendo momentos de gran estrés para el personal a cargo. Los cálculos de dosificación de fármacos suelen hacerse mentalmente, ajustándose al peso del paciente, el cual puede variar considerablemente. Son de uso medicaciones que requieren varias diluciones por su presentación comercial y diversidad de tamaños de materiales para la vía aérea. Con el fin de disminuir los errores en estas situaciones, diseñamos la herramienta Neodisc.*

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Métodos: *Proyecto de investigación para el diseño de la herramienta y posteriormente, realización de un estudio cuasiexperimental con medidas post-intervención, para la evaluación de la eficacia de la Neodisc.*

Resultados: *En un 76,7% de los casos, se observaron errores en el procedimiento sin el uso del Neodisc. En contraste, la utilización de la herramienta diseñada redujo los errores al 10%, un hallazgo que es significativo a nivel estadístico y de gran relevancia clínica. Además, el tiempo de preparación del material se vio reducido con el uso del Neodisc 142 segundos. Sin ella, los participantes admitieron no sentirse seguros, el 93,3% en la preparación del material para la vía aérea y el 63,3% en la preparación de la medicación. La Neodisc les proporcionaba seguridad y reducía la posibilidad de cometer un error.*

Conclusiones: *La implementación de la Neodisc aportaría estandarización y reduciría significativamente el riesgo de cometer errores en situaciones de emergencia. Reduciría el tiempo empleado y mejoraría la percepción de seguridad y confianza del personal, reduciendo el estrés y aumentando la seguridad del paciente.*

INTRODUCTION

Emergencies are frequent and unpredictable in neonatal intensive care units (NICU), often resulting in high levels of stress for the attending staff. In these contexts, medical prescriptions are commonly given verbally, and dose calculations are typically performed mentally, adjusted according to the patient's weight, which can range significantly, from approximately 500 grams to 4000 grams[1].

Currently, there are no commercially available drug formulations with concentrations and volumes tailored to the weight of neonatal patients. As a result, nurses in neonatal intensive care units have to dilute medications and recalculate doses to prepare formulations suitable for administration. Medication dosing in neonates is always adjusted based on their weight and body surface area, often requiring the administration of extremely small doses that differ significantly from standard commercial preparations[2,3].

This combination of factors, particularly in emergency situations, can result in errors at any stage of the medication administration process, putting the safety and the life of the patient at risk[4].

The incidence of medication administration errors in hospitalized patients varies significantly depending on reporting rates and hospital departments, with higher rates observed in intensive care and emergency care units. A systematic review[5] has found that the incidence of such errors in pediatric settings ranges from 5% to 20%.

The idiosyncrasies of newborns—such as their physiological and metabolic immaturity, unique pharmacokinetic and pharmacodynamic profiles, the high number of procedures they undergo, the need for extremely small doses, and the impossibility to perform active checks or report adverse effects[6]—make them the group most at risk for this type of error. One study[7] demonstrates that potentially harmful medication errors may occur up to three times more frequently in the pediatric population than in adults.

Given the above, implementing strategies that can reduce and detect errors before medication administration and simplifying the calculation of doses and dilutions is crucial.

Patient safety remains a constant concern among healthcare professional[8]. However, existing strategies are often inadequate or poorly adapted to the specific needs and characteristics of neonatal patients and NICUs[9,20]. Although in the literature different solutions are proposed to enhance medication safety for neonates in emergency situations, many fail to address the actual needs perceived by healthcare providers[10,11,18].

Consequently, a decision was made to design a safety tool for medication preparation and airway equipment handling that would be user-friendly and easily accessible, aiming to support its effective use in emergency situations within the neonatal intensive care unit. The tool was named Neodisc.

The **primary objective** of this study was to assess the effectiveness of the Neodisc system in improving safety and efficiency during the preparation of medications and airway management equipment, in comparison to standard practice, within a simulated environment.

The specific objectives were to:

1. Examine the errors made in the preparation of medications and airway equipment when using the Neodisc versus standard practice.
2. Evaluate the time required to prepare medications and airway equipment using the Neodisc in comparison to traditional methods.
3. Analyze healthcare professionals' perceptions of safety when using the Neodisc compared to conventional practices.

METHODOLOGY

This research project involved the development and validation of a clinical tool, designed and tested experimentally in both simulated and real clinical environments to assess its efficacy. The study was conducted in two main phases.

The first phase focused on the creation and design of a tool to improve patient safety. To this end, a literature review was conducted on available market solutions, as well as the studies that support and validate them, identifying limitations in the existing options. These solutions, although useful, did not fully meet our specific needs. This led us to design our own tool that would be convenient, portable, and easy to consult in critical situations. Digital formats for mobile

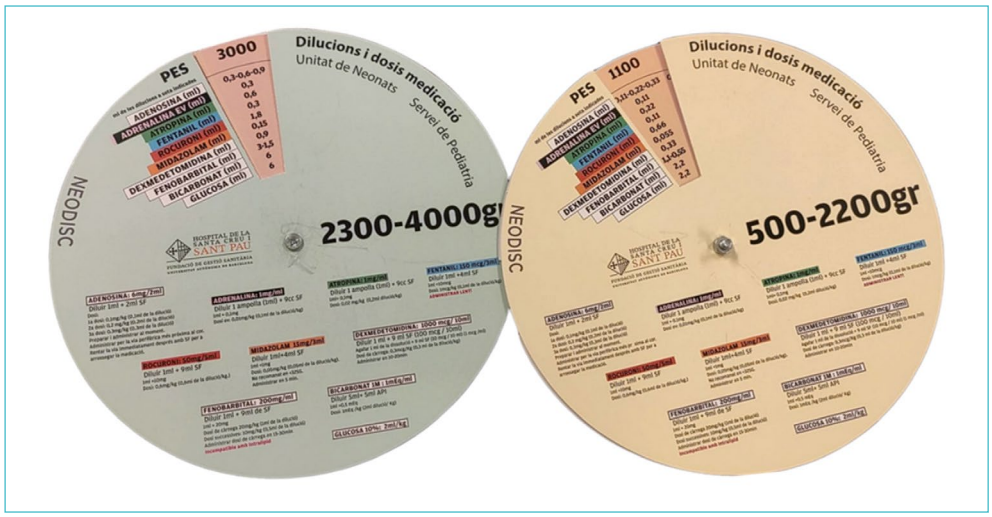

FIGURE 1. General view of the disc, side A (medication).

FIGURE 2. Detailed view of the disc.

devices were ruled out due to the risk of nosocomial infections linked to cross-contamination from surface contact. Instead, a physical format was chosen to minimize these risks and ensure safe and efficient access. A team consisting of two nurses (M.A. and A.R.) and two pediatricians (M.J. and E.M.) from the NICU was formed, in collaboration with the Innovation Unit of the Hospital de la Santa Creu i Sant Pau. The most commonly used emergency medications in our unit were selected, dosage per kilogram was reviewed, and airway equipment was defined according to weight. Based on this information, the Neodisc tool was developed. The calculations generated by the computer system were reviewed by all the authors, and any potential errors were corrected.

Neodisc is a support tool for the preparation of medications and dilutions, as well as for calculating medication volumes and airway equipment appropriate to the patient's weight in emergency situations within the neonatal unit.

Based on the information obtained, a polypropylene disk was designed in two versions, according to the patient's weight, in 100-gram increments (500 g-2200 g and 2300 g-4000 g). It was also produced in two formats: a large version, 29.5 cm in diameter, to be placed on the trolley for quick and easy reference, and a smaller version, 14 cm in diameter, to be carried in a uniform pocket for use during transfers, in the delivery room, etc. One side of the disk contains information on airway equipment and medications; the other side details the standard preparation and dilution of emergency drugs. The disk is rotated around the central slit to select the patient's weight in grams, displaying the most appropriate dosage or equipment for each case (Figures 1 and 2).

The initial prototype was presented to the unit's professionals, and training on its features and use was offered to the entire healthcare team.

Following its implementation, the second phase of the study was started: a quasi-experimental study with post-intervention measurements to evaluate the effectiveness of the Neodisc in simulated neonatal emergency situations, using the participating professionals themselves as the control group.

The study was conducted between January and September 2023 in the Neonatology Department of Hospital de la Santa Creu i Sant Pau, Barcelona, after obtaining approval from the institution's Ethics Committee (reference number IIBSP-NEO-2022-113).

In 2023, Hospital de la Santa Creu i Sant Pau attended 1,803 births. The unit is accredited as a level 3A NICU, equipped with 10 critical care stations and 7 semi-critical care incubators. In 2023, 389 newborns requiring urgent care were admitted, including 142 preterm infants under 36 weeks of gestation from our catchment area, as well as from other towns in Catalonia and Andorra, transferred by the Medical Emergency Service (SEM) via pediatric medicalized transport.

A targeted sample was selected, consisting of the nursing team that regularly works in the unit. A total of 86% of the staff participated (30 out of 35 professionals), all of whom were nurses with varying levels of experience. The researchers were excluded from the study. Participation was voluntary.

Each participant completed two simulation exercises, with a total duration of approximately 20 minutes.

TABLE 1. Preparation time for equipment and medication in the two study groups.

	Without Neodisc	With Neodisc	t	p
Preparation time for equipment Mean (SD) in sec	93.9 (40.4)	79 (34)	2.45	0.02
Preparation time for medication Mean (SD) in sec	421 (162)	279 (88.8)	6.23	< 0.01

t: Student's t value; p: significance value.

The simulations were conducted using standard unit equipment, in front of the medication trolley, and for a simulated patient with a randomly generated weight obtained via a mobile app. Participants were required to prepare the appropriate airway equipment based on that weight (including the laryngoscope blade, endotracheal tube, and self-inflating bag-mask). After being verbally given three medication doses in milligrams (adrenaline, midazolam, and rocuronium), calculated according to the simulated weight, participants had to prepare the corresponding dilutions and accurately measure the prescribed doses.

In the second simulation, the same procedure was followed, with the difference that this time the Neodisc was used as a support tool. Each participant was provided with a sheet of paper, a pen, and a calculator, along with two bowls: one for airway equipment and the other for medications.

During the verbal medication orders, the dose of midazolam was deliberately given with a guideline error (x10) in all cases, in order to assess the rate at which participants detected the error when receiving verbal instructions.

During the simulated scenarios, the researchers collected data on predefined variables using a recording sheet. Participants recorded their impressions by completing a Likert-type survey, which had been developed by consensus among the research team.

The primary study variable was the incidence of errors, which were classified as follows:

- Absence of airway equipment (laryngoscope blade, endotracheal tube, or self-inflating bag-mask).
- Size of equipment inappropriate for the patient's weight.
- Incorrect transcription of the prescribed dose.
- Miscalculation of the dose or dilution.
- Incorrect preparation of the dose.

The following secondary variables were also defined:

- Type of incident during the preparation of medication or airway equipment (dose calculation errors, dilution or dose preparation errors, incorrect transcription of verbally indicated doses, use of inappropriate equipment for the patient's weight, and absence of required airway material).
- Time (in seconds) required to prepare the airway equipment and the medications.
- Nurses' perception of safety and satisfaction with the use of the Neodisc.

Data were collected using an ad-hoc survey and entered into a database created in Clinapsis for descriptive analysis using SPSS version 26 with a significance level of $p< 0.05$. Descriptive analysis was conducted for all variables, and bivariate analysis was performed for the primary outcome variable. The bivariate analysis of the primary variable was performed using the Chi-square test, while secondary variables were analyzed using the paired Student's t-test.

RESULTS

A total of 60 simulations were conducted with 30 participants, including nurses who work in the NICU. Ninety-seven percent of the sample was female. Of these, 50% had less than 5 years of experience (16.7% with less than 1 year and 33.3% between 1 and 5 years), while the remaining 50% had more than 5 years of experience.

In 76.7% of cases, errors were observed during the procedure without the use of the Neodisc. In contrast, the use of the tool reduced the error rate to 10%, a difference that was statistically significant (Pearson's Chi-square = 27.149; $p< 0.001$).

Among the professionals who performed the first simulation, errors in equipment selection were observed in up to three-quarters of the cases (73.4%). Years of experience reduced the number of errors related to equipment size selection by half. The mean number of errors per simulation among nurses with less than 5 years of experience was 1.67 (SD= 1.2), compared to 0.80 (SD= 0.676) among those with more than 5 years of experience (t= 2.47; p= 0.02).

Errors in the preparation of dilutions or doses were not highly prevalent; however, 26.7% of professionals made medication administration errors without the use of Neodisc, compared to 3.3% when using the tool.

In addition, material preparation time was reduced with the use of the Neodisc and with greater professional experience. When comparing the mean preparation times, a significant difference of 14.8 seconds was observed (SD= 33.1) (Table 1).

When grouping the data by years of experience, it was observed that professionals with more than 5 years of experience had significantly shorter material preparation times, both with and without the use of the tool, as shown in Table 2.

On the other hand, use of the tool significantly reduced medication preparation time by 142 seconds (SD 125), as shown in Table 1. However, the differences observed between the two groups based on professional experience were not statistically significant. The group with less than 5 years of experience took one minute longer to prepare medication without the use of the Neodisc, but this difference was reduced by half when the tool was used in the group with more than 5 years of experience (Table 2).

During the simulations, an intentional verbal prescription error was introduced during medication preparation. In the first simulation, conducted without the Neodisc, 93.3%

TABLE 2. Preparation times for equipment and medication according to professional experience.

		< 5 years Mean (SD) sec	> 5 years Mean (SD) sec	dif	t	p
Preparation time for equipment	WITHOUT Neodisc	111 (46.4)	76.7 (24.6)	34.3 (13.6)	2.56	0.017
	WITH Neodisc	93 (38.5)	65 (22.3)	28 (11.5)	2.44	0.021
Preparation time for medication	WITHOUT Neodisc	453.5 (172.4)	388.8 (149.9)	64.7 (59)	1.10	0.283
	WITH Neodisc	292 (85.8)	265.8 (94.6)	26.3 (33)	0.80	0.433

t: Student's t value; p: significance value.

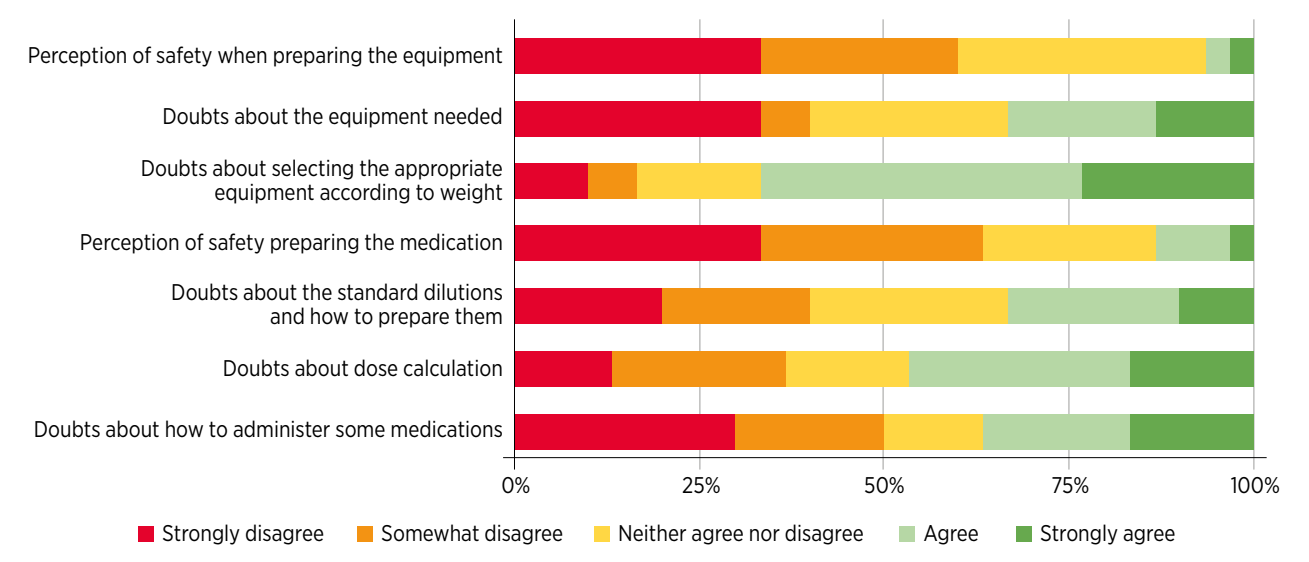

FIGURE 3. Results of the post-simulation survey in participants without the Neodisc.

(n= 28) of participants failed to detect the error. In the second simulation, the same verbal prescription error was present; however, this time, the medication was prepared using the Neodisc, bypassing the verbal instruction. Error detection increased to 23.3% (n= 7) with the use of the tool. Although the increase in error detection was not statistically significant, medication was prepared according to the dosage indicated on the Neodisc, preventing the error from reaching the simulated patient.

Professional experience was not found to significantly influence error identification (χ= 2.143; p= 0.143).

In the final brief survey, 93.3% of participants reported not feeling fully confident in preparing airway equipment without the use of the Neodisc, and up to 83.3% expressed doubts about selecting the appropriate equipment based on the patient's weight without the support tool. Regarding medication preparation, 63.3% admitted feeling not very confident; 33.3% reported doubts about dilution preparation, 46.7% expressed uncertainty in dose calculation, and 36.7% in administration. These results are illustrated in Figure 3.

Professionals' satisfaction with the use of the tool was very positive, as shown in the results presented in Figure 4. The use of the Neodisc increased their confidence in preparing both equipment and medication, and they felt it helped reduce preparation time.

DISCUSSION

Systematic reviews[5,13,15] indicate that in pediatrics, medication administration errors are detected in 5% to 20% of cases, with serious clinical impact reported in 0.6%. The most frequent errors involve administration (68.1%) and prescription (39.5%), with nurses reporting the majority of incidents (65.4%). Although 89.4% of these errors do not cause harm, a small percentage result in permanent injury or death.

The main causal factor identified is distraction (59%), along with the complexity of dose calculation. Although 17% of errors are intercepted, there remains significant room for improvement in prevention[13,15].

In our study, we identified an incidence of 26.7% for this type of error, a figure that rises to 93.4% when verbal prescription errors are included. These figures are influenced by the rate of error reporting and detection; thus, we observed a higher incidence, as errors in critical situations, where prescriptions are given verbally and calculations are done mentally, are rarely identified.

Strategies to reduce errors in neonatal units—such as standardization and dose calculation charts, electronic medical prescribing, educational simulation and training programs, and smart infusion pumps—as well as the underlying causes of these errors, have been extensively analyzed in the

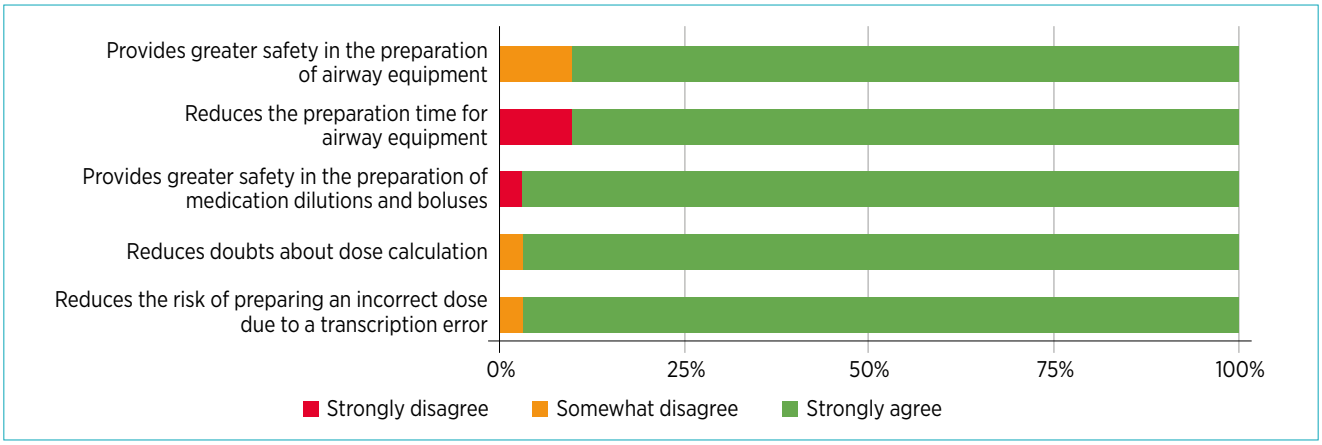

FIGURE 4. Results of the post-simulation survey in participants with the Neodisc.

literature[1,2,5,9-12,14,16]. However, there remains a lack of tools and strategies specifically adapted to the unique needs of NICUs. Process standardization has been shown to enhance safety and significantly reduce errors[16]. The Neodisc proves to be an effective standardization solution, with a highly favorable cost-benefit ratio.

Observation facilitates the identification of errors in emergency situations—even in simulated contexts—yielding more representative data on their incidence. Our study observed a reduction in both equipment and medication preparation times, as well as a decrease in preparation errors through the use of the Neodisc. The standardization of these procedures, as suggested by multiple authors[1,2,5,9-12,14,16], decreases the incidence of errors and, consequently, increases the safety of our patients and healthcare personnel.

Our study underscores the importance of the learning curve[17] among healthcare professionals in neonatal emergency situations, which helps reduce response time and improve the accuracy of care. The use of the Neodisc contributes significantly to these positive outcomes, and its implementation could make a meaningful difference in the quality of care, particularly in critical situations.

During the simulations, a scenario was recreated involving an error in the verbal communication of the medication regimen. Although the use of the tool did not guarantee detection of the error, it effectively prevented the error from reaching the simulated patient. In this scenario, participants prepared the correct dose as indicated by the tool, rather than the incorrect verbally communicated dose, thereby avoiding potential negative consequences for the simulated patient.

Some of the errors considered during the simulations, such as mask size, are theoretical and subjective. Although mask size is determined based on the patient's weight, in practice, material selection may also depend on other factors, such as the size of the face.

During the course of the study, the developed tool was well received, as evidenced by favorable results in the evaluation of its usability and perceived usefulness. Professionals who participated in the simulations expressed a positive perception of the safety and efficiency the tool provided. This contributed to increased confidence in their ability to manage critical situations and enhanced their work efficiency, factors that could ultimately improve the quality of care and patient safety.

In this study several limitations and potential sources of bias were identified that should be considered when interpreting the results. First, the small sample size, consisting of permanent staff (25 individuals) and rotating staff (10–12 individuals) from the NICU, may limit the generalizability of the findings. However, we consider this sample to be representative of the unit's regular clinical team. Additionally, as the study was based on simulated scenarios rather than real emergency situations, the recorded times and observed errors may not fully reflect actual clinical conditions. On the other hand, the quasi-experimental design with post-intervention measurements may be subject to bias related to healthcare professionals' perceptions of the Neodisc tool. Despite these limitations, the study aims to contribute to improving patient safety in critical situations by reducing errors in the preparation of medication and airway equipment. These findings highlight the need for further research using more robust study designs and larger sample sizes to validate the results and enhance their applicability in neonatal care settings.

CONCLUSIONS

The use of the Neodisc can significantly reduce the risk of errors in equipment selection and medication preparation during emergency situations in neonatal care. Additionally, it can markedly decrease the time required for these tasks, helping to streamline the overall process.

The implementation of the Neodisc in clinical practice would provide standardization in both equipment selection and the preparation of dilutions and medication dosages in ml/kg. This standardization could help reduce errors in medication preparation, prescription, and administration. Furthermore, the use of a tool like the Neodisc would enhance healthcare professionals' perception of safety and confidence when managing neonatal emergencies, thereby reducing the stress associated with such high-pressure situations and contributing to the delivery of high-quality patient care.

Our two-year experience using this tool in the delivery room, NICU, and during neonatal air transport has been highly positive, with strong acceptance from all professionals involved, including both nurses and physicians.

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