Original Article

The effects of risk factors on the improvement of neonatal hypothermia using fuzzy transition

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Accepted for publication: 22 Feb 2016

Abstract

Background: Neonatal hypothermia is a major risk factor for mortality after delivery. The present study aims to identify the risk factors associated with transition in hypothermia state with new definition of hypothermia states.

Methods: A total of 479 neonates hospitalized in Neonatal Intensive Care Unit of Valiasr Hospital, Tehran, Iran, in 2005, participated in the study. The rectal temperature of neonates were measured immediately after delivery and every 30 min afterwards, until their temperature became normal.

Results: The mean weight of neonatal was 2580±882.9 grams and the mean of delivery room temperature was 29.2±1.45 °C. Most of the neonates had mild hypothermia. There were significant associations between the weight of neonate, Cardiopulmonary Resuscitation, and Apgar scores and hypothermia state (P<0.05). Also, death of neonates was related to hypothermia state.

Conclusion: Findings of the current study indicated that a major risk factor for hypothermia was low weight of the neonates.

Keywords: Neonatal; Hypothermia; Temperature; Fuzzy transition model

Cite this article as: Salmani F, Abadi A, Taheri M, Alavi majd H, Nayeri F. The effects of risk factors on the improvement of neonatal hypothermia using fuzzy transition. SDH. 2016;2(1):15-20.

Introduction

Hypothermia in newborns is described as an abnormal thermal condition in which the body temperature of the neonates drops below 36.5°C. Gradual reduction in body temperature leads to unpleasant clinical effects. One of the most important risk factors for morbidity and mortality in newborn infants is hypothermia (1). There Mota Silveira et al. suggested hypothermia as a risk factor of death in newborn (3). are several possible causes of hypothermia in the newborn infant: evaporation (by wet skin or blankets or low humidity in the ambience), radiation (by large areas of skin exposed to cooler surroundings), conduction (contact with cooler bed materials), and convection (by flow of cooler air across baby's skin or mucous membranes) (2).

Therefore, hypothermia and its risk factors are often considered momentous for the

newborn baby. Researchers are interested in studying the risk factors for hypothermia. For instance, Delavar studied neonatal hypothermia and associated risk factors and concluded that spontaneous labor and warm room are associated with reduced risk of hypothermia (4).

According to the findings of several studies, low weight neonates are confronted with various degrees of hypothermia. In addition, environment temperature, low Apgar scores, birth rank, and receiving cardiopulmonary resuscitation (CPR) are risk major factors for hypothermia (5-8).

World Health Organization (WHO) has graded hypothermia into three groups based on core temperature. If the body temperature of a newborn is between 36.0 to 36.5°C, the patient is considered as mild hypothermia, if the temperature is between 32.0 to 35.9°C, the baby is diagnosed with moderate hypothermia, and if temperature is <32.0°C, the baby is considered as having severe hypothermia (9).

Therefore, we used "severe", "moderate", "mild" and "normal" as states of hypothermia.

Different studies have employed different criteria to study hypothermia. For instance, they differ in the cut-off points decided for the categories. Kumar et al. reviewed 20 studies for definition of hypothermia and found only 7 studies that applied WHO criteria (10).

According to WHO criteria, the difference between lower bound of mild state and upper bound of moderate state was 0.01°C. In other words, 0.01°C decrease in body temperature changed hypothermia level. In addition, if body temperature is 32.01°C, the baby falls into severe hypothermia and when temperature is 31.99°C, baby falls into moderate hypothermia. However, hypothermia status basically evaluated by verbal reports, linguistic variables, and borderlines of categories of linguistic variables are not accurate (11).

The point of view is that the reported borderline between subcategories of patient status is vague. This is because fuzziness must be considered in modeling systems where human estimation is influential (12). Therefore, it is preferable to apply fuzzy logic for modeling the risk factors of hypothermia in newborns.

Although literature on neonatal hypothermia is extensive, previous studies with logistic regression have described odds of risk factors on hypothermia status (hypothermia/normal). Nevertheless, in the current study, we surveyed factors, including environment temperature and weight of infants that affect transition from hypothermic state in neonates, using a flexible scale of hypothermia states and reported the rate of transition between states.

Methods

In the present longitudinal study, statistical population included all newborn infants who had hypothermia and were hospitalized in NICU of Valiasr Hospital in Tehran, Iran in 2005. A total of 479 infants were randomly selected for the first pool. For each newborn infant, the rectal temperature was measured repeatedly after birth and every 30 minutes thereafter until neonates passed hypothermia stages. The neonate's birth weight, gestational age, and Apgar score were considered as risk factors. For reliability, body temperature of newborn infants was measured by two nurses; the Kappa statistics was 100% for these nurses.

The information provided in many areas of medical diagnosis are not completely clear; therefore, making correct diagnosis is difficult in such a condition. In such a situation, fuzzy logic is suggested (11).

Fuzzy states of hypothermia are defined according to WHO criteria. Figure 1 shows the membership function of hypothermia.

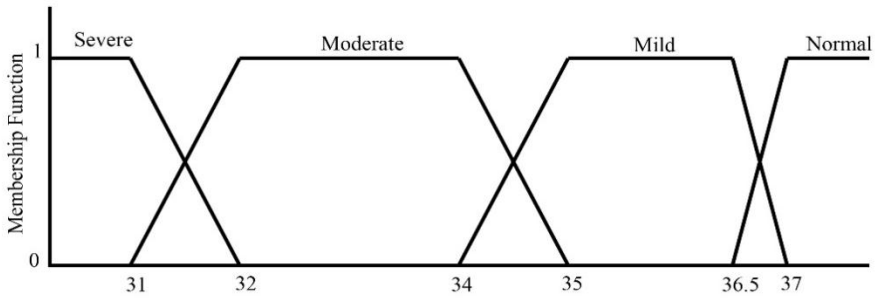

Figure 1. Membership function of hypothermia stats

The followings are membership function of hypothermia stats:

$$\mu_{Severe}(x)=\begin{cases}1 & x<31\\ 32-x & 31\le x<32\end{cases},\quad \mu_{Moderate}(x)=\begin{cases}x-31 & 31<x<32\\ 1 & 32\le x<34\\ 35-x & 34\le x<35\end{cases},$$

$$\mu_{Mild}(x)=\begin{cases}x-34 & 43<x\le 35\\ 1 & 35<x<36.5\\ \dfrac{37-x}{0.5} & 36.5\le x<37\end{cases}\quad \text{and}\quad \mu_{Normal}(x)=\begin{cases}\dfrac{x-36.5}{0.5} & 36.5<x\le 37\\ 1 & x>37\end{cases}$$

We calculated possibility transition matrix for transition between hypothermia states and used fuzzy logistic regression for association between risk factors and odd of transition between hypothermia states. To analyse the information, R3.2 was used.

Results

The mean temperature of environment was 29.2±1.45°C. Other characteristics of newborn infants are shown in Table 1.

Table 1. Characteristics of the newborns infants in the first visit

Characteristics		N (%)
Weight	<1500 gr	78 (16.3%)
	1500-2500 gr	139 (29%)
	≥2500gr	262 (54.7%)
Apgar score	<8	176 (36.7%)
	≥8	303 (63.3%)
Survived	Death	42 (9%)
	Alive	424 (91%)
CPR	Yes	80 (16.7%)
	No	399 (83.3%)

Table 2. Hypothermia stat in the first visit according to WHO guideline

Hypothermia stat	N (%)
Sever	3 (0.6%)
Moderate	201 (42%)
Mild	275 (57.4%)

According to WHO guidelines, only 0.6% of neonatal had severe hypothermia and 42% were diagnosed with moderate hypothermia, while 57.4% had mild hypothermia. Also, most of the neonates were reported to have Apgar score greater than 8.

Table 3 shows significant association between severity of hypothermia and Apgar score and CPR after birth. Moreover, there was a significant relationship between death and severity of hypothermia.

The possibilistic transition matrix was

$$\Pi = \begin{array}{c} \\ Severe \\ Moderate \\ Mild \\ Normal \end{array} \begin{array}{c} \begin{array}{cccc} Severe & Moderate & mild & Normal \end{array} \\ \begin{bmatrix} 0.333 & 0 & 0.467 & 0.2 \\ 0 & 0.095 & 0.846 & 0.059 \\ 0 & 0 & 0.436 & 0.564 \\ 0 & 0 & 0 & 1 \end{bmatrix} \end{array}$$

Table 3. Fuzzy Chi-square association between hypothermia stats and risk factor in the first visit and survival of neonatal

	Variables	Fuzzy Chi-square value	*P*
Fuzzy severity of hypothermia	CPR	12.99	0.002
	Apgar score	16.77	<0.001
	Survival	12.41	0.002

According to the transition matrix, the possibility of transition from severe to mild state in the next visit was 0.467 and the possibility of transition to normal state was 0.2. Moreover, the possibilities of transition from moderate to mild state and to normal state in the next visit were 0.846 and 0.059, respectively. When newborn infant was in mild state, the possibility of transition to normal state was 0.564.

According to the literature and these definitions and fuzzy logic, CPR after birth, Apgar score, weight, and environmental temperature are risk factors for hypothermia of neonates. After selection of model process for all transitions, we used the weight of newborn infants and environmental temperature as risk factors for hypothermia.

For each transition, the model was:

$$\tilde{W}_{ij} = \tilde{b}_0 + \tilde{b}_1 Weight + \tilde{b}_3 Environment\ Temperature, \quad i, j = 1,...,4.$$

Where $\tilde{W}_{ij} = \ln \frac{\mu_{ij}}{1-\mu_{ij}}$ is possibilistic odds of hypothermia, and $\tilde{b}_0, \tilde{b}_1, \tilde{b}_2$ are triangular fuzzy coefficients.

Table 4 shows the results of fuzzy logistic regression with fuzzy parameters modeling for surveying the effect of neonatal weight and environment temperatures risk factors on neonatal hypothermia.

Table 4. Estimated parameters and goodness of fit of transitions

Transition	Estimated Model*	Number of transition	Goodness of fit
π_{22}	$\tilde{W}_{ij} = (0,0.06)_T + (0.22,0.06)_T\, Weigth + (0,0)_T\, ET$	٣	0
π_{23}	$\tilde{W}_{ij} = (0,1.11)_T + (0.21,0.06)_T\, Weigth + (0,0.8)_T\, ET$	٢٢	0.21
π_{24}	$\tilde{W}_{ij} = (0,0)_T + (0.1,0.06)_T\, Weigth + (0,0)_T\, ET$	٤	٠
π_{33}	$\tilde{W}_{ij} = (0,1.84)_T + (0.24,0)_T\, Weigth + (0,0)_T\, ET$	٤١٢	0.87
π_{34}	$\tilde{W}_{ij} = (0,1.66)_T + (0.23,0)_T\, Weigth + (0,0)_T\, ET$	٤٦٤	0.52

*Because of low frequency, other models are not estimable.

These results show that the neonatal weight was associated with neonatal hypothermia. In other words, in all the models for all transitions, for each unit increase in weight, the possibility of transition to the next state (recovery) was

0.22 and the environmental temperature had no effect on the recovery.

Discussion

Hypothermia in neonates is considered as a major synergetic cause of significant morbidity in developing countries. Increased risk of mortality, bleeding lungs, metabolic acidosis, and hypoglycemia are severe complications of neonatal hypothermia. Studies in the developed countries have shown that hypothermia involves neonates with low weight while it involves all the neonates in developing countries. In the present study, we found the relationship between odds of hypothermia and weight of neonatal. In a similar study, Miller et al. (6) showed significant relationship between hypothermia and weight. Furthermore, Kumar et al. in a review study in developing countries, introduced the birth weight as a risk for hypothermia (10).

Our observation was that most neonatal transited to a better state or remained on the previous state and there were no transitions to the worse state. Those who had CPR or low Apgar score were also found to be at increased risk of hypothermia, a finding which is in line with those reported in Ali et al. (5).

In the present study, we did not find any relationship between environmental temperature and hypothermia, but there are studies that suggested plastic wraps combined with other environmental heat sources cause decrease in hypothermia (13). In addition, Akbarzadeh Baghban et al. found significant relationship between environmental temperature and hypothermia (14).

In addition to these results, we used the fuzzy method to describe hypothermia. Fuzzy regression was considered appropriate because the assumption of statistical models, such as distribution assumptions, adequate sample size, and exact observations were not established (11). In the present study, hypothermia was measured using linguistic terms, fuzzy Chi-square, and fuzzy logistic regression.

One of the first fields of interest in fuzzy application is medicine. In the present study, making use of fuzzy definition for hypothermia, we found the relationship between some risk factors (weight, Apgar score, and CPR and hypothermia, which are not under control, but delivery room temperature is under control. Therefore, sufficient care after delivery could help neonatal to pass through the hypothermia stages faster.

Acknowledgments

The present article is financially supported by "Research Department of the School of Medicine Shahid Beheshti University of Medical Sciences" (Grant No 7109).

Conflicts of Interest

Authors declare no conflicts of interest.

References

1. Zahedpasha Y, Agajani Delavar M, Akbarian Z, Hajiahmadi M, Hassanpour Hadighi M. Improvement of Hypothermia Control and Management Methods in Term Newborns after Training on Neonatal Hypothermia with the Help of Clinical Audit. J Babol Univ Med Sci. 2015;17(12):12-8.

2. Bhatt D, White R, Martin G, Van Marter L, Finer N, Goldsmith J, et al. Transitional hypothermia in preterm newborns. J Perinatol. 2010;10(S1):15-7.

3. da Mota Silveira SM, de Mello MJG, de Arruda Vidal S, de Frias PG, Cattaneo A. Hypothermia on admission: a risk factor for death in newborns referred to the Pernambuco Institute of Mother and Child Health. J Trop Pediatr. 2003;49(2):115-20.

4. Delavar MA, Akbarianrad Z, Mansouri M, Yahyapour M. Neonatal hypothermia and associated risk factors at baby friendly hospital in Babol, Iran. Annals of medical and health sciences research. 2014;4(8):99-103.

5. Ali SR, Mirza R, Qadir M, Ahmed S, Bhatti Z, Demas S. Neonatal hypothermia among hospitalized high risk newborns in a developing country. Pak J Med Sci. 2012;28(1):49-53.

6. Miller S, Lee H, Gould J. Hypothermia in very low birth weight infants: distribution, risk factors and outcomes. J Perinatol. 2011;31(S1):S49-S56.

7. Mullany LC, Katz J, Khatry SK, LeClerq SC, Darmstadt GL, Tielsch JM. Neonatal hypothermia and associated risk factors among newborns of southern Nepal. BMC Med. 2010;8(43):1-13.

8. Zayeri F, Kazemnejad A, Ganjali M, Babaei G, Khanafshar N, Nayeri F. Hypothermia in Iranian

newborns. Incidence, risk factors and related complications. Saudi Med J. 2005;26(9):1367-71.
9. World Health Organization . Thermal protection of the newborn: A practical guide. World Health Organization; Geneva: 1997. Report No.: WHO/RHT/MSM/97.2.
10. Kumar V, Shearer J, Kumar A, Darmstadt G. Neonatal hypothermia in low resource settings: a review. J Perinatol. 2009;29(6):401-12.
11. Pourahmad S, Ayatollahi S, Taheri S. Fuzzy logistic regression: a new possibilistic model and its application in clinical vague status. Iranian Journal of Fuzzy Systems. 2011;8(1):1-17.
12. Tanaka H, Uejima S, Asai K. LINEAR REGRESSION ANALYSIS WITH FUZZY MODEL. IEEE Transactions on Systems, Man and Cybernetics. 1982;12(6):903-7.
13. Oatley H, Blencowe H, Lawn J. The effect of coverings, including plastic bags and wraps, on mortality and morbidity in preterm and full-term neonates. J Perinatol. 2016;36(S):S83-S9.
14. Akbarzadeh Baghban A, Jambarsang S, Pezeshk H, Nayeri F. The effects of temperature and birth weight on the transition rate of hypothermia in hospitalized neonates using Markov models. Tehran University Medical Journal. 2012;70(5):282-8.