International Journal of Research and Reports in Hematology

1(2): 58-63, 2018; Article no.IJR2H.45338

Interaction between Malnutrition and Severe Malaria among Children at the National Hospital of Niamey-Niger

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Authors' contributions

This work was carried out in collaboration between all authors. Authors IA, MD and MD participated in writing the manuscript and analysing the results. Authors MMA, SB and KM conducted the study. Author MML participated in writing the project and the manuscript. Authors RHL and DYH participated in the statistical analysis of the data. Author IML drafted the project, analysed the results and wrote the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJR2H/2018/45338
Editor(s):
(1) Dr. J.A. Olaniyi, Associate Professor, Department of Haematology, University of Ibadan, Ibadan, Nigeria.
Reviewers:
(1) Kojom Foko Loick Pradel, The University of Douala, Cameroon.
(2) Nejat Akar, TOBB University of Economics and Technology, Turkey.
(3) Ibama, Asiton-a Solomon, Federal University of Technology, Nigeria.
Complete Peer review History: http://www.sciencedomain.org/review-history/28120

Short Research Article

Received 29 September 2018
Accepted 16 December 2018
Published 04 January 2019

ABSTRACT

Summary: Problem: Malnutrition and malaria are responsible for high mortality rate in Niger. The interaction between malnutrition and malaria remains controversial.
Methodology: We analyzed the retrospective data (2014 and 2015) of malarious children referred to the pediatric departments of Niamey National Hospital. Malnutrition was assessed by measuring

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MUAC and weight-height index. The criteria for the severity of malaria are those defined by the World Health Organization (WHO) in 2015. The present study aimed at assessing the relative risk between malnutrition and the severity of malaria.

Results: Nine point thirty-four percent (91/974) of patients were malnourished, of which 38.46% (35/91) were severely malnourished and 61.54% (56/91) were moderately malnourished. Seventy-nine point twelve percent (72/91) of the malnourished had severe malaria compared with 20.88% (19/91) who had uncomplicated malaria (Odds Ratio = 0.7, p = 0.3). There is a statistically significant difference in parasite density between the two malnourished groups (p=0.02). Fourteen point twenty eight percent (5/35) of the malnourished had died of malaria (Odds Ratio = 1.6, p = 0.2). Forty percent (2/5) of the severely malnourished died of malaria, compared to 60% (3/5) of the moderately malnourished (Odds Ratio = 0.9, p = 0.6). The leading causes of death among malnourished people were severe anemia (80%) and shock (20%).

Conclusion: Global acute malnutrition is a factor of severity of malaria. There is no statistically significant difference in risk of malaria death between moderate malnourished and severe malnourished.

Keywords: Malaria; malnutrition; interaction; children; Niger.

1. INTRODUCTION

Malnutrition and malaria are among the main causes of mortality in sub-Saharan Africa [1]. Niger republic faces these two major challenges. On one side, it faces a recurring food crisis that mainly affects children under 5 years and on the other side, it is confronted with malaria, which is one of the main causes of hospitalization and death of children. Five million two hundred thousand (5 200 000) cases of malaria and 10.000 deaths were recurrent in 2015 [2]. About two million people are food insecure in 2017. The global acute malnutrition rate was 11.4% in 2016 and 13.9% in 2017 [2]. The rate of severe acute malnutrition is 1.9% while the critical threshold set by WHO is 2% [1]. Child mortality in Niger is one of the highest in the world. It is about 198/1000 [3]. This malnutrition leads to stunting, cognitive delay, vulnerability to diseases, a reduction in their productivity and finally a decrease in their life expectancy [4]. Low birth weight of the newborn and the risk of a pathology associated with malaria in the mother are the main consequences of malaria in pregnant women [5,6]. In children, malaria has a negative impact on their physical and cognitive performances through school absenteeism and brain damage during cerebral malaria attacks [7].

The relationship between malnutrition and malaria remains complex and controversial [7]. This problem is all the more difficult to elucidate, as in Niger, malnutrition and malaria occur most often concomitantly in children because during the food lean season (June, July) succeeds the season of high transmission of malaria (August, September, October) [8].

Several hypotheses have been established to explain the relationship between malnutrition and malaria: The first claims that malnutrition and malaria act synergistically. Indeed, previous studies suggest that malaria may increase the incidence and severity of malnutrition, while malnutrition may increase the risk of infection including malaria [8-9]. The second hypothesis defends an antagonistic effect between malnutrition and malaria. Indeed, some studies have shown that malnutrition would protect against severe forms of malaria as others have shown that malaria increases the risk of malnutrition [10]. Finally, the last hypothesis shows that malnutrition is not associated with malaria [11,12]. The divergence of results and lack of consensus on this point illustrate the complexity of the interaction between malaria and malnutrition [13]. There is a vicious circle between malaria and malnutrition [11] so that the question of their interaction remains.

It is in this context that we conducted a two-year retrospective study at Pediatric Services of the National Hospital of Niamey (HNN) to describe the interaction between malnutrition and severe malaria by calculating the relationship risk between the two affections.

2. METHODOLOGY

2.1 Type and Site of Study

This is a descriptive and retrospective two-year study (2014-2016), which aimed to describe the relationship between malnutrition and the severity of malaria. The study took place at the pediatric services of Niamey National Hospital (HNN).

2.2 The Study Population

The study population consisted of 974 children aged from 0 to 15 years, hospitalized in the pediatric services of HNN. All children included were confirmed infected with malaria parasites using Giemsa-stained thick smear findings.

2.3 Data Collection Tools

Data of children were documented using survey forms. These consisted in socio-demographic, clinic, nutritional and biological characteristics along with those on both malaria and malnutrition.

2.4 Variables Analyzed

The main factors studied are the severity of malaria and malnutrition. Severe malaria has been defined by the presence of at least one of the WHO criteria of severity [14]) which are: Coma (Glasgow less than 11 in adults and Blantyre less than 3 in children); prostration, repeated convulsions (≥ 2 / 24 h), jaundice (Bilirubin> 50 µmol / L (3 g / dl) with parasitaemia> 100,000 / µl), pulmonary edema, abnormal bleeding, shock, Metabolic acidosis (A base deficit of > 8 mEq / L or bicarbonate <15 mmol / L or lactate ≥ 5 mmol / L), hypoglycemia (<2.2 mmol / L), severe anemia (Hb ≤ 5 g / dl / Ht ≤ 15% with parasitaemia> 10,000 / µL in children under 12 years, (<7g / dl and <20% in adults) with parasitaemia> 10,000 P / µl), renal failure (Creatinine> 265 µmol / L (3 mg / dL) or urea> 20 mmol / L) and hyper-parasitaemia (> 10%) [15].

Malnutrition was characterized by MUAC (Mid Upper Arm Circumference) or weight-height index. A value less than 11 cm is interpreted as severe malnutrition while a value between 11 and 12.4 is interpreted as moderate malnutrition. In children less than six months of age, the body mass index (BMI) is calculated by dividing the child's weight (in kilograms) by his height squared (BMI = P / T2). It is interpreted as follows: If the weight-for-height ratio between 80 and 90% we have moderate malnutrition. If the weight-for-height ratio is less than 80%, we have severe malnutrition [14].

2.5 Statistical Analysis

The data was analyzed by EPI INFO version 7.3.0. The multivariate analysis was used to establish the associations between malaria and malnutrition. The odds ratio (OR) was used to determine the relationship between malnutrition and severe malaria. A *p* value less or equal to 5% is considered statistically significant.

3. RESULTS

3.1 Epidemiological Characteristics

Nine hundred and seventy four patients (974) infected with *Plasmodium falciparum* were included in the study. 83.06% (809) of the malaria cases were complicated. 9.34% (91/974) of the patients were malnourished. The mean age of the patients was 53.69 months (SD = 41.23; IC95%: [3; 168]). Male-to-female sex ratio was 1.28.

3.2 Clinical Features

Seventy-nine point twelve percent (72/91) of the malnourished had severe malaria (Odds Ratio = 0.7, *p* = 0.3). Seventy-four point twenty-nine percent (26/35) of the severely malnourished had severe malaria and only 25.71% (9/35) had uncomplicated malaria. Eighty-two point fourteen percent (46/56) of the moderately malnourished had severe malaria and only 17.86% (10/56) had uncomplicated malaria (Odds Ratio = 1.5, *p* = 0.4).

The main clinical manifestations of severe malaria among malnourished people were severe anemia (46.1%), cerebral malaria (7.6%) and digestive disorders (5.1%).

Fourteen point twenty eight percent (5/35) of the malnourished had died of malaria (Odds Ratio = 1.6, *p* = 0.2). Forty percent (2/5) of the severely malnourished died of malaria, compared to 60% (3/5) of the moderately malnourished (Odds Ratio = 1.9, *p* = 0.6). The leading causes of death among malnourished people were severe anemia (80%) and shock (20%).

3.3 Nutritional and Biological Characteristics

Thirty eight point forty six percent (35/91) of patients were severely malnourished and 61.54% (56/91) were moderately malnourished. The arithmetical mean of parasite density of the patients was 4947 P/µL. The arithmetical mean of parasite density in moderate

Table 1. Relationship between severe malaria and malnutrition

Nutritional	Malaria			
Nutritional	**Severe malaria**	**Uncomplicated malaria**	**Odds ratio**	**P***
Global malnutrition	79.12% (72 /91)	20.88% (19/91)	0.7	0.3
Severe malnutrition	74.29% (26/35)	25.71% (9/35)		
Moderated malnutrition	82.14% (46/56)	17.86% (10/56)	1.5	0.4
Nutritional	**Death**			
Global malnutrition	14.28% (5/35)		1.6	0.2
Severe malnutrition	40% (2/5)			
Moderated malnutrition	60% (3/5)		0.9	0.6

malnourished patients is 2880 P/µL (SD = 5905, 95% CI: [40, 20000]). The arithmetical mean of parasite density in severe malnutrition is 285 P/µL (SD = 460, 95% CI: [33,2000]). There is a statistically significant difference of parasite density between the two malnourished groups (P=0.02). The average hemoglobin was 7.7 g/dL. Twenty-one point tree percent (21.3%) of patients had a hemoglobin level less than 5 g /dL otherwise had severe anemia. The mean of hemoglobin is 7.6 g / dL in severely malnourished patients compared to 6.9 g / dL in moderate malnourished patients. There is no statistically significant difference in hemoglobin between the two groups (p = 0.3). The average blood glucose was 3.7 mmol/L. Twenty-eight point nine (28.9%) had blood glucose lower than 2.2 mmol/L. Table 1 summarizes the association between severe malaria and malnutrition.

4. DISCUSSION

This retrospective study describes the interaction between nutritional status and the severity of malaria in children referred to the pediatric departments of Niamey National Hospital. Nine hundred and seventy four (974) medical records were reviewed over a two-year period from January 2014 to December 2015.

This study shows that children with acute global malnutrition are more likely to have severe malaria. Indeed, 79.12% (72/91) of the malnourished had severe malaria compared to only 20.88% (19/91) who had uncomplicated malaria (Odds Ratio = 0.7, p = 0.3). This observation was frequently encountered in the literature [9,10,16] even though there were opposite hypotheses or those that found no association between malaria and malnutrition [17,11]. The study of the interaction between malnutrition and malaria is complex because of the multifactorial aspects of each of these two conditions. Consequently, due to many confounding factors, the assessment of the effect of malnutrition on malaria, and vice versa, requires the use of an appropriate methodology [13]. The immune system of malnourished children is weak and therefore less able to fight against infections in general and malaria in particular [18].

The lethality attributable to malaria is 14.28% (5/35) among malnourished people. There is no statistically significant difference in risk of death between moderate malnutrition and severe malnutrition. In fact, 60% (3/5) of the dead are moderately malnourished and 40% (2/5) of the dead are severely malnourished.

This study shows that 38.4% (35/91) of our study population are severely malnourished and 61.54% (56/91) are moderately malnourished. Malnutrition and malaria are two major burdens in the sub-saharian countries [19]. Indeed, 5.9 million children suffer from severe acute malnutrition worldwide [20] of which nearly 3 million children under five die each year [18] and 70% of malnourished live in the three countries of Sahel: Mali, Niger and Chad [20]. In Niger, 2 to 2.5 million people were food insecure in 2017. The global acute malnutrition rate was 13.9% in 2017 [2]. The rate of severe acute malnutrition was 1.9% [1]. Infant and child mortality is 198/1000 [3] and one of the highest in the world.

The main limitations of the study are: (I) it is a retrospective design and (II) the absence of taking into account many confounders of the relation between malaria and malnutrition such as use of preventive methods (Having a bed net, a suit house or an big out income), because malnutrition and malaria are governed by many social, epidemiological, biological and economic determinants [21]. Alternatives such as "cash for work" or "unconditional cash transfer" have been proposed to relieve poor families where malnourished people are most often found [22]. The most sustainable approach is the

establishment of moderate malnutrition recovery centers (CRENAM) and recovery centers for severe malnutrition (CRENIS).

5. CONCLUSION

Malnutrition and malaria are major causes of death among children in sub-Saharian countries. Global acute malnutrition is a factor of severity of malaria. Moderate and severe malnutrition recovery centers must be established for prevention.

CONSENT AND ETHICAL APPROVAL

As per university standard guideline participant consent and ethical approval has been collected and preserved by the authors.

FUNDING

This study is included in the list of doctoral thesis topics of the Faculty of Health Sciences of Abdou Moumouni University of Niamey for the 2016-2017 financial year.

ACKNOWLEDGEMENTS

We thank Dr. Jean Testa, Scientific Director of CERMES for reading and editing the manuscript.

COMPETING INTERESTS

The authors declare that there is no conflict of interest.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/28120