Low birth weight as a determinant of protein energy malnutrition in '0-5 years' Omani children of South Batinah region, Oman

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ABSTRACT

Objective: To determine the risk factors of protein energy malnourishment (PEM) among 0-5 year old children in South Batinah region, Oman.

Methods: Five hundred and ninety-nine randomly selected children with PEM and 599 children without PEM were identified from the child health registers that are maintained at the primary health institutions of the study area. This case control study was conducted between March 2003 and May 2003. The information of their birth weight, birth interval, birth order, twin pregnancy, history of underweight and death among siblings, presence of congenital anomalies, breast feeding status, social problem and other ailments in mothers were collected. Univariate and multivariate analysis were carried out to determine the risk and predictors of PEM.

Results: The median birth order among PEM cases was significantly higher compared to the children without PEM (Mann Whitney test; p=0.029). Using multivariate logistic regression technique, we found that low birth weight (odds ratio [OR] 2.32; confidence intervals [CI] 95% 1.61-3.33), higher birth order (OR 1.04; CI 95% 1.01-1.08) and sibling with history of under weight [OR 1.79 (CI 95% 0.97- 3.28)] were significant predictors of PEM.

Conclusion: It is possible to identify children with high-risk of PEM using information on birth weight, birth order and history of PEM in sibling. This non-anthropometric method can be used as an additional tool for monitoring growth of children and formulate preventive interventions.

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Protein energy malnutrition (PEM) is a health problem that defies standard epidemiological explanations and readymade solutions. Multifactor etiology leads to PEM; however, understanding the different ways in which they combine by place and time could help in fine-tuning the interventions that are appropriate for each community. Oman is a country in the Middle Eastern Peninsula that has achieved remarkable improvement in socio-economic status of its citizens in the last quarter of twentieth century. In the year 2002, the national crude birth rate was 25.65/1,000 and crude death rate was 3.47/1,000 population. The life expectancy was 73.78 years. The children 0-5 years of age were estimated to be 25,5112, which constituted 13.6% of the total population.[1] The health initiatives in Oman aim to reduce the childhood mortality and improve their quality of life. Due to the primary health care approach, improved antenatal care and universal immunization strategies, Oman was ranked one of the top 10 World Health Organization (WHO) member

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countries.[2] It is worth noting that the health services even of tertiary nature are provided free of cost and easily accessible to all Omani nationals. The health programs activities are successfully implemented through primary and Wilayat health systems in all 10 regions of Oman. The impact of these initiatives is evident from the decline of infant mortality rate from 29/1,000 live births in 1990 to 16.2/1000 in 2002.

South Batinah region of Oman is situated North of Muscat, the capital of Oman and is separated from Dhakhiliya region by a mountain range. It has a population of 255,383 and a population density of 55.9 per square kilometer. The population of 0-5 children in the region was 34,667 (14% of the total population).[3] The terrain varies from coastal areas to inaccessible mountainous areas. There are 15 health institutions in the region. Twelve are primary health centers and 2 are polyclinics. They have well-defined catchment areas. One secondary level hospital provides primary care and function as the referral hospital for the region. The secondary level hospital and 2 primary care polyclinics have specialist pediatric units for seriously ill children. In South Batinah region; as per national policy, each child at birth is allotted a unique number (MR2 number) and given a child health card that becomes the health record of the child in addition to the institution records.[4] This card includes the immunization history, growth records and illness details. In a section of the child health card, the presence of "at risk" factors are recorded when the child is registered. These risk factors are low birth weight (LBW), low birth interval, high birth order, twin pregnancy, sibling underweight, sibling death, congenital anomaly, absence of breast feeding, social problems and need for special care. All of them are known to have direct or indirect influence in the development of PEM.[5-9]

In spite of health initiatives and their evident success, the incidence of PEM remains relatively high in Oman and varies regionally. The PEM rate in 0-5 children in Oman was 14/1,000 in 2002. It was as low as 3/1,000 in Dhahira and as high as 32/1,000 in North Sharqiya region.[1] The PEM rate in South Batinah region was 17/1,000 in 2002 and this region's rates were consistently higher than the national rates during the past 5-years. The PEM rates also varied in 5 Wilayats within the region.[1] Therefore, it is crucial to determine the risk factors for PEM and the rationale for the variation in the region. In Oman, the current strategies for management of PEM at the primary care level includes a notificaion process and established guidelines. Severe cases of PEM are individually notified and managed by a child specialist in the hospital. The mild and moderate cases are not notified but given care at the health centers. There is no doubt that these steps will help in the successful management of PEM. A reduction in the incidence of PEM requires feasible interventions on proximate determinants of PEM. The 'at risk' concept provides an important tool for targeting needy '0-5 years' children in the community setting.[7,10] In this context, we aimed to explore the possibility of early identification of infants that could be considered as 'at risk' for developing PEM.

Methods. This was a case control study. The study population was selected from the new PEM registered cases maintained in the 15 institutions of Ministry of Health in the region. Non-Omani children were excluded. Details of all PEM registered cases belonging to the catchment area of the institution were noted. The Child Health card number (MR2 number) of the PEM cases was noted, which in turn was used to obtain data on 'at risk' details from the child health register. The register also had information on all children belonging to the catchment area of the institution and this formed the reference for getting data of the controls.

Sample size required for the study was calculated using the Epi-info 2002 program. Prevalence rates obtained from a pilot study were used for the calculation. The sample size was calculated using a LBW prevalence of 8% among controls, odds ratio (OR) of 2 and case is to control ratio of 1:1. Assuming the alpha error to be 0.01 and the power of the study as 80%; it was found that the sample size required for each group was 536. To compensate the subjects with missing data and since the total number of new cases during a year were 600, it was decided to include all children registered with new PEM during one year of the study period as the cases.

A case was defined as a child who was diagnosed with PEM during the period between May 2001 and April 2002. The important indicator for PEM is underweight for age and the use of growth charts was the best way for detection of such children in the field.[11] According to the guidelines regarding PEM, a child is diagnosed as having PEM when found to be having weight for age of <2 SD from the median. Omani children having the MR2 number, which comes one after the next MR2 number of the cases in the same institutuion were taken as controls. If the child thus selected had PEM, it was excluded and the penultimate MR2 number before the case was selected. Thus, details of 599 children with PEM and 599 controls were collected for the study. The definitions of the study variables were the same as that used in the community setting (**Table 1**). As per guidelines issued by the Ministry of Health in Oman, a child is diagnosed to suffer from severe PEM if the weight for age is <3 SD from the median. If the weight is <2 SD below the median, the child is defined as and will be diagnosed as moderate PEM. The growth reference used in Oman is based on the National Centre for Health Statistics (NCHS) standards. Data with regard to the cases and controls were collected from the child health and antenatal registers using a standard pre-tested data collection form. The variables included the demographic details, at risk details, birth weight, birth order for cases and controls and also age at presentation for the cases. The investigator piloted the data collection initially to ascertain feasibility and possible data collection errors before the formats were sent to the institutions. Designated nursing staffs from each institution were trained in the study methodology and they collected the data from the registers. The investigator scrutinized the data to minimize possibility of missing data.

The data were entered into the computer using the Microsoft Access program and analyzed using Statistical Package for Social Science 9. Univariate data analysis using parametric and nonparametric methods were conducted to determine the frequencies and proportion of risk factors in cases and controls. To identify the predictors, multiple regression analysis was carried out using logistic regression model. For statistical validation OR and their 95% CI were estimated.

The consent of regional health administrators was taken to conduct this study. The information of the individual children was kept confidential by using unique identifying code of each subject. The results of the study were used to improve the child health care of the region. They were discussed among the scientific fraternity at the national levels.

This study has been undertaken by extracting data from registers maintained in the health institutions with an objective to identify predictors for PEM utilizing the existing recording system. Therefore, the causal link of identified factors to the PEM should be carried out with caution.

Results. The study sample consisted of 1,198 children (599 cases and 599 controls). Approximately 70% of the children were residents of Rustaq and Barka Wilayats. Out of 1,198 children; 554 (46%) were female children and 644 (54%) male children. Out of children with PEM, 329 (55%) were males while 270 (45%) were females. The median age at which children presented with PEM was 14 months with mean age of 15 months. The 3rd and 97th percentiles corresponded to 6 and 33 months. Fifty percent of the cases presented between 10 and 19 months (Interquartile range=10). The incidence rate for the PEM during the period selected for study was 17.3 per 1,000 in '0-5 years' children. Forty-seven (7.2%) children had a severe grade of malnutrition (weight for age was 3 SD below the median). The difference in the distribution of male and female

Table 1 - Definitions of the study variables.

Risk factors	Definitions
Low birth weight	Birth weight less than 2.5 Kg
Low birth interval	Birth Interval less than 2 years
Higher birth order	Birth order more than 5
Twin pregnancy	Two babies born of a mother during a delivery
Sibling underweight	Last sibling underweight (low birth weight)
Sibling death	Last sibling death
Congenital abnormality	Presence of congenital abnormality as diagnosed by qualified pediatrician
No breast feeding	Bottle fed only in neonatal period
Social problems	Presence of social problems like family separation
Special care needs	Presence of other reasons for special care such as prematurity, maternal illness

Table 2 - Risk factors of protein energy malnourishment (PEM).

Risk factors	PEM cases (n= 599)	Controls (n= 599)	OR	CI 95% for OR
Birth weight			2.36	1.64-3.38
Normal	495	550		
Low	104	49		
Birth interval			1.15	0.85-1.54
>2 years	485	497		
<2 years	114	102		
Birth order			1.13	0.89-1.43
<5	364	381		
>5	235	218		
Twin pregnancy			0.69	0.29-1.62
No	590	586		
Yes	9	13		
Underweight sibling			1.96	1.1-3.62
No	566	582		
Yes	33	17		
Death sibling			1.20	0.52-2.81
No	587	589		
Yes	12	10		
Congenital problems			1.77	0.74-4.25
No	585	591		
Yes	14	8		
Bottle fed			-	-
No	599	599		
Yes	0	0		
Social problems			0.5	0.05-5.52
No	598	597		
Yes	1	2		
Others (maternal illness)			0.82	0.52-1.31
No	564	557		
Yes	35	42		

OR - odds ratio, CI - confidence interval children among cases and control was not significant [OR = 0.91 CI 95% 0.72 to 1.15)]. The gender variation by severity of PEM was also not significant.

Risk factors for protein energy malnutrition. The frequencies and percentage proportions of cases and controls by different epidemiological variants were calculated for comparison (**Table 2**). Low birth weight and presence of underweight sibling was significantly associated to the risk of PEM in the study subjects with PEM.

Birth weight and protein energy malnutrition. The exact birth weight and birth order of PEM cases and controls were also compared. Mean birth weight of the PEM cases were 2.85 kg (95% CI 2.81 - 2.88) and that of the controls were 3.04 kg (95% CI 3-3.07). The difference in mean birth weight (0.230 kg) was significant (p<0.001).

Birth order and protein energy malnutrition. The median birth order among PEM cases was 5 (25th percentile 3 and 75th percentile 8). In contrast, the median birth order of children without PEM was 4 (25th percentile 2 and 75th percentile 7). Thus, birth order of children with PEM was significantly higher compared to children without PEM (Mann Whitney test p=0.029).

Identification of predictor variables. A prediction model using multivariate regression technique was attempted and all variables with a p<0.25 in univariate analysis and those that were clinically significant (Birth interval <2 years) were included in the model. It was found that LBW, higher birth order and positive history of sibling under weight are significant predictors of PEM (**Table 3**).

Table 3 - Predictors of protein energy malnourishment.

Predictors	ß coefficient	SE of ß	Odds Ratio Estimate	Odds Ratio 95% CI	*p* value
Birth order	0.04	0.02	1.04	1.01-1.08	0.02
LBW	0.84	0.19	2.32	1.61-3.33	<0.001
History of sibling underweight	0.58	0.31	1.79	0.97-3.28	0.06
Constant	0.34	0.11			

LBW - low birth weight,
SE - standard error, CI - confidence interval, ß - beta

Discussion. The study covered all 15 health institutions of the South Batinah region that catered to their respective catchment areas. Thus, results of our study represent a true reflection of the situation in the community setting of this region during the period. The recordings of birth weight and weight for age were made using standardized techniques in the health institutions. The health staffs were trained in weighing techniques. All institutes were having the same type of machines. These machines were calibrated on daily basis. Hence, measurement bias in our study is less likely. A standard definition is used for definition of PEM throughout the country; hence, misclassification of cases and control is unlikely. In addition, the risk factors studied were based on findings recorded in the Child Health Register; therefore, possibility of recall bias is less in this study. The findings provide clear indications on the role of LBW in contributing to PEM in the region. The risk of developing PEM in a child with LBW is 2.36 (CI 95% 1.64-3.38) times more than a normal birth weight child. As expected, there is significant difference between the mean birth weight of PEM cases and normal controls. Low birth weight children can be born at term or before term and had varying degrees of social and medical risk. While the vast majority of LBW children have normal outcomes, as a group, they generally have higher rates of subnormal growth, illnesses, and neuro-developmental problems.[10,12] Studies in different settings on risk-factors of PEM have identified LBW as an independent risk factor.[13,14] However, factors such as nutritional, socio-economic and so forth could contribute to development of PEM in children. In this study, all these factors were not included and could be studied further through prospective generation of such information in a separate study. The objective of the study was to find out whether LBW could predict development of PEM so that LBW could be used as a starting point for preventive interventions. The results suggest that LBW children could be targeted in the community setting for above.

The higher the birth order the greater the risk of developing PEM will be [OR 1.04 (CI 95% 1.004-1.07)]. In the child health card, this information has been summarized by categorizing into 2 groups; namely, those children with a birth order of more than 5 and those with birth order <5 (OR 1.12, 95% CI 0.89-1.43). It is found that birth order is a better predictor of PEM as categorization results in loss of influence of higher birth order, which is relatively common in the region as well as in the country (median birth order value is 5 and maximum value is 17). It could be argued that the children with higher birth order have mothers who are less educated. Thus, education is actually the underlying risk and not birth order. It can be seen that the estimated risk is only minimal. However, this has to be interpreted based on the fact that on one hand the birth weight increases with increasing parity and on the other hand, it decreases due to problems contributed by increasing family size and poor maternal health. If there is a history of underweight in a sibling, the risk of PEM increases [OR 2 (CI 95% 1.1-3.62)]. This again seems to indicate multiple factors contributing to the etiology of PEM. It is of particular interest to note that a lower birth interval; namely, <2 years was not found to be associated with increased PEM. Even within the control group, there was no difference in mean birth weight between children born with a birth interval of <2 years and those with more. In our study, none of the other risk factors that are routinely entered in the child health card; such as multiple pregnancies, history of sibling death, presence of congenital abnormality, absence of breast feeding, social problems and maternal illness were found to have a significant role in the development of PEM. A review of studies on risk factors for PEM from other countries also showed that LBW and higher birth order were the commonly identified risk-factors.[7,13,14] The relationship of breast-feeding practices, and growth pattern is of much interest. Infants of lesser birth weights may have such rapid rates of growth that human milk alone may not supply sufficient essential nutrients for the normal growth. Objective nutritional studies of growing infants (for example rate of growth in weight and length, normality of various constituents in blood, performance in metabolic studies, body composition) show relatively small differences between infants fed from human milk and those fed from cow's milk.[15] However, such techniques may not record small but important qualitative variations in the growth and development. Another aspect worth mentioning is that a growing body of literature suggests that prolonged breast-feeding may be a risk factor for malnutrition. In a review of data from 19 demographic and health surveys, a meta analysis concluded that important differences in nutritional status associated with prolonged breast feeding without appropriate complementary feeding are observed throughout the developing world, and are unlikely due to confounding by socio-demographic characteristics, healthcare utilization or recent child illness.[14,16] In our study, the variable relating to breast-feeding reflects only the situation in the neonatal period. This narrows the scope of this variable as a risk factor in our study. None of the study subjects had history of absent breast-feeding. The details of breast-feeding practices during infancy might not be routinely recorded in the child health card. Therefore, the role of this variable in PEM in our study could be interpreted with caution.

The child with PEM is defined in Oman using NCHS standards. The mean birth weight of normal controls in the study was found to be 3.04, which is less than NCHS standards (3.23 kg for girls and 3.27 kg for boys). This indicates that the growth pattern of Omani children may be different from the NCHS standards. In addition, this supports the argument that nutrition programs need to adopt community nutrition interventions that aim resources at young children from families where LBW for age z-scores are found to cluster.[15] However, the observation on differences in growth pattern needs further studies for confirmation. The lower growth curve of the children also means that early identification of a child that may slip beyond the -2 SD line and designation as having PEM would be difficult. This early prediction will be possible by utilizing the results of the regression analysis. It is found that a child with LBW, especially with a higher birth order and with history of sibling under weight has a very high and significant probability of developing PEM.

In addition, we found that the age at which PEM is detected is between 10 and 18 months indicating that the problem corresponds to the period following the start of weaning. The findings of the PEM survey conducted in Oman in the year 1999 also suggested that age at detection of PEM coincides with the period of introducing supplementary foods.[17] Therefore, a strategy for a close monitoring and nutritional interventions in children with these risk factors in the first 2-years could prevent the development of PEM. Orozco et al[14] have reported a scale without anthropometric measurements, which can be used to identify low weight for age in children <5-year-old. This scale also included potential predictive variables such as LBW, delayed weaning, low weight of siblings and so forth.[14] The findings of this study are reflective of the actual situation in the community setting. A cross-sectional study on PEM from Dhakhiliya region where there is a higher prevalence of PEM also pointed to the role of LBW and higher birth order.[18] Although this indicates that the findings can be generalized, similar studies in other regions especially those with increased prevalence of PEM could help in a more specific strategy for that region. It is possible to develop a strategy for identifying high risk children for close monitoring of growth and preventive interventions as a step for prevention of PEM. This also provides scope for considering direct nutritional interventions in these cases.

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