Modeling birth weight neonates and associated factors

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Background: Neonate with abnormal weight is at risk of increased mortality and morbidity. Many factors affect pregnancy outcome. Because of the importance and vital role in birth weight, in this study, some of the factors associated with birth weight in a sample of Iranians neonates were investigated. **Materials and Methods:** In this cross-sectional study, 245 newborns in a sample of Iranians neonates in the year 2013 were selected, and characteristics of neonate and their mothers were derived. Birth weights were registered by the neonatal scale. To identify the direct and indirect factors affecting birth weight, we used path analysis (PA) and IBM AMOS and SPSS software. **Results:** The mean ± standard deviation of weight in girls (3200 ± 421) g less than boys (3310 ± 444) g significantly ($P = 0.04$). Gestational age ($P < 0.001$), birth rank ($P = 0.012$), distance from a previous pregnancy ($P = 0.028$), and mother weight ($P = 0.04$) had a statistical significant relationship with birth weight. In the final PA model, gestational age has a highest total effect, type of delivery with gestational age-mediated had the highest indirect effect and type of delivery, and gestational age had the greatest total impact on the birth weight. **Conclusion:** Gestational age, sex, distance from a previous pregnancy, maternal weight, type of delivery, number of abortion, and birth rank were related with birth weight. Due to the termination of pregnancy and avoid unnecessary deliveries through cesarean section and other related factors should be further consideration by childbirth experts. In addition, factors affecting these variables are carefully identified and prevented as much as possible.

Key words: Birth weight, delivery, gestational age, neonate

INTRODUCTION

Birth weight is a major criterion indicating a neonate's optimal growth and a main determining component for its survival.[1-4] Neonates with a birth weight of over or under the normal indices are at a higher risk of morbidity and mortality (1–2 and 5). Neglecting neonates' health increases the likelihood of morbidity, leading to mental, psychological, and financial problems.[3] It has also been proposed that adult morbidity and mortality rates due to conditions such as hypertension, arteriosclerosis, diabetes, and even malignancies be correlated with neonatal birth weight (NBW).[6,7] The WHO annually reports children's physical and mental health based on such factors as weight, height, skull size, and a few more factors, while putting special emphasis on weight.[8] Maternal factors can affect the outcome of a pregnancy.[9] This study utilizes the path analysis (PA) procedure to study and propose a model depicting factors which affect NBW. The hope is to determine the direct and indirect (DAI) predicting factors that might have an impact on NBW. PA is an advanced statistical procedure that can help to explore the DAI effects of each independent variable on the dependent one. Therefore, the most significant advantage of PA over regression analysis is that in the latter, one can detect only the direct effect each independent variable on the dependent one. In PA, however, in addition to direct effects, it is possible to discover the indirect effects of each independent variable on the dependent one. For

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this reason, PA deals with several standardized linear regression equations, while in regression analysis, there is only one standardized linear regression equation.[10,11] In fact, PA is an extension of regression methods.[12] Another interesting feature of PA is that it can test a proposed hypothetical causal model as a whole.[11] In addition to investigating DAI effects among variables, one can include covariance or correlation structures between variables in the analyses, contributing to a lower level of standard errors of comparison to regression models. Another advantage of PA is that it analyses the correlation between two variables both separately and collectively. Analysis of correlation is important since it not only provides information about causal relations but also allows us to test model fit and adequacy when some relations are deleted in the first place. In a model with no deleted relationships, analysis of correlations cannot be used as a test for the model fit since the relationship is a mathematical one.[10,13]

PA does not prove causality. It is a procedure to indicate logically observed correlation among variables in a study encompassing cause/effect relationships. In other words, through analyzing observed correlations among variables, PA investigates the direct and the total effects of each causal variable on the dependent variables.[14,15]

This study aimed to determine the DAI predicting factors affecting NBW in Shoushtar (South-West of Iran) in 2013 and to present a thorough analysis for the causal models. It is worth stating that a large number of studies have been done on NBW, but given the importance of their weight at birth, this issue still deserves further investigation. Considering previous studies in this regard, it is obvious that NBW are different in different societies. In this area, in particular, no studies have been carried out dealing with this matter. Therefore, the purpose of this study was to investigate NBW and to point out some contributing factors in 2013, while utilizing the PA procedure.

MATERIALS AND METHODS

Study design and participants
In this cross-sectional study, viable neonates in Shoushtar were survived. Of the 1800 recorded births in the year 2013, using structural equation formula sample size was 245 persons. In structural equations, like multiple regression, five to fifteen observation for each variable (v) is measured ($5v < n < 15v$).[13]

The samples were chosen by cluster sampling method. From five centers in the city, three centers were randomly selected, and then samples were randomly chosen from these centers. Inclusion criteria were birth in 2013 at the site studied and exclusion criteria were incomplete records and multiple births and the mother's underlying disease.

Study instruments and measured variables
The information was derived from the existing records there and comprised two parts. The first one dealt with such neonates' characteristics as weight at the birth time, intrauterine age, gender, birth rank, interval time to the previous pregnancy, and delivery type. The second part included the neonates' maternal information, being age, job, education level, history of abortion, number of pregnancies, number of children, weight, maternal hemoglobin level, and blood sugar in the last trimester.

The NBW had been recorded on the 1st day of birth using baby scales. To recognize the DAI factors influencing NBW, the PA procedure was used.

Statistical analysis
The IBM AMOS version 18 software was chosen to carry out analyses on the collected data. To predict NBW, the same PA procedure was used.

All variables were first loaded onto the model, and the results were studied, followed by deleting meaningless paths from the model. The model was tested again, at the presence of significant variables, to come up with a final model for the data through analyzing paths. We used goodness of fit (GOF) criteria CMIN/df (Chi-square/DF), goodness of fit index (GFI), Tucker–Lewis index (TLI), comparative fit index (CFI), standardized root mean square residual (SRMR), and root mean square error of approximation (RMSEA). Scope of acceptance CMIN/df <2, GFI >0.9, TLI >0.9, CFI >0.9, SRMR <0.1, RMSEA <0.05.[11,12]

Direct effects in PA are in fact the same regression coefficients for each independent variable exerted on the dependent one. The amount for which can be extracted from the output standardize beta of the software to calculate the indirect effect of each independent variable on the dependent one. At first, all the paths for indirect effects of each independent variable on the dependent one need to be multiplied, and the results of all those effects are summed up. The overall effect indicates the total sums of all DAI effects of the independent variables on the dependent one. To obtain this amount, DAI figures for each independent variable need to be summed up.[6] To compare the NBWs mean values, the Kolmogorov–Smirnov test for normality was run first. Pearson's correlation test was used for correlations between variables. All analyses were carried out using IBM SPSS Statistics version 18.

RESULTS

In this study, 245 neonates were studied, with a mean ± standard deviation of (3257 ± 436) g for their weights. About 47.75% of the total was female. The female weight (3200 ± 421) was smaller than that of the

males (3310 ± 444) g, (*P* = 0.04). Maternal age did not indicate a significant statistical correlation with neonates' birth weights (*P* = 0.053, *r* = 0.124). About 27.3% of the mothers had a higher education with the smallest birth weight (3220 ± 385) g, and a very slight statistical difference was observed among the different educational groups in terms of NBW (*P* = 0.66). Around 12.7% of the mothers had a history of abortion with an NBW mean of (3313 ± 511) g, which was higher than that of the mothers with no history of abortion (3248 ± 422) g. However, the relationship between abortion and birth weight was not statistically significant number of abortions (*P* = 0.68, *r* = 0.026). There was a statistically significant relationship between NBW and the number of pregnancies (*P* = 0.03, *r* = 0.136).

There was also a significant relationship between pregnancy termination age and NBW so that there was a reduction in the NBW with a decline in the pregnancy age (*P* < 0.001, *r* = 0.423). Another significant relationship was between maternal weights and NBW (*P* = 0.03, *r* = 0.139). There was no statistically significant relationship between maternal hemoglobin level (*P* = 0.43) or blood sugar level (*P* = 0.18) with NBW. About 39.2% of the mothers experienced their first pregnancy, and no statistically significant relationship was discovered between the mean weight of their neonates (3206 ± 377) g and that of the neonates of the mothers with multiple pregnancies (3290 ± 468) g, (*P* = 0.14). Similarly, there was no significant relationship between type of delivery and NBW (*P* = 0.96), the same with the time period to the previous pregnancy and NBW (*P* = 0.12, *r* = 0.099). In 22.85% of the mothers, the time period to of the previous pregnancy was smaller than 3 years. The mean NBW belonging to this group (3195 ± 417) g was smaller than that of the neonates of the mothers with a time period of more than 3 years between pregnancies (3353 ± 496) g. A significant relationship was detected between NBW and birth ranks (*P* = 0.013, *r* = 0.158) [Table 1].

Once all the variables under study were put on the model, and the relationships among them were

drawn based on previous research history, an initial hypothetical model was designed. PA for parameter estimation uses maximum likelihood method, which the assumptions necessary for this method, the multivariate normal of data. That after identification of outliers and remove them, normal multivariate data were established. In addition, the model fit indices were also studied, which indicated low validity of the initial hypothetical model. To improve the model fit indices, through careful examination of the modification indices and theoretical justification of the corrections, some covariance or regression paths were added to or deleted from the model, and the diagram together with the standardized estimations was drawn [Figure 1]. The DAI and total effects were then obtained [Table 2], and model fit indices for the model were estimated [Table 3].

After making modifications to the initial model, the GOF values improved although they were still far from acceptable. Therefore, those variables with little contribution to the dependent variable were deleted from the model. After deleting each, the GOF was again calculated for the model to come up with a model indicating the best fit for the data. The diagram for the improved model was drawn together with the standardized estimations. In the modified model, six variables were included: gender, delivery type, maternal weight, number of abortions, child ranking, and age of pregnancy termination [Figure 2]. Subsequently, the path coefficients for the DAI effects were calculated [Table 2], and based on the GOF values, the final model was considered as an acceptable one [Table 3]. In this model, the age of pregnancy termination exerted the greatest amount of direct effect (β = 0.4806) on NBW. Among indirect effects, the variable of "delivery type" mediated by the age of pregnancy termination (β = −0.1485) exerted the greatest amount of indirect effect. Considering the total effects of all variables, we discovered the age of pregnancy

Table 1: Relationship of neonates' birth weights with studied variables

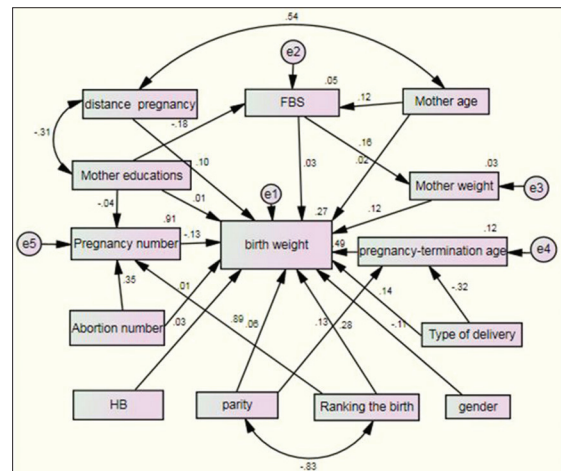| Variables	Mean±SD	Correlation, *r* (*P*)
Mother age (year)	28.2±5.6	0.124 (0.053)
Mother weight (kg)	66.1±11.3	0.139 (0.03)
Abortion number	0.18±0.44	0.026 (0.68)
Pregnancy number	1.91±0.93	0.136 (0.03)
Pregnancy-termination age	38.2±1.1	0.423 (<0.001)
Fasting blood sugar	81.5±10.3	0.084 (0.18)
Hemoglobin	11.1±1.0	0.050 (0.43)
Distance from previous pregnancy (year)	2.87±3.23	0.099 (0.123)
Ranking the birth of child	1.79±0.76	0.158 (0.013)

SD=Standard deviation

Figure 1: The path analysis diagram with all the independent variables (the initial model)

Table 2: Standardized direct, indirect, and total effects of independent variables on neonates' weight in the first and final models

Modeles	Variables	Direct effect	Indirect effect	Total effect
Initial model	Mother age	0.0193	0.0064	0.0258
	Mother educations	0.009	−0.0036	0.0057
	Time from previous pregnancy	0.099	0.000	0.099
	Parity	−0.0635	−0.0614	−0.1249
	Ranking the birth of child	0.2816	−0.1182	0.1634
	Gender	−0.1124	0.000	−0.1124
	Type of delivery	0.1395	−0.1562	−0.0167
	Mother weight	0.1243	0.000	0.1243
	Abortion number	0.0122	−0.0467	−0.0345
	Pregnancy number	−0.1334	0.000	−0.1334
	Hemoglobin	0.0335	0.000	0.0335
	Fasting blood sugar	0.0339	0.0197	0.0537
	Pregnancy-termination age	0.4915	0.000	0.4915
Final model	Gender	−0.1129	0.000	−0.1129
	Type of delivery	0.1465	−0.1485	−0.0019
	Mother weight	0.1417	0.000	0.1417
	Abortion number	−0.0337	0.0455	0.0118
	Ranking the birth of child	0.1786	0.0175	0.1961
	Pregnancy-termination age	0.4806	0.000	0.4806

Table 3: Goodness of fit values and scope of acceptance for the initial and final models

Models	Goodness of fit indices					
	CMIN/df	GFI	TLI	CFI	SRMR	RMSEA
Initial model	5.587	0.856	0.706	0.784	0.1720	0.137
Final model	1.127	0.985	0.976	0.986	0.044	0.022
Scope of acceptance	<2	>0.9	>0.9	>0.9	<0.1	<0.05

CMIN/df = Chi-square/df; GFI = Goodness of fit index; TLI = Tucker-Lewis index; CFI = Comparative fit index; SRMR = Standardized root mean square residual; RMSEA = Root mean square error of approximation

Figure 2: The path analysis diagram with meaningful variables (final model)

termination having the greatest amount of influence on NBW, followed by delivery type.

DISCUSSION

Studying NBW bears a significant importance as those neonates form the future generation of and given society. Their health will indicate a brighter and healthier society. One such factor of health being their NBW, therefore, a thorough scrutiny of the factors that influence NBW is of paramount importance. So far a large number of studies have been carried out on NBW that has examined direct effects of each variable. The advantage of this study over the others lies in the fact that utilizing a PA model, the direct effects as well as the indirect ones of each variable has been investigated. Besides, examining variables simultaneously instead of individual examination of each is a positive aspect that can be taken advantage of statistical models like PA. Structural equation modeling, a branch of which was utilized in this study as PA, enables researchers to develop a conceptual graphic model encompassing cause/effect relations among variables to assess those
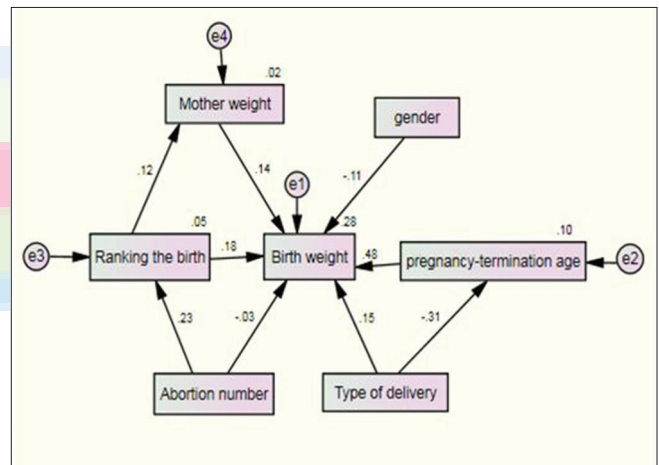
relations and to measure and compare DAI effects of one variable on another.[10,13,16] According to the findings of the study, among the variables, NBW had a significant positive correlation with age of pregnancy termination, gender of the neonate, time period between the last two pregnancies, and maternal weight. In Tootoonchi's study,[17] the average NBW showed a statistically significant correlation with the gender of the neonates, intrauterine age, condition of the fetus, and the number of pregnancies. In another study carried out by Eghbalian,[18] the findings indicated a relationship between low birth weight (LBW) and maternal age, age of pregnancy, maternal weight, maternal height, period between the last delivery and the present one, number of family members, smoking, history of abortion, and maternal education. Eshraghian *et al.*[19] reported a significant correlation between LBW and pregnancy age,

maternal weight, maternal height, maternal age, maternal history of chronic diseases, hemorrhage during pregnancy, maternal education, and the birth rank. In the presence of all those factors, LBW was significantly correlated with age of pregnancy, maternal height, hemorrhage during pregnancy, and maternal history of chronic diseases. According to Takimoto *et al.*,[20] analyzing all factors using logistic regression, LBW seemed to be caused by preterm delivery, gender of the neonate, number of pregnancies, maternal height, maternal age, and maternal smoking habits.

In the PA procedure with filling indices employed, these variables were placed in the model: neonates' genders, delivery type, maternal weight, number of abortions, the neonate's ranking, and age of pregnancy termination.

This last variable, i.e., the age of pregnancy termination, imposed the greatest amount of direct effect on NBW, a point which is also reported in other studies.[17-19,21] Those concerned with related clinical practices need to bear this important variable in mind and try to identify and prevent those causal factors that lead to preterm termination of pregnancy one such factors is type of delivery. An inspection of the PA model reveals that among all variables, type of delivery exerted the greatest amount of indirect negative effect mediated by the age of pregnancy termination and the third direct effect on NBW. Type delivery affected NBW both directly and indirectly. Its indirect effect mediated by the age of pregnancy termination indicates that type of delivery effects NBW when it influences age of pregnancy termination. It is assumed to stem from the fact that age of pregnancy termination in cesarean deliveries occurs prematurely, leading to the birth of neonates with lower weights in comparison to those delivered naturally. Child rank exerted the greatest direct effect on NBW after the age of pregnancy termination. This might be due to the fact that in later pregnancies both the maternal experience and body are prone to deliver a neonate with a higher weight, which has also been pointed out by some researchers.[19,21,22] Child rank mediated by maternal weight left a positive indirect effect in NBW, indicating that the higher the rank, the heavier the maternal and neonatal weights. Maternal age showed a positive direct effect on NBW so that the higher the maternal weight in the first trimester of pregnancy, the more the likelihood of delivering heavier neonates. Low maternal weight in the first trimester has been found to lead to the birth of neonates with low weight.[19,23,24] The gender of the neonates accounted for the fifth direct effect on their birth weight, a point supported by higher frequencies of heavier weights of boys in comparison to girls at birth and also in previous studies.[23,25-27] The number of abortions left a direct negative effect on NBW. Some other studies have also demonstrated this finding.[18] It is assumed that maternal history of abortion indicates weaker maternal physical conditions compared to mothers with no such history, leading to the LBW. In addition, number of abortions indicated the second indirect positive effect mediated by the child rank on neonates, NBW. In other words, when the number of abortions influences the child rank, it leads to an increase in NBW, probably because of adequate resting and care together with more experience of mothers in later pregnancies. In a PA study carried out by Mahmoodi *et al.* on LBW rate, the final model showed perfect fitting (RMSEA = 0.00, CFI = 1) indicating that among direct effect while the family income was the most effective among indirect effects ($\beta = -0.42$), leaving the greatest total effect for unemployed spouse ($\beta = -0.183$). Negative values show a decline in the effect on NBW.[28] In another study by Hamta *et al.* performed on LBW using the PA procedure, the greatest direct effects were due to preterm delivery and unwanted pregnancy, and age left a significant positive indirect effect while IUGR showed a significant negative effect on LBW. In addition, marriage age, age at first pregnancy, education, number of pregnancies, and unexpected pregnancies had indirect but insignificant effects on LBW.[29]

CONCLUSION

Regarding the find PA model, the greatest direct effect was due to the age of pregnancy termination and the greatest indirect effect to delivery type mediated by the age of pregnancy termination, followed by delivery type with the greatest total effect on NBW. Careful examination of the findings seems that passing laws to prevent preterm deliveries, especially cesarean types and providing more education and care for mothers might increase the likelihood of the birth of neonates with normal weights

Suggestions
A shortcoming of PA is that dependent variables can only appear as interval or ordinal ones. It is suggested that in future studies the Bayesian PA will include nominal variables as dependent one, too. Another limitation of this study relates to the lack of access to other influencing pieces of information due to collecting data from records. Future studies can incorporate other relevant factors such as maternal nutrition, family economic status, activity and rest of the pregnant mother, maternal social relations during pregnancy, and diseases. In this way it is possible for a relationship between these factors and the NBW to identify pregnant mothers at the risk of neonatal LBW or neonatal macro birth weight and take measures for its prevention.

Conflicts of interest
There are no conflicts of interest.

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