Prevalence and Factors Associated with Rickets-like Bone Deformities in Rural Cameroon: A Cross-Sectional Study of Children in M'mockmbie Village in the southwest region

Abstract

Background: Rickets remains a significant public health concern in resource-limited settings, causing bone deformities through impaired mineralization. While traditionally linked to vitamin D deficiency, calcium deficiency appears predominant in Sub-Saharan Africa (SSA). Nevertheless, studies have not examined rickets-like bone deformities (RLBD) in rural Cameroon. This study assessed RLBD prevalence and associated factors in M'mockmbie village, in the southwest region of Cameroon.

Methodology: We conducted a community-based cross-sectional study from October 2021 to July 2022, employing a multi-step stratified random sampling technique across M'mockmbie's 12 quarters. The study population comprised children aged 6 months to 16 years (n=455). Data collection included sociodemographic, nutritional status, vaccination history, and clinical features of RLBD. Statistical analysis used Epi-Info version 7.2.5.0, with multivariate logistic regression to identify factors associated with RLBD ($p \leq 0.05$ significance).

Results: From the 455 children included, the study revealed a 12.31% RLBD prevalence, predominantly knock-knee deformities (60.71%). Most cases (76.79%) manifested by age 2. Significant associations emerged with incomplete vaccination (aOR=2.78, p=0.033), poor nutrition (aOR=0.57, p=0.025), parental loss (aOR=0.36, p=0.033), and family history of RLBD (aOR=0.31, p=0.017). Nutritional data revealed 58.9% of children experienced food insecurity, with 91.7% consuming carbohydrate-dominated diets and only 6.2% regularly consuming protein-rich foods. Healthcare-seeking behaviour showed 42.9% visited hospitals for deformities, while 25.0% used self-medication.

Conclusion: The high RLBD burden in M'mockmbie reflects intersecting nutritional and healthcare access challenges. Our findings highlight the critical need for integrated interventions addressing childhood malnutrition, complete vaccination coverage, and targeted screening for at-risk families. The predominance of early-onset cases suggests vulnerability during critical growth periods, warranting focused prevention strategies.

Keywords: Rickets, bone deformities, malnutrition, vaccination, M'mockmbie, Cameroon

Introduction

Rickets is a childhood disorder of bone mineralization at the growth plate, usually caused by inadequate concentrations of extra-cellular calcium or phosphate. The delay in or failure of endochondral ossification leads to deformation of the growth plate, the development of bone deformities and a reduction in linear growth (1). Children with bone deformities may be severely disabled, have increased morbidity and decreased quality of life. The burden is currently greatest and the public health impact most substantial in developing countries, where crippling deformities reduce physical capacity and drain economic prospects (2).

The global health community recognizes nutritional rickets and associated vitamin D/calcium deficiencies as entirely preventable public health problems (3). Concern has been expressed about the rising incidence of rickets with its associated long-term sequelae in children globally (4). Low dietary calcium intakes and poor vitamin D status are common findings in children living in developing countries. Despite many of the countries lying within the tropics and subtropics, overcrowding, atmospheric pollution, a lack of vitamin D-fortified foods, and social customs that limit skin exposure to sunlight are major factors in the development of vitamin D deficiency. Low dietary calcium intakes are typically observed as a consequence of a diet limited in dairy products and high in phytates and oxalates, which reduce calcium bioavailability (5).

Rickets is most commonly caused by vitamin D deficiency, although rickets in Sub-Saharan Africa (SSA), India and Bangladesh has been reported in children with a biochemical profile that does not suggest vitamin D deficiency but who may have calcium deficiency (6). Nutritional rickets results from inadequate vitamin D and/or calcium nutrition resulting to bone weakness and bending because both nutrients are essential for bones to become mineralized. The bending of bones is most prominent in the legs, manifest as bowleg or knock-knee deformities. Global consensus recommendations for the treatment and prevention of nutritional rickets have been recently published (7).

Cameroon's rural communities, including M'mockmbie village in the Southwest Region, face heightened vulnerability due to ongoing socioeconomic crises that exacerbate malnutrition and limit healthcare access. This study was designed to determine the prevalence of rickets-like bone deformities and identify factors associated with rickets-like bone deformities (RLBD) in the M'mockmbie village in children aged between 6months and 16 years.

Methodology

Study design, period and setting

We conducted a community-based cross-sectional study in M'mockmbie village, located in the Alou subdivision of Cameroon's Southwest region. The study was implemented from October 2021 to July 2022. The village was selected due to anecdotal reports of high bone deformity prevalence, and exacerbated malnutrition from ongoing regional crises. M'mockmbie comprises 12 quarters with an estimated population of 3,080 (2021), predominantly engaged in subsistence farming.

Study population and sampling procedure

The study population was made up of children aged 6 months to 16 years in M'mockmbie village. Children with trauma-related deformities and cases where parents/guardians declined consent were excluded from our study.

Using Epi-Info version 7.2.5.0, we calculated a minimum sample size of 180 based on the prevalence of rickets-like bone deformities of 5.7% from a study done in a rural region of West Africa in 2007 (1), 95% confidence level, 5% margin of error and design effect of 2 for cluster sampling. We employed multi-stage stratified random sampling by 1) dividing the village into 12 quarter-based clusters, 2) mapping households using Google Earth's "My Position" function, 3) randomly selected 8 households per cluster and 4) enrolling all eligible children per household.

Data collection procedures

The data collection tools were pretested in a sample of 5 children aged 6 months to 16 years in Bangou village. A total of thirty (30) surveyors were recruited, trained and then divided into ten (10) teams, each made up of three (3) members headed by a supervisor. In each quarter, the administrative authority (quarter head) was sought for authorization to have access to households. The questionnaire covered: section A: Sociodemographic (age, parental education, occupation), section B: RLBD prevalence and characteristics, section C: Nutritional status (breastfeeding history, dietary patterns) and section D: Risk factors (vaccination status, sunlight exposure, family history).

Data analysis

Data were cleaned and analyzed in Epi-Info version 7.2.5.0. Descriptive statistics, including frequencies and proportions, were used to summarize participant characteristics and outcome measures. With a statistically significant threshold set at p-value≤0.05, Multivariate logistic regression was used to identify factors associated with RLBD and selected covariates.

Ethical considerations

The study protocol was approved by the Faculty of Medicine and Pharmaceutical Sciences, University of Dschang and the South-west Regional Ethics Committee. Also, an administrative authorization was

obtained from the chief medical officer of Alou. All participants provided written informed consent through parents/guardians. Data were anonymized using coded identifiers.

Results

Among the 480 children aged 06 months to 16 years reached, 455 completed the interview (response rate of 94.8%) with 25 excluded (figure 01).

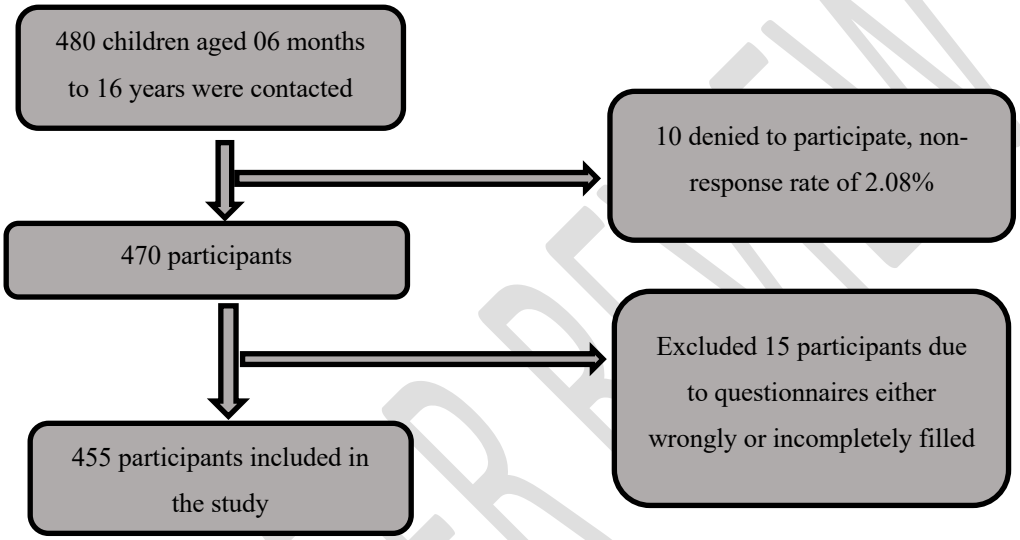

Figure 1: Flowchart of inclusion

Socio-demographic characteristics of the participants

The study included 455 children aged 6 months to 16 years, with a median age of 10 years. Most children (78.84%) had both parents alive. Parental education levels were predominantly primary (39.02%), with only 4.88% attaining higher education. Most parents (93.83%) worked had unskilled occupations, and nearly all participants (93.35%) identified as Christian (Table 01).

Table 1: Socio-demographic characteristics of participants

Variables	**Frequency**	**Percent (%)**
Parents/Guardians (head of family) level of education		
Never schooled	90	19.96
Primary	176	39.02
Secondary	163	36.14
Tertiary	22	4.88
Occupation of parents/guardians (head of family)		
Skilled	28	6.17

Unskilled	426	93.83
Religion		
Christian	421	93.35
Muslim	28	6.21
Atheist	1	0.22
Animist	1	0.22
State of parents		
Both alive	354	78.84
One alive	82	18.26
Both dead	13	2.90

Prevalence of Rickets-Like Bone Deformities (RLBD)

The prevalence of RLBD among the study population was 12.31% (56 out of 455 children). Knock-knee deformities were the most common (60.71%), followed by bowlegs (26.79%) and other deformities (12.5%). Most cases (76.79%) were first noticed by age 2. Regarding healthcare-seeking behaviour, 42.86% of parents took their children to a hospital upon noticing deformities, while 25% resorted to self-medication. Among those who sought treatment, 60.71% reported partial resolution of deformities, 30.36% saw no change, and 8.92% experienced worsening conditions (Table 02).

Table 2: Prevalence of RLBD in our study population

Variables	**Frequency**	**Percent (%)**
Presence of RLBD		
Yes	56	12.31
No	399	87.69
Age when the deformity was noticed (years)		
1	8	14.29
2	43	76.79
3	5	8.93
Nature of deformity		
Bow leg	15	26.79
Knocked knee	34	60.71
Others	7	12.5

Actions taken after noticing deformity		
Auto medication	14	25.0
Went to the hospital	24	42.86
Went to a traditional doctor	7	12.5
Nothing	11	19.64
Evolution of the deformity after actions taken		
Unchanged	17	30.36
Partially resolved	34	60.71
Became worse	5	8.93

Nutritional Status of Participants

Most children (95.82%) were breastfed for at least one year. However, dietary patterns revealed significant deficiencies: only 6.15% regularly consumed protein-rich foods, while 91.65% relied on carbohydrate-dominated diets. Food insecurity was prevalent, with 58.9% of children never eating to satisfaction, and 48.24% consuming fewer than two meals per day. Household income further highlighted economic challenges, with 47.67% of families earning less than 25,000 Francs CFA monthly (Table 03).

Table 3: Evaluation of nutritional status of our study population

Variables	**Frequency (T=455)**	**Percent (%)**
Breastmilk received for at least a year		
Yes	436	95.82
No	19	4.18
Diary product consumption		
At least once a month	163	35,90
At least once a week	86	18.94
At least once in six months	128	28.19
Others	78	16.96
Eating till satisfaction		
Never	268	58.90
Only at the beginning of the month	78	17.14
two times a week	81	17.76
Often	28	6.15
The number of times eating is done per day		
Less than 2	219	48.24
Between 2 to 3	178	39.26
Greater than 3	58	12.58

Types/classes of food consumed the most		
Carbohydras	417	91,65
Lipids	1	0.22
Proteins	28	6.15
Vegetables	9	1.98
Average monthly revenue of the family		
Less than 25000 Frs CFA	215	47.67
Between 25000 Frs CFA and 50000 Frs CFA	133	29.49
Above 50000 Frs CFA	75	16.63
Others (varying per months)	28	6.21
Number of children aged 06 months to 16 years in the house		
Less than 5	140	30.84
Between 5 and 10	306	67.40
Between 10 and 15	7	1.54
Greater than 15	1	0.22

Factors associated with RLBD

Following bivariate logistic regression (Table 04), the following factors were identified for the multivariate logistic regression: vaccination [3.68 [1.70- 7.99] P- value <0.001], state of parents [(0.55 [0.25- 1.20]), P -value 0.028], relative with a similar problem [0.31 [0,17- 0.54], P-value <0.001], parental level of education [0.50 [0.26-0.96] P-value0.035], antenatal ca(ANC) visits [0,31 [0.17-0.59], P-value <0.001] and poor nutrition [0.58 [0.39-0.85], P-value 0.005].

Table 4: Bivariate analysis between covariates and RLBD

	Rickets-like bone deformities (RLBD)			
Variables	Yes (%)	No (%)	cOR [95%CI]	P-value
Received breastmilk (At least one year)				
Yes	54 (12.84)	380(87.16)	0,04 [0,02-1,78]	0.095
No	2(3.00)	17(97.00)		
At least one parent alive				
Yes	8(7,92)	93(92,08)	0.55 [0.25- 1.20]	0.028*
No	48(13.56)	306(86.44)		
Incomplete vaccines				
Yes	8(5.03)	151(94.97)	3.68 [1.70- 7.99]	<0.001*
No	48(16,33)	246 (83.67)		
Area exposed to sunlight				
Yes	22(11.76)	165(88.24)	0.90 [0.51- 1.60]	0,723
No	34(12.88)	230(87.12)		
Caesarian section				
Yes	3(30.00)	7(70.00)	0.32 [0.08- 1.27]	0,088
No	53(12.05)	387(87.95)		

First degree relative with a similar problem				
Yes	25(24.04)	79(75.96)	0.31 [0,17- 0.54]	<0.001*
No	31(8.83)	320(91.17)		
ANC done during pregnancy				
Yes	14(6.36)	206(93.64)	0.31 [0.17- 0.59]	<0.001*
No	42(17.87)	193(82.13)		
Occupation of parents/guardians (head of family)				
Yes	3(10.71)	25(89.29)	1.18 [0.35- 4.06]	0.787
No	53(12.44)	373(87.56)		
Poor nutrition (carbohydrates only)				
Yes	52(12.47)	365(87.53)	0.58 [0.39-0.85]	0.005*
No	4(10.81)	33(89.19)		
Members of household occupants (> 5)				
Yes	54(12.74)	370(87.26)	0.47 [0.11-2.03]	0.303
No	2(6.45)	29(93.55)		
Average monthly revenue (Less than 25000 Frs CFA)				
Yes	11(14.67)	64(85.33)	0.78 [0.35-1.73]	0.538
No	19(11.80)	142(88.22)		
Educational level of parents (Did not schooled)				
Yes	43(14.78)	248(85.22)	0.50 [0.26-0.96]	0.035*
No	13(7.98)	150(92.02)		

cOR=Crude Odd Ratio, **CI**=Confidence Interval, ***= Factors that were statistically significant

To control confounders, the multivariate regression analysis included factors that were statistically significant from the bivariate logistic regression. Factors significantly associated with RLBD included: children with incomplete vaccinations were 2.78 times more likely to develop RLBD (aOR = 2.78, p = 0.033), children who had atleast one parent alive were less susceptible to RLBD (aOR = 0.36, p = 0.033). Furthermore, a first-degree relative with RLBD increased the likelihood of developing the condition (aOR = 0.31, p = 0.017), and children with inadequate nutrition were more prone to RLBD (aOR = 0.57, p = 0.025)

Table 5: Multivariate analysis of factors associated with RLBD

Variables	**Rickets-like bone deformities**	
	aOR [95%CI]	P-value
Incomplete vaccines (yes/no)	2.78 [1.08 -7.15]	0.033*
State of parents (atleast one parent alive) (yes/no)	0.36 [0.14- 0.91]	0.033*

Mode of delivery (caesarian section) (yes/no)	0.75 [0.16-3.50]	0.719
First degree relative with similar problem (yes/no)	0.31 [0.17- 0.54]	0.017*
Parents' level of education (never schooled /schooled)	1.67 [0.31- 8.87]	0.546
ANC done during this pregnancy (Yes/No)	0.80 [0.36-1.77]	0.584
Poor nutrition (carbohydrates only) (yes/no)	0.57 [0.39-0.89]	0.025*

aOR=Adjusted Odd Ratio, CI=Confidence Interval *= Factors found to be statistically significant

Discussion

This study aimed to assess the prevalence and associated factors of rickets-like bone deformities (RLBD) among children aged 6 months to 16 years in M'mockmbie village, Cameroon. The findings revealed a high prevalence of RLBD (12.31%), with knock-knee deformities being the most common (60.71%). Most cases (76.79%) were identified by age 2, highlighting early childhood as a critical period for disease manifestation. Key risk factors included incomplete vaccination, parental loss, family history of RLBD, and poor nutrition.

The observed prevalence of 12.31% aligns with findings from rural Northern China (13%) (8) but was notably higher than the 5.7% reported in rural Gambia (1). This increase may be because M'mockmbie is found in a region which has been under internal crisis since 2016. This crisis may have exacerbated malnutrition and limited healthcare access. We noted from this study that the majority (76.79%) RLBD was noticed at the age of 2 years. This finding was similar to that of *Mejı́a-Guevar et al (*2019) in which 2years (71.26%) was the year in which rickets was noticed most

The predominance of knock-knee deformities (60.71%) is consistent with a Gambian study (1), suggesting shared etiological factors such as calcium deficiency in Sub-Saharan Africa. Healthcare-seeking behaviour in M'mockmbie differed from other regions, with 42.86% of parents visiting hospitals for deformities, contrasting with studies in Northern Nigeria (41.2% traditional healers) ( ) and Kenya (51.3% self-medication) (11). This may reflect Cameroon's relatively accessible healthcare infrastructure, including the presence of an integrated health centre in the village. However, the partial resolution of deformities in 60.71% of cases underscores the need for improved treatment protocols. The study revealed severe dietary deficiencies, with 91.65% of children consuming carbohydrate-dominated diets and only 6.15% regularly eating protein-rich foods. These findings mirror reports from

the U.S. on immigrant populations (12) but contrast with Kenyan data showing higher protein consumption (13). The high prevalence of food insecurity (58.9%) and low household income (47.67% earning <25,000 CFA/month) highlight the economic constraints contributing to malnutrition.

Children with incomplete vaccinations were 2.78 times more likely to develop RLBD (p = 0.033), corroborating studies from Kuwait (14) and Ghana ( ). This association may reflect increased susceptibility to infections and subsequent malnutrition in unvaccinated children (11). Orphaned children were more vulnerable to RLBD (aOR = 0.36, p = 0.033), consistent with findings from Congo ( ). The loss of caregivers likely exacerbates food insecurity and reduces access to healthcare. A first-degree relative with RLBD significantly increased risk (aOR = 0.31, p = 0.017), supporting genetic or shared environmental influences, as suggested in Gambian studies (2) but differ with a study carried out in Yemen (16) who reported no association between parents or relatives having deformity and their children having it. This association is suggestive of the implication of genetic factors which may be further investigated. Inadequate dietary quality was strongly linked to RLBD (aOR = 0.57, p = 0.025), aligning with research from Kuwait (17) but diverging from Gambian data (1). The reliance on carbohydrate-rich, nutrient-poor diets underscores the need for targeted nutritional interventions.

Strengths and limitations of the study

The study's community-based design and stratified sampling enhance its representativeness, while multivariate analysis strengthens the validity of identified risk factors. Several limitations should be considered when interpreting these findings. The cross-sectional design precludes the establishment of causal relationships between identified risk factors and RLBD outcomes. Recall bias remains possible for historical variables like dietary patterns and vaccination history, particularly given the reliance on parental reporting. The study's focus on children aged 6 months to 16 years excludes potential late-onset cases that might manifest in early adulthood. The study did not assess genetic contributors to RLBD, which could interact with the identified nutritional and socioeconomic factors. Future research should employ longitudinal designs to establish causal pathways and evaluate intervention effectiveness, while incorporating biochemical and radiographic measures to refine case identification.

Conclusion

This study reveals a significant burden of rickets-like bone deformities (12.3%) among children in rural M'mockmbie, Cameroon, with most cases emerging by the age of two years. The findings

highlight incomplete vaccination, parental loss, family history of RLBD, and poor nutrition as the factors associated with RLBD. The predominance of knock-knee deformities and early age of onset underscore the window for intervention during infancy and early childhood. These results call for integrated public health strategies combining nutritional supplementation (particularly calcium and vitamin D), complete immunization coverage, and targeted screening for high-risk families in rural Cameroonian communities. By addressing the intersecting nutritional and healthcare access challenges documented in this study, policymakers and health practitioners can substantially reduce the disability burden associated with RLBD in resource-limited settings like M'mockmbie.

References

1. Jones HL, Jammeh L, Owens S, Fulford AJ, Moore SE, Pettifor JM, et al. Prevalence of rickets-like bone deformities in rural Gambian children. Bone. 2015 Aug;77:1–5.

2. Braithwaite V, Jarjou LMA, Goldberg GR, Jones H, Pettifor JM, Prentice A. Follow-up study of Gambian children with rickets-like bone deformities and elevated plasma FGF23: possible aetiological factors. Bone. 2012 Jan;50(1):218–25.

3. Munns CF, Shaw N, Kiely M, Specker BL, Thacher TD, Ozono K, et al. Global Consensus Recommendations on Prevention and Management of Nutritional Rickets. J Clin Endocrinol Metab. 2016 Feb;101(2):394–415.

4. Pettifor JM. Screening for nutritional rickets in a community. J Steroid Biochem Mol Biol. 2016 Nov;164:139–44.

5. Pettifor JM. Calcium and vitamin D metabolism in children in developing countries. Ann Nutr Metab. 2014;64 Suppl 2:15–22.

6. Ahmed S, Goldberg GR, Raqib R, Roy SK, Haque S, Braithwaite VS, et al. Aetiology of nutritional rickets in rural Bangladeshi children. Bone. 2020 Jul;136:115357.

7. Thacher TD, Pludowski P, Shaw NJ, Mughal MZ, Munns CF, Högler W. Nutritional rickets in immigrant and refugee children. Public Health Reviews [Internet]. 2016 Jul 22 [cited 2021 Sep 3];37(1):3. Available from: https://doi.org/10.1186/s40985-016-0018-3

8. Strand MA, Perry J, Jin M, Tracer DP, Fischer PR, Zhang P, et al. Diagnosis of rickets and reassessment of prevalence among rural children in northern China. Pediatr Int. 2007 Apr;49(2):202–9.

9. Mejía-Guevara I, Zuo W, Bendavid E, Li N, Tuljapurkar S. Age distribution, trends, and forecasts of under-5 mortality in 31 sub-Saharan African countries: A modeling study. PLoS Med. 2019 Mar;16(3):e1002757.

10. Misra M, Pacaud D, Petryk A, Collett-Solberg PF, Kappy M, Drug and Therapeutics Committee of the Lawson Wilkins Pediatric Endocrine Society. Vitamin D deficiency in children and its

management: review of current knowledge and recommendations. Pediatrics. 2008 Aug;122(2):398–417.

11. Ngari MM, Thitiri J, Mwalekwa L, Timbwa M, Iversen PO, Fegan GW, et al. The impact of rickets on growth and morbidity during recovery among children with complicated severe acute malnutrition in Kenya: A cohort study. Matern Child Nutr. 2018 Apr;14(2):e12569.

12. Gonzalez RM, Gilleskie D. Infant Mortality Rate as a Measure of a Country's Health: A Robust Method to Improve Reliability and Comparability. Demography. 2017 Apr;54(2):701–20.

13. Karuri SW, Murithi MK, Irimu G, English M. Using data from a multi-hospital clinical network to explore prevalence of pediatric rickets in Kenya. Wellcome Open Res [Internet]. 2017 Nov 1 [cited 2021 Oct 25];2:64. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5629544/

14. Molla AM, Badawi MH, Al-Yaish S, Sharma P, El-Salam RS. Risk factors for nutritional rickets among children in Kuwait. Pediatrics International [Internet]. 2000 [cited 2021 Sep 8];42(3):280–4. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1046/j.1442-200x.2000.01230.x

15. Keskin M, Savaş-Erdeve Ş, Sağsak E, Çetinkaya S, Aycan Z. Risk factors affecting the development of nephrocalcinosis, the most common complication of hypophosphatemic rickets. J Pediatr Endocrinol Metab. 2015 Nov 1;28(11–12):1333–7.

16. Zegeye B, Shibre G, Haidar J, Lemma G. Socioeconomic, urban-rural and sex-based inequality in infant mortality rate: evidence from 2013 Yemen demographic and health survey. Arch Public Health. 2021 Apr 29;79(1):64.

17. Ahrens KA, Rossen LM, Thoma ME, Warner M, Simon AE. Birth Order and Injury-Related Infant Mortality in the U.S. Am J Prev Med [Internet]. 2017 Oct [cited 2022 Jun 12];53(4):412–20. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5697982/