JMCH Journal of Maternal and Child Health (2024), 09(03): 421-432
Masters Program in Public Health, Universitas Sebelas Maret

Systematic Review

Open Access

Hypothermia Management in Newborns Artificial Intelligence Based: Systematic Review

Ika rahmawati[1)], Melyana Nurul Widyawati[1)], Kurnianingsih Kurnianingsih[2)], Walin Walin[1)]

[1)]Midwifery Studies Program, Applied Master Program Postgraduate, School of Health Polytechnic Semarang, Indonesia
[2)]Faculty of Electrical Engineering, School of Polytechnic Semarang, Indonesia

Received: March 13, 2024; Accepted: April 02, 2024; Available online: May 16, 2024

ABSTRACT

Background: Hypothermia in newborns that is not treated properly will lead to respiratory failure and death. Hypothermia in newborns is 4 times more dangerous than hypothermia in adults. Care in the delivery room plays an important role in it. Neonatal service technology in the delivery room must be responsive, able to monitor and effective. Artificial intelligence can help determine management as needed. This study aims to analyze and examine the management of hypothermia in newborns based on artificial intelligence using the systematic review method.
Subjects and Method: This study is a systematic review with PICO including: (1) Population: newborns; (2) Intervention: artificial intelligence; (3) conventional hypothermic treatment; (4) Artificial intelligence is feasible to be used in the management of neonatal hygiene. The databases used are Google Scholar, PubMed, Science Direct, and Proquest. The inclusion criteria include fulltext in Indonesian and English with the study subject of newborns with hypothermia. The exclusion criteria for this study are articles published under the last five years.
Results: A total of 9 articles show that the existence of artificial intelligence can provide feedback support in the prevention of hypothermia efficiently and facilitate effective treatment.
Conclusion: Hypothermic prevention feedback with artificial intelligence Fuzzy logic can save time and facilitate appropriate treatment.

Keywords: artificial intelligence; hypothermia; newborns

Correspondence:
Ika Rahmawati. Midwifery Studies Program, Applied Master Program Postgraduate, School of Health Polytechnic Semarang, Indonesia. Email: ika.rahmawati86@gmail.com. Mobile: 0822-29934596.

Cite this as:
Rahmawati I, Widyawati MN, Kurnianingsih, Walin (2024). Hypothermia Management in Newborns Artificial Intelligence Based: Systematic Review. *J Matern Child Health*. 09(03): 421-433. https://doi.org/10.26911/thejmch.2024.09.03.12.

BACKGROUND

The proportion of neonatal hypothermia incidence in hospitals is very large, even 27/1000 live births. It is cited as one of the biggest causes of infant mortality up to 28 days of age. Hypothermia incidence in low-income countries occurs in almost every primary delivery 5 minutes after birth, even up to the next 24 hours (Phoya et al., 2020). Hypothermy is a predictor of the risk of

illness and death, especially in preterm neonates. Regular monitoring of body temperature is a critical and major factor (Trevisanuto et al., 2018). The most effective type of hypothermic preventive intervention is not yet known, although it is closely related to an increase in core body temperature in neonates. So far, thermal treatment interventions can reduce the risk of moderate to severe hypothermia. Limited resources have a prevalent role in maintaining core body temperature (Abiramalatha et al., 2021) not yet using artificial intelligence.

The transfer of body heat of a newborn to its surrounding surfaces needs to be considered for its survival (Hannouch et al., 2020). Conventional treatments are used as a barrier to remove body heat only, in addition to interventions can be in the form of skin-to-skin treatments, incubators, thermal mattresses, and PCMs. The additional intervention of Embrace warmer is much more useful in preventing hypothermia during transportation, especially short-term even though artificial intelligence has not been used. Moreover, so far it is still not possible to rely on the properties, types, thickness, and environmental temperature of fabrics without additional warming. However, it is still recommended because clothing covers all of the baby's body for skin color, heart rate or chest wall retraction. Clothes are inherently soft and get wet easily because urine can spark evaporation (Morgaonkar et al., 2020).

Heat transfer with multiple radiation, evaporation, conduction and convection pathways is a way to achieve the goal of comfort through heat preservation and release (Kalaoglu-Altan et al., 2022). Homeothermic traits in newborns are less efficient than in adults, especially when exposed to extreme environments, while this is reflected in the results of interventions during emergency transportation and evaporation risks. Unorganized transportation endangers the sustainability of the warm chain, so critical that it causes the physiological status to decline. Short-term referrals in sick newborns need attention, as well as thermal care as a routine care pattern.

The occurrence of complications that often appear in the early period of birth causes the baby's mother to be unable to accompany to refer the baby. This is because of the condition of the body after giving birth besides her family who are unable to support. Although the transfer in utero continues to be sought, there are still neonates in it (Morgaonkar et al., 2020). Pre-referral care, emergency transportation access, ambulance characteristics and measures to ensure that the red thread of referral is required cannot be underestimated. Transport incubators have not used artificial intelligence and are not widely used, instead neonates are referred to using local clothes and only a few in KMC (Kiputa et al., 2022). Transportation even if it is short can be a stressful period for the baby (Kumar et al., 2022). The decrease in the prevalence of hypothermia occurs within 24 hours of delivery (Trevisanuto et al., 2018), this figure is critical.

Hypothermy results in a high prevalence of neonate deaths, as much as 80% for every 1°C temperature drop especially in low-income countries, although outcomes vary by agency. Newborns have the potential to suffer from hypothermia 4 times more, especially in premature babies due to the lack of temperature-controlling nerve mechanisms, thinner skin and unstable hypothalamic function. Thermal protection includes essential neonatal services after birth. Almost all are aware that the prevention of hypothermia is especially important in preterm infants, infants with a history of vaginal delivery, and referred neonates, although until now many studies have stated

that referred neonates have been proven to have hypothermia when dating (Urubuto et al., 2021). Neoanal health problems, prematurity and the mother experiencing complications until childbirth at night will increase the risk of hypothermia. Warm transportation, the use of hats and skin to sin contact give a higher chance of hypothermia being resolved. The temperature of the maternity room can be determined to maintain its stability and humidity (Bayih et al., 2019).

Healthcare facilities, obstetric care and neonatal conditions are strongly linked to the incidence of hypothermia affecting most neonates in Ethiopia (Girma et al., 2021). The recognition of early contact is increasingly massive and growing, although the safety still needs to be studied. No difference in age or body temperature of newborns was found shortly after delivery to determine the dose of hypothermic response to death. The incidence of hypothermia lasted 12 hours in 55% of preterm neonates and from normo or hyperthermia to hypothermia at that time (Clarke et al., 2021). As many as 80% of neonates preterm hypothermia (Demtse et al., 2020) with an overall prevalence of 32% to 85% but rarely recognized and poorly monitored. In addition to inadequate temperature measurements during resuscitation or referral, the vigilance of care personnel against hypothermia is also lacking (Yu et al., 2020).

Generally, the officer is not aware of hypothermia and with a sparse duration of examination, it is very likely that hypothermia will occur without symptoms that are not easily seen. Technological advances that aid in the transition of babies in the delivery room often lag behind intensive care units (Batey et al., 2022). The number in a thermometer should be immediately recognized as an emergency that needs analysis. The analysis for neonate safety is greatly influenced by the expertise, competence and skills of health workers (Kiputa et al., 2022). The success of hypothermic treatment is influenced by the speed of recognizing the situation, the accuracy of diagnosis and assessment by health workers and decisions by the family. Failure of early detection increases the burden on hospitals with high oxygen needs to the valuable use of CPAP (Urubuto et al., 2021). Interest in technology and artificial intelligence has grown, but it has rarely been applied to the management of hypothermia in neonates. Artificial intelligence can help healthcare workers make fast, accurate, and useful decisions (Aini et al., 2019), accelerate diagnosis (Gojak et al., 2022) with data as the key (Simbolon et al., 2020). It has the ability to think intelligently similar to the human brain (Oktaviana et al., 2020) reduce unnecessary error variability (Cramer et al., 2022).

SUBJECTS AND METHOD

1. Study Design

The study design used is a systematic review. Systematic review is a study method that summarizes the results of primary studies to present more comprehensive and balanced facts. The selected article is a study article that has a similar correlation with the study topic.

2. Steps of Systematic Review

Systematic review is carried out through the following 4 steps:

1. Formulate study questions using the PICO model
2. Look for major review articles from electronic databases such as Google Scholar, PubMed, Science Direct, and Proquest.
3. Screening and critical assessment of primary studies.
4. Interpret the results and draw conclusions.

3. Inclusion Criteria

The inclusion criteria in this systematic literature review study are artificial intelligence in the management of hypothermia in newborn babies who use Indonesian and English.

4. Exclusion Criteria

The exclusion criteria in this systematic literature review study are publication periods under the last five years that do not discuss artificial intelligence in preventing hypothermia in newborns or that are not in accordance with the study topic.

5. Operational Definition of Study

Artificial Intelligence (AI) is a branch of computer science that focuses on creating machines or computer programs that are capable of performing tasks that typically require human intelligence. It includes a variety of activities such as language comprehension, learning, speech recognition, problem-solving, and decision-making. AI can be divided into two main categories: narrow AI (or applied AI), which is designed to perform specific tasks, and general AI, which has the ability and general understanding of a human. AI has applications in many fields, including medicine, automotive, finance, video games, and more, offering great potential for innovation and efficiency improvement.

Artificial intelligence (AI) is feasible to use in the management of hypothermia in newborns for the following reasons:

1. Early detection and accuracy, AI can analyze various health parameters in real-time with high accuracy. This allows for early detection of hypothermic conditions, even before clinical symptoms appear, so that measures can be taken early to prevent complications
2. Personalization of care: by using machine learning algorithms, AI can tailor treatment recommendations based on each baby's unique characteristics, such as birth weight, gestational age, and other health conditions, ensuring that each baby receives the most suitable treatment.
3. Continuous monitoring, AI enables continuous monitoring of baby health without interruption, ensuring that changes in baby body temperature are detected and responded to quickly.
4. Complex data analysis: AI is capable of processing and analyzing large and complex volumes of data from various sources, such as electronic medical records, health monitors, and environmental data, to identify risk factors and health trends that may not be visible to humans.
5. Supporting clinical decisions, artificial intelligence systems can provide evidence-based recommendations to healthcare professionals regarding the best treatment measures. This helps in quick and effective clinical decision-making.
6. Education and training, AI can also be used to train and educate health workers on best practices in managing hypothermia in newborns, based on the latest data and continuously updated algorithms.
7. Cost Efficiency: The use of AI can improve healthcare efficiency by reducing the time required for diagnosis and decision-making, as well as potentially reducing the need for more expensive and invasive medical interventions.
8. Studies and development, data collected through AI applications can be used for further studies on hypothermia in newborns, aiding in the development of better treatment guidelines and innovations in medical management.

With its vast capabilities, AI offers great potential to improve the management of hypothermia in newborns, save lives, and reduce the burden on the health system.

Some of the artificial intelligence that is feasible to use in the management of newborn hypothermia are computer vision, artificial neural networks, Fuzzy Logic, Neural

Network, and thermostat automation.

6. Study Instruments

A study instrument is defined as a tool to assist researchers in collecting study data. This study instrument uses documentation. Documentation is a data collection method that produces important records related to the problem being researched and then complete and valid data is obtained. The documentation in this study is by looking for publication journals that contain an outline or category according to the variables studied.

The literature that was documented and identified was through Google Scholar 224 articles, pubmed science direct and proquest 228 articles with a total of 512 articles, then articles discussed through title, year and silence amounted to 67 articles, and articles that were complete in the feasibility test amounted to 31 articles, and eligible articles amounted to 9 articles.

7. Data Analysis

The data was analyzed by grouping the data according to variables and presenting the researched data to answer the objectives of the study. The study uses a qualitative method by organizing the data, finding what is important and what can be interpreted. The data analyzed was sourced from the results of literature studies from journals taken from Google Scholar, PubMed, Science Direct, and Proquest, then the researcher analyzed the journals obtained to draw conclusions.

RESULTS

The search and selection process of literature in this review is illustrated in the form of a Flow diagram Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) (Figure 1).

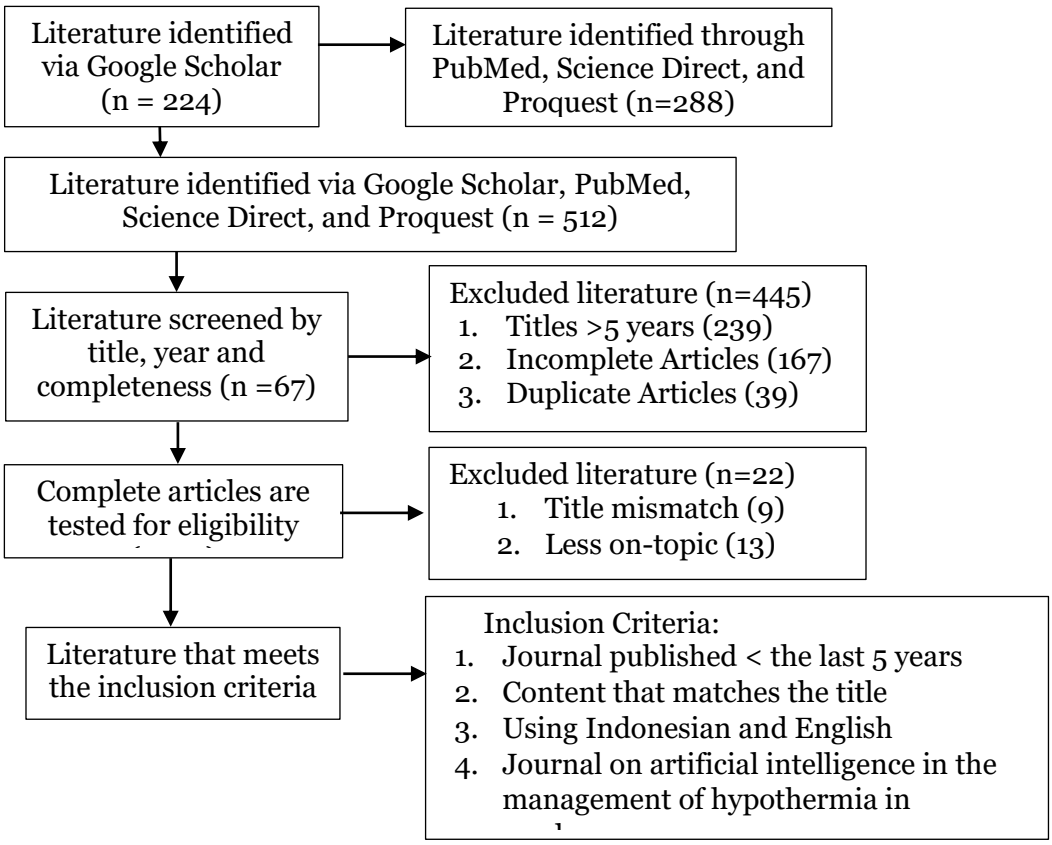

Figure 1. PRISMA flow diagram

Table 1 explains that the results of the analysis show that from nine journals, it was found that in the management of hypothermia in newborns, artificial intelligence technology can be used.

Table 1. Summary of primary studies on the role of AI in hypothermic infant care

Author (Year)	Population	Speakers	Comparison	Outcome	Conclusion
(Batey et al., 2022)	Neonates in the delivery room	Computer vision and Artificial neural networks	Kangaroo method hypothermic treatment	Computer vision and Artificial neural networks are feasible for use in hypothermy and oxygen saturation management	vision and Artificial neural network as a tool Conventional hypothermic treatment of BBL respiratory resuscitation and BBL temperature assessment
(Gojak et al., 2022)	BBL with neonatular sepsis	Artificial neural networks	Conventional hypothermic treatment	Artificial neural networks are suitable for use in measuring body temperature, CRP levels, leukocyte count and platelet levels	Disease progression prediction, early diagnosis and early access to antimicrobial therapy in patients with neonatal sepsis
(Li et al., 2023)	BBL hipotermi	Fuzzy logic and Neural network	Conventional hypothermic treatment	Fuzzy logic and Neural networks are feasible to adjust the baby's body temperature	A type of algorithm that is often used is Fuzzy Logic to turn the thermal sensor power on and off
(Wang et al., 2021)	BBL hipotermi	Fuzzy Logic	Conventional hypothermic treatment	Fuzzy logic for thermal sensor allocation optimization using a simple ring oscillator on an FPGA Chip is feasible for use in hypothermic infants	Optimizing thermal sensor allocation
(Ramadhanty and Puspitasari, 2022)	diagnosis ikterus neonaturum	Fuzzy Logic	Conventional hypothermic treatment	Fuzzy's logic as a website-based neonatal jaundice diagnosis information system is suitable for use in infants with hypothermia	Detecting the severity of jaundice
(Sabariman and	BBL hipotermi	Fuzzy Logic Control	Conventional hypothermic treatment	baby monitoring feature with IOT on Grashoft Type	Interprets the combination of infant weight

Author (Year)	Population	Speakers	Comparison	Outcome	Conclusion
Nofriyadi, 2022)				G – 62 incubator, suitable for use in monitoring heart rate, body temperature, humidity and cabin temperature	input and cabin humidity to adjust the ideal cabin temperature for the infant
(Fauzi et al., 2023)	BBLR and premature babies	Thermosta t control	Conventional hypothermic treatment	Thermostat Auto-mation for Con-trolled Tempe-rature in Simu-lated Incubator can be used to obtain the upper & lower limit tempe-rature of the incubator	Thermostat can be used to get the upper & lower limit temperature that has been Determined incubator
(Prasojo and Suprianto, 2019)	BBL hypothermia	Fuzzy Logic Controller	Conventional hypothermic treatment	Fuzzy Logic Controller is suitable for use in baby temperature control	Incubator temperature handler suitable for the baby's weight
(Setiawan et al., 2018)	BBL	Fuzzy Tsukamto	Conventional hypothermic treatment	Fuzzy Tsukamto is suitable for use in the detection of baby conditions	Decision support system prototype Detection of the baby's condition

DISCUSSION

These nine articles mention that artificial intelligence can be used in the management of hypoyermyosis in newborns. Batey in his study discusses the importance of the relationship between artificial intelligence-based technology for newborn monitoring and care in the delivery room to reduce the number of high-risk illnesses to death. Researchers recognize that there are major and unique challenges in the transition period of neonates in the delivery room by focusing on renewable technologies and best practices. The thermoregulation process is given an additional intervention in infants <32 weeks with thermal mattresses. The researchers mentioned the importance of further studies on the algorithm generated by electrical impedance tomography for premature babies. Artificial neural networks are used at the time of resuscitation with the trainer using video. The new equipment that is expected is wireless to make maintenance easier and remain comfortable to use in the kangaroo method, facilitate family integration maintenance, informative presenting temperature output, heart rate, oxygen saturation. Sensor screens are small and light (Batey et al., 2022).

Gojak mentioned in his study on infants with cases of neotonatory sepsis. The use of artificial intelligence in diagnosing to overcome the difficulties of caring for newborns with complications that initially require high resources in both case recognition and treatment. Artificial neural networks were selected in the study with a database as parameters in the form of body temperature, CRP levels, leukocyte count and platelet levels. The number of babies included in the study was 1,000 babies with 200 healthy subjects and the rest sick babies. This algorithm is used to map the types of disease cases. Sensitivity, specificity

and accuracy reach more than 90% in prediction, diagnosis and precision of therapy. Researchers expect further studies that allow for early detection before the clinical picture emerges (Gojak et al., 2022).

Li et al. (2023) mentioned that Fuzzy Logic is one of the popular types of artificial intelligence. Fuzzy logic is easy in application and technical use. Generally used for energy center control. Another purpose that has been studied is to minimize power consumption in the operation of equipment and power supply. The information mentions for power fault compensation the need of the tool. Reduced power production load using ANFIS. A general explanation of fuzzy logic is used when it comes to selecting the energy load supply, energy charging-discharging and turning the load on-off. However, this method requires electrical information. Fuzzy logic can estimate actions based on approximate data adjusted to the most recent data to display actions quickly in a neural network (Li et al., 2023).

Wang (2021) uses Fuzzy Logic for thermal sensor allocation optimization using a simple ring oscillator on an FPGA Chip. The use of the incubator requires the duration and temperature settings to be adjusted immediately in the unstable condition of the baby. Yavuz in Yeller (Yeler and Koseoglu, 2022) mentions the creation of a cooling helmet in cases of neonatal therapeutic hypothermia with Fuzzy logic of heat and cool control. Anatychuk et all in Yeler set up programs and algorithms to calculate how much time and flow a thermoelectric conversion device needs on medical devices (Wang et al., 2021).

Ramadhanty 2022 uses Fuzzy Logic as a website-based neonatal jaundice diagnosis information system, so diganosis can be done from various places and flexibly according to the desired time so that the diagnosis process can be carried out quickly and precisely using the fuzzy logic of the Sugeno method. The testing method is carried out using the Black Box and UAT (User Acceptance Testing) methods. UAT testing is a test carried out to determine the level of user acceptance of the system (Ramadhanty and Puspitasari, 2022).

Sabariman in his study discussed the automatic temperature control system and baby monitoring features with IOT on the Grashoft Type G - 62 incubator. Using Fuzzy Logic, the baby's weight and cabin humidity are set as inputs. In the time function, the parameters controlled during the operation of the baby incubator are weight, heart rate, body temperature, humidity and cabin temperature. All of these parameter values are then transmitted in real time through the Internet of Things (IoT) features embedded in the system. The Kalman Filter method is applied to reduce errors in load cell weight sensor readings. The control system successfully interprets accurately a combination of inputs in the form of baby weight data and cabin humidity to then adjust the ideal cabin temperature for the baby (Sabariman and Nofriyadi, 2022).

Fauzy in his study discussed Thermostat Automation for Controlled Temperature in Simulated Incubator. The thermostat can be used to obtain the predetermined upper & lower limit temperature in the incubator. Furthermore, the simulated incubator has a relay lock that functions to prevent the device from being damaged due to unstable electricity flow from the power source. In addition, this simulated incubator can specifically be used in the reality of the incubator system in the incubator device to treat premature birth or low birth weight (BBLR) (Fauzi et al., 2023).

Prasojo in his study reviewed the Design and Design of a Temperature Control System for Baby Incubators Based on Fuzzy Logic Controllers. The system test was

carried out with a temperature stability tolerance of ±0.10C and was carried out in 2 test stages, namely the test without a controller and the test using a Fuzzy controller. The test was carried out with an ambient temperature outside the incubator between 250C – 260C, which can be seen at the initial temperature in each setpoint test. Because at that point the temperature outside the incubator is the same as the temperature inside the incubator. The Fuzzy controller test had a higher error, but had a steady light of light. While testing without a controller has a lower error, but constant dim light can reduce the comfort of the baby (Prasojo and Suprianto, 2019).

Setiawan in reviewing the prototype of the decision support system for detecting baby conditions with fuzzy tsukamoto. The Tsukamoto method is an extension of monotonous reasoning. In Tsukamoto's method, every consequence of the IF-THEN rule must be represented in a Fuzzy set with a monotonous membership function. The result value in the consequence of each Fuzzy rule is in the form of a crisp value obtained based on the fire strength of the anticedent. The output of the system is generated from the concept of the weighted average of the output of each Fuzzy rule (Setiawan et al., 2018).

The most important part of artificial intelligence is knowledge in the form of knowledge in broad form as a knowledge base to solve problems according to the purpose. In this study, an analysis of the use of Fuzzy Logic as a derivative of artificial intelligence for the treatment of newborns with hypothermia was obtained. The initial step of neonate stabilization in hypothermy prevention should be to be able to provide feedback and recommendations with the help of tools or technology because manual methods are prone to subjectivity (Cramer et al., 2022) to variability and unnecessary errors. A combination of interventions is needed to improve quality as well as a key success factor. Trained staff, wearing of stoplists, feedback on maintenance especially during precarious transportation (Trevisanuto et al., 2018) easier with the help of artificial intelligence and its derivatives. Artificial intelligence assistance in reducing the need for laborious training of health workers. Fuzzy logic is used to turn the battery power on and off and is able to optimize the thermal sensor. In its implementation for newborns, there have been no articles that discuss performance measurement and system performance regarding accuracy, precision, Recall, Specivicity and F1 Score. So it needs to be developed in the implementation of the next study. Ease of mobilization with tool portability, evidence-based practice, and training when the tool is used in a special control environment.

Based on the results of the review, it was found that artificial intelligence can be used in the management of hypothermia in newborns. Babies, especially newborns, are particularly susceptible to hypothermia for several physiological and environmental reasons. Some of the factors that make babies susceptible to hypothermia include: large body surface area compared to body mass, Limited Ability to Produce Heat, Inability to regulate Body Temperature (stage of development of the regulatory system), Evaporation from the Skin (having thinner and more permeable skin), Environmental Conditions (cold room, direct exposure to cold air, or inadequate use of clothing).

Therefore, it is important for health workers and parents to recognize these risks and take appropriate precautions, such as ensuring babies stay warm and protected from exposure to cold air, use appropriate clothing and cover the baby's head to minimize heat loss, and monitor room temperature to ensure a warm and stable

environment as well as consideration in providing conventional care and treatment using foam One of the technologies in the health sector is the use of artificial intelligence for health practitioners.

Of the articles that researchers found and analyzed, researchers did not find articles that specifically opposed the use of artificial intelligence (AI) in the management of hypothermia in newborns. The available information generally discusses the importance of managing hypothermia in newborns and the various approaches used, including guidelines from health organizations and clinical practice, without mentioning any controversy or criticism of the specific use of AI in this context.

The use of AI in health management, including in the management of hypothermia in newborns, is a relatively new and developing field. While many studies and applications of AI show significant potential for improving patient care, there may also be ethical, technical, and practical concerns that need to be addressed, such as patient data security, automated interpretation of clinical data, and the system's ability to adapt to individual cases. However, specific information about objections or criticisms of the use of AI in the management of hypothermia in newborns was not found in the researchers' search.

AUTHOR CONTRIBUTION

In the preparation of this journal, Ika Rahmawati sorted the journals that would be used according to the inculcation and exclusion criteria that had been determined. Ika Rahmawati, Melyana Nurul Widyawati, Kurnianingsih and Walin collaborated to analyze the results of the study.

ACKNOWLEDGMENT

The researcher would like to thank the Midwifery Study Program of the Applied Master's Program of the Ministry of Health of the Ministry of Health, Semarang, Indonesia so that this research can be carried out

FUNDING AND SPONSORSHIP

This study is self-funded.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

REFERENCE

Abiramalatha T, Ramaswamy VV, Bandyopadhyay T, Pullattayil AK, Thanigainathan S, Trevisanuto D, Roehr CC (2021). Delivery Room Interventions for Hypothermia in Preterm Neonates: A Systematic Review and Network Meta-analysis. JAMA Pediatr. 175(9): e210775. https://doi.org/10.1001/jamapediatrics.2021.0775.

Aini FN, Wisyawati MN, Santoso B (2019). Diagnosa preeklampsia pada ibu hamil menggunakan sistem informasi berbasis web (Diagnosis of preeclampsia in pregnant women using a web-based information system) Jurnal Keperawatan Silampari, 2(6): 1–9. https://doi.org/.1037//0033-2909.-I26.1.78.

Batey N, Henry C, Garg S, Wagner M, Malhotra A, Valstar M, Smith T, et al (2022). The newborn delivery room of tomorrow: emerging and future technologies. Pediatric Research, (September 2021): 1–9. Available at: https://doi.org/10.1038/s41390-022-01988-y.

Bayih W, Assefa N, Dheresa M, Minuye B, Demis S (2019). Neonatal hypothermia and associated factors within six hours of delivery in eastern part of Ethiopia: a cross-sectional study. BMC Pedriatr. 19(1):252. https://doi.org/-10.1186/s12887-019-1632-2.

Clarke P, Allen E, Atuona S, Cawley L (2021). Delivery room cuddles for extremely preterm babies and parents: concept, practice, safety, parental feedback. Acta Paediatr. 110(5): 1439–1449. https://doi.org/10.1111/apa.15-716.

Cramer SJE, Kuypers KLAM, Martherus T, Dekker J, Te Pas AB (2022). Technology in the delivery room supporting the neonatal healthcare provider's task. Seminars in Fetal and Neonatal Medicine, 27(5): 101333. https://doi.-org/10.1016/j.siny.2022.101333.

Demtse AG, Pfister RE, Nigussiye AK, Mcclure EM, Ferede YG, Tazu BZ, Mekasha A, et al. (2020). Hypothermia in Preterm Newborns: Impact on Survival. Glob. Pediatr. Health, 7(3). https://doi.org/10.1177/2333794X20-957655.

Fauzi ER, Maharesi A, Doungjan K (2023). Thermostat automation for controlled temperature in simulated incubator. Jurnal Arus Elektro Indonesia (JAEI), 9(1): 17–21. https://doi.org/10.19184-/jaei.v9i1.34354.

Girma B, Tolessa BE, Bekuma TT, Feyisa BR (2021). Hypothermia on admission to a neonatal intensive care unit in Oromia, western Ethiopia: A case-control study. BMJ Paediatrics Open. 5(1): e001168. https://doi.org/10.1136/-bmjpo-2021-001168.

Gojak DZ, Gvosdar K, Hecimovic Z, Smajovic A, Becic E, Deumic A, Becirovic LS, et al (2022). The use of artificial intelligence in the diagnosis of neonatal sepsis. IFAC-PapersOnLine, 55 (4): 62–67. https://doi.org/10.1016/-j.ifacol.2022.06.010.

Hannouch A, Lemenand T, Khoury K, Habchi C (2020). Heat and mass transfer of preterm neonates nursed inside incubators - A review. Thermal Science and Engineering Progress, 18: 100553. https://doi.org/10.1016/j.ts-ep.2020.100553.

Kalaoglu A, Ipek O, Kalaoglu BK, Trabzon, L (2022). Improving thermal conductivities of textile materials by nano-hybrid approaches. Science, 25(3): 103825. https://doi.org/10.1016/j.is-ci.2022.103825.

Kiputa M, Salim N, Kunambi PP, Masawe A (2022). Referral challenges and outcomes of neonates received at Muhimbili National Hospital, Dar es Salaam, Tanzania. PLOS ONE, 176. 1–14. https://doi.org/10.1371/journal.pone-.0269479.

Kumar R, Wasim S, Gupta G, Mathur S, Kahlon DS (2022). Experience of mass intrahospital neonatal transport : impact on vitals. Cureus. 14(3):e22785. https://doi.org/10.7759/cureus.2278-5.

Li Sacit M, Nathwani J, When JZ (2023). Energy and AI methods and applications for artificial intelligence, big data, internet of things, and blockchain in smart energy management. Energy and AI. 11: 100208. https://-doi.org/10.1016/j.egyai.2022.100208.

Morgaonkar VA, Patel DV, Phatak AG, Nimbalkar AS, Nimbalkar SM (2020). Embrace versus cloth wrap in preventing neonatal hypothermia during transport: a randomized trial. J Perinatol. 41(2):330-338. https://doi.org-/10.1038/s41372-020-0734-x.

Oktaviana F, Widyawati MN, Kurnianingsih K, Kubota N (2020). Early detection of the risk of stunting in pregnant women and its recommendations. 2020 international symposium on community-centric systems. CcS 2020. 0–5. https://doi.org/10.1109/-CcS49175.2020.9231464.

Phoya F, Langton J, Dube Q, Tam PYI

(2020). Association of neonatal hypothermia with morbidity and mortality in a tertiary hospital in Malawi. J Trop Pediatr. 66(5): 470–478. https://doi.org/10.1093/tropej/fmz086.

Prasojo S, Suprianto B (2019). Rancang Bangun sistem pengendalian suhu pada inkubator bayi berbasis fuzzy logic controller (Design and construction of a temperature control system for a baby incubator based on a fuzzy logic controller). Jurnal Teknik Elektro. 08(01): 163–171. https://doi.org/10.26740/jte.v8n1.p%25p.

Ramadhanty J, Puspitasari TD (2022). Sistem informasi diagnosis ikterus neonatorum menggunakan logika fuzzy (Neonatal jaundice diagnosis information system uses fuzzy logic). Jurnal Teknologi Informasi dan Terapan, 9(1): 1–8. https://doi.org/10.25047/jtit.v8i2.187.

Sabariman S, Nofriyadi N (2022). Design Sistem kendali temperature otomatis dan fitur baby monitoring dengan IOT pada inkubator grashof Tipe G - 62 (Design of an automatic temperature control system and baby monitoring features with IoT on the Grashof Type G - 62 incubator). Telcomatics, 7(2): 42. https://doi.org/10.37253/telcomatics.v7i2.7323.

Setiawan A, Yanto B, Yasdomi K (2018). Prototipe sistem pendukung keputusan pendeteksian kondisi bayi dengan fuzzy tsukamoto (Prototype of decision support system for detecting baby's condition with fuzzy Tsukamoto). Riau Journal of Computer Science, 4(2): 87–94. https://e-journal.upp.ac.id/index.php/RJOCS/article/view/1645.

Simbolon O, Widyawati MN, Kurnianingsih K, Kubota N, Nawi NG (2020). Predicting the risk of preeclampsia using soft voting-based ensemble and its recommendation. 2020 International Symposium on Community-Centric Systems, CcS 2020 [Preprint]. https://doi.org/10.1109/CcS49175.2020.9231400.

Trevisanuto D, Testoni D, Almaida M, De FD (2018). Maintaining normothermia: Why and how?. Seminars in Fetal and Neonat Med. 23(5): 333–339. https://doi.org/10.1016/j.siny.2018.03.009.

Urubuto F, Agaba F, Choi J, Dusabimana R, Teteli R, Kumwami M, Cunard C (2021). Prevalence, risk factors and outcomes of neonatal hypothermia at admission at a tertiary neonatal unit, Kigali, Rwanda a cross-sectional study. J Matern Fetal Neonatal Med. 34(17): 2793–2800. https://doi.org/10.1080/14767058.2019.1671334.

Wang S, Feng S, Xiao Y, Hu C (2021). Build-in compact and efficient temperature sensor array on field programmable gate array. Microelectronics J. [Preprint]. https://doi.org/doi:10.1016/j.mejo.2021.105018.

Yeler O, Koseoglu MF (2022). Energy efficiency and transient-steady state performance comparison of a resistance infant incubator and an improved thermoelectric infant incubator. Eng Sci Technol Int J. 31: 101055. https://doi.org/10.1016/j.jestch.2021.09.001.

Yu YH, Wang L, Huang L, Wang LL, Huang XY, Fan XY, Ding YJ, et al (2020). Association between admission hypothermia and outcomes in very low birth weight infants in China: A multicentre prospective study. BMC Pediatrics, 20(1). 1–9. https://doi.org/10.1186/s12887-020-02221-7.