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Socio-economic determinants of mortality among children aged 0–10 years in Béré, Chad

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Abstract
Child mortality is a key indicator of child health worldwide. Chad has one of the highest African child mortality rates. The absence of updated and accurate health records in rural Chadian regions such as Béré, due to decades of armed conflicts and deficient administrative infrastructure, hinders the development of customized health interventions by non-governmental entities such as Project 21, a community health program in Béré. This study aims to gain a better understanding of the sociodemographic context and mortality of children in Béré. We report on a cross-sectional study completed by trained community health workers using a survey questionnaire targeting sociodemographic factors, child mortality, and sources of health advice, all known determinants of child health. Descriptive, linear regression and odds ratio analyses were performed on data collected from 517 respondents. Most household heads are Nangtchéré Christian male farmers aged 30–59 years old, with primary or secondary level education. Infant mortality rate and risk are the highest. Child mortality is predicted by household children number ($B = 0.876$; $r = 0.44$; $p < .001$). Child mortality risk is affected by child age and gender, household location, family structure and reception of traditional birth assistants (TBAs) health advice. Infant mortality risk is the worst in Béré-Mouraye [OR = 5.073 (1.047–24.57)] for males. Receiving health advice from TBAs reduces female infant mortality risk [OR = 0.255 (0.065–0.997)]. These findings confirm a role for sociodemographic factors in child mortality in Béré and provide baseline data to plan future health interventions.

Significance
Chad has been listed as one of the poorest countries globally and has some of the worst health indicators, including neonatal, infant, and child mortality rates, which are among the highest rates globally. The most elevated rates of child mortality are found in the Southern region of Chad, which includes the rural city of Béré. However, risk factors for child mortality in Béré have not been studied and reported. This study is the first to report information on the sociodemographic determinants of the population in Béré, their characteristics in each quartier, and their connection to child mortality.

Keywords Rural health · Child mortality · Community health workers · Low-income children health issues

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1 Introduction

Child mortality is a key indicator of child health worldwide. An estimated 4.9 million children born alive worldwide died before being five years old [1]. While global child mortality declined by sixty percent between 1990 and 2022 despite an increase in the number of livebirths, many children deaths are still preventable [1]. The current Sustainable Development Goal's target for global child mortality is to end preventable deaths of newborn and children under five years old by 2030, with countries aiming to reduce under-five mortality to at least 25 deaths/ 1000 live births by that year [2].

Chad, a country located in Central Africa in the Sub-Saharan region has consistently experienced civil strife and subsequent poverty for decades and shows poor health indicators [3–5]. Although the total fertility rate seems high (6 live births per woman), the neonatal, infant, and child under-five mortality rates (32 deaths/1000 live births, 64 deaths/1000 live births, 103 deaths/1000 live births, respectively) are among the highest rates worldwide, and thus of concern [6, 7]. Poverty is mainly a problem in rural areas, with noticeable inter- and intra-regional disparities, resulting in inequalities in life expectancy, life education, and income [5, 8]. School attendance, an influencer of child mortality is also of concern. Generally, children in Chad attend school around the age of 6 years old to 11 years old. Unfortunately, half of these children do not attend school and are engaged in work either at the limit or beyond the authorized activities [9]. These data suggest issues in child mortality, school attendance, and work practices.

The highest rates of child mortality are found in the Southern region of Chad, which includes the area of Tandjilé, and the rural city of Béré. A previous study using data from the 2014–15 Chad's Demographic and Health Survey reported that child mortality risk was higher in children born of Baguirmi mothers (from South-Central Chad and located North of Béré), from mothers without education, for male children under five years old, and first rank children [9, 10]. However, recent and accurate official records on child mortality for rural locations such as Béré, a city 258 miles Southeast of N'Djamena, the capital of Chad, are not available due to decades of civil strife and resulting poverty and deficient administrative infrastructure. Also, access to official hospitals or clinics is very difficult in these rural locations, compromising regular collection of health data. Non-governmental organizations and international institutions with medical resources are the main providers of healthcare and health interventions in rural locations such as Béré. Project 21, a community health project named after the twenty-one quartiers (neighborhoods) of Béré promotes health in the rural city by targeting four main topics: community health education, midwife training with traditional birth attendants (TBAs), community health worker (CHW) training, and a dental clinic.

While Project 21 can provide health education in the quartiers, plans for focused long-term health programs in Béré have been halted due to a lack of information. Up-to-date and reliable official health data for the population in Béré are not available because of sustained civil armed conflicts, and subsequent poverty and lack of official health records. Therefore, this study aims to provide baseline data for Béré and a better understanding of the sociodemographic context and mortality of children through the administration of a survey targeting sociodemographic factors, child mortality, and sources of health advice, all known determinants of child health. This study provides valuable information and direction for the planning of future interventions targeting child mortality in Béré.

2 Methods

2.1 Study setting and design

Project 21, through the assistance of trained CHWs and personnel, conducted a community-based cross-sectional study in the twenty-one quartiers of the city of Béré, a 27 square miles rural location with negligible administrative infrastructure, relying predominantly on rice agriculture and farming, located in the Béré District, in the Tandjilé area, 258 miles Southeast of N'Djamena, the capital of Chad. The rural location of Béré combined with a lack of administrative infrastructure fueled by years of sustained conflict in Chad, make it very challenging to obtain complete and reliable official data on Béré's population, economy and other characteristics of the town. Since Project 21 aims to carry out focused health interventions in Béré and data on the population in Béré is lacking, quartier residents were considered the priority population for the study to directly gather relevant population data. Village chiefs were also involved during the planning and preparation of the study for cultural fluency and easier facilitation of the survey.

2.2 Survey respondents

Following cultural standards, the survey was administered to household heads since children were too young to be interviewed and official administrative records were not readily available or lacked information. Household heads who were surveyed are designated as "respondents" in the study. Respondents included all genders, ethnicities, religious and socio-economic backgrounds and individuals of eighteen years minimum age. Individuals below eighteen years old, who were not the household head nor recommended by the household head, mentally unsound or unable to give consent, and who lived less than one year in the household were excluded from participating in the survey.

One family unit was defined as one husband, wife/wives, and children, or one adult (at least eighteen years old) either male or female and children, or one single adult (at least eighteen years old). A household was defined as a group of persons who shared the same kitchen or hearth, or a group of persons who eat from the same cooking pot/kitchen. Households could be made of a nuclear family or a combination of co-habiting families (multi-family household). To promote good standards of sampling, only one family per multi-family household was interviewed. Respondents answered questions about all the children in their household, from birth age to ten years old, as directed by survey questions.

2.3 Sample size calculation

The sample size was determined with the standard commonly used sample size PASS software for a cross-sectional study (https://www.ncss.com/software/pass/), taking into consideration the expected malaria prevalence in children. In Chad, malaria is the main cause of mortality, with children under five years old being the most affected, at a proportion of 41% [11]. The parameters used for sample size determination were the commonly used power of 80% (0.8), desired precision of 5%, and 95% confidence interval. With this selection of parameters, an estimated mean household size of 7, and with children younger than ten years old comprising 39% of the population, the minimum sample size needed to guarantee statistical power for the study was a total of 400 households [12]. However, to boost the statistical power of the study, the sample size was increased to 517 households.

2.4 Data collection

Respondents' houses were chosen using the simple random sampling method and promoted sample diversity. Using a map of the city, residential houses were numbered, and house numbers randomly selected using an online tool (www.randomizer.org). If the household head of the family was not present, permission was requested to interview the next adult in charge. In a case where adults were absent, the houses were revisited at a time when they were at home.

The survey tool used in the study was a questionnaire based on previously validated questionnaires that targeted demographics, child school attendance and child mortality by age group and gender, and the source of health information received within the last twelve months [9, 13–20]. The questionnaire was developed in English, translated to French and administered in French. Qualified Project 21 trainers trained local CHWs based on World Health Organization guidelines and protocols for teaching and conducting survey data collection. Training to administer the survey using the French questionnaire lasted for approximately two weeks until CHWs had a good command of the questionnaire and interviewing process, and could also translate the questionnaire into local languages, if needed. Each CHW received hands-on training from Project 21 trainers by administering the survey to each other and participating in survey pilot events in Béré's community under the supervision of the trainers. The CHWs who collected the data were recruited from a pool of CHWs previously trained by Project 21 professionals for health programs, and who had good job performance and efficient interactions with residents.

The data was collected during household visits through face-to-face interviews using the questionnaire and direct observations such as house standard. Following the cultural context, house standards were indicators of economic status, with houses of high standard defined as having an external wall in good standing, houses of medium standard as having an external wall with some damage, and houses of low standard as having a very damaged or no external wall. The questionnaires were administered to respondents by trained CHWs in or close to their quartiers of residence to promote cultural fluency, social interactions, and income security while collecting surveys.

2.5 Variables included in the study

The dependent variable in the study was child mortality. Since accurate and up-to-date official records were not available from official sites due to decades of civil strife, child mortality data within the last twelve months was recorded during the survey of household respondents. The respondents were asked about the number of child death occurrences for each age group within the last twelve months in their household, and the gender of the child for each mortality case. The mortality of children aged five years old to ten years old was also investigated in this study because (1) the consequences of Chadian warfare and poverty on health also extend to children aged 5 years old and older in Béré; (2) previous observations from Project 21 personnel revealed that children five years old and older also experience mortality; (3) factors affecting the mortality of children five years old and older in Béré are unknown and related peer-reviewed publications are severely lacking, making the planning of health interventions for these age groups very challenging; and (4) these findings will help to address the absence of accurate and up-to-date official mortality data for all children age groups in Béré.

Additionally, the study included independent sociodemographic variables related to children and respondents. Data for the independent variables were gathered through respondents' survey using the questionnaire. Household respondents were asked about their gender, age group, ethnic and religious affiliations, education level (as per Chadian education system levels), household head gender, household location and type, number of household members and their primary and secondary professions, house components, number of children in their household per age group, the children's gender and school attendance, and whether they received health advice from TBAs and/or CHWs within the last twelve months. Observations on the house standard, presence of an external wall and its state were also recorded by CHWs for indications on household economic status. Since the study targeted sociodemographic factors (which include age and education), the age groups used in the study were defined by taking into consideration established pediatric and Centers for Disease Control and Prevention (CDC) age categories and the stages of education in Chad: infant (< 12 months old), toddler (12 to 35 months old), preschool (3 to 5 years old), and primary school-aged children (6 to 10 years old) [21–23].

2.6 Human subject protection

Protection of personal information collected during the survey was done through anonymous participation and data recording. To respect the rights of individuals to participate or not in the survey, a verbal consent statement was read to every individual to obtain their informed consent prior to taking part in the survey. IRB authorization was also obtained (IRB approval #5150151) and the IRB ethical guidelines followed when carrying out the survey and handling resulting data.

2.7 Data analysis

Following data collection, each questionnaire was checked by Project 21 trainers for completeness, clarity and logical consistency. Each questionnaire was subsequently double-checked by qualified Project 21 personnel before data entry. Once the questionnaires were cleared for entry, the data collected was entered, processed and analyzed as a dataset using SPSS version 27 (IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp, USA) and SAS version 19.4 (SAS Institute Inc., Cary, NC, USA).

Descriptive data analyses were generated as frequencies, means, percentages and child mortality rate to provide information on sociodemographic and child mortality characteristics of the population in Béré. Child mortality rate is a crucial indicator of children health and children up to ten years old were included to address the important lack of information on child health determinants in Béré due to decades of civil strife. Age-specific mortality rates were used in this study since they are more specific than all-age mortality rates, and thus more beneficial for targeted health interventions planning and monitoring, Project 21's goal. Age-specific mortality rates (ASMR) were calculated with the commonly used formula: mortality rate per 1000 population = (age-specific number of deaths/age-specific population) × 1000 [24]. In this study's context, the numerator representing deaths was the variable "respondents' children reported dead" (A) and the age-specific population was the "respondents' children number" (B) variable (see Table 1). The ASMR per 1000 (C) = ((A)/(B)) × 1000.

Bivariate data analyses were performed to identify predictors and risk factors for child mortality. First, simple linear regression was used to identify factors/predictors of child mortality (continuous variables, e.g. household children

Table 1 Sociodemographic characteristics of respondents and their children

Characteristics	Item	Count	Percentage (%)
Respondents (n = 517)			
Household type	Nuclear family	402	77.8
	Multi-family	115	22.2
Religion	Seventh Day Adventist	20	3.9
	Evangelical	321	62.1
	Muslim	14	2.7
	Catholic	124	24.0
	Animist	13	2.5
	Other	9	1.7
	No religion	16	3.1
Ethnicity	Ngambay	51	9.9
	Nangtchéré	446	86.3
	Fulani	2	0.4
	Arabic	9	1.7
	Other	9	1.7
Gender	Male	417	80.7
	Female	100	19.3
Age group	< 20 years old	4	0.8
	20–29 years old	79	15.3
	30–39 years old	174	33.7
	40–59 years old	217	42.0
	60 + years old	43	8.3
Education level	None	107	20.7
	Primary	151	29.2
	Secondary	191	36.9
	Baccalauréat	37	7.2
	Baccalauréat +	31	6.0
Education period	Number of years	Mean = 7.9	n/a
Household head gender	Male	447	86.3
	Female	70	13.5
Household size	Number of members	Mean = 6.6	n/a
Occupation of household members	Unemployed	36	1.7
	Employed	2034	98.3
	Primary occupation	(n = 1492)	73.35
	Agriculture	1320	63.7
	Business	98	4.7
	Healthcare	7	0.3
	Education	38	1.8
	Government	14	0.6
	Construction	11	0.5
	Transportation	1	0.05
	Other	3	0.1
	Secondary occupation	(n = 542)	26.65
	Agriculture	29	1.4
	Business	376	18.2

Table 1 (continued)

Characteristics	Item	Count	Percentage (%)
	Healthcare	15	0.7
	Education	51	2.5
	Government	18	0.9
	Construction	31	1.5
	Transportation	8	0.4
	Other	14	0.6
House standard	Low standard	94	18
	Medium standard	288	56
	High standard	135	26
House components	*House walls*		
	Mud: No	173	33.5
	Yes	344	66.5
	Semi-cement: No	433	84
	Yes	84	16
	Windows with mosquito nets		
	No	502	97
	Yes	15	3
	Ceiling present		
	No	510	98.6
	Yes	7	1.4
	Roof		
	Metal sheet: No	263	51
	Yes	254	49
	Straw: No	471	91
	Yes	46	9
	Raffia: No	333	64
	Yes	184	36
Respondents children (n = 1361)			
Children gender	Male	712	52.31
	Female	649	47.69
Children number	< 12 months old (infant)	115	8.45
	12–35 months old (toddler)	211	15.50
	3–5 years old (preschool)	366	26.89
	6–10 years old (primary school age)	669	49.15
Children reported dead		(n = 94)	6.90
	< 12 months old (infant)	39	33.91
	12–35 months old (toddler)	27	12.79
	3–5 years old (preschool)	16	4.37
	6–10 years old (primary school age)	12	1.79
Children in school		(n = 560)	41.14
	< 12 months old (infant)	0	0
	12–35 months old (toddler)	0	0
	3–5 years old (preschool)	82	22.40[a]
	6–10 years old (primary school age)	478	71.45

Table 1 (continued)

Characteristics	Item	Count	Percentage (%)
Mortality rates			
Age	Population	Number of deaths	Age Specific Mortality Rate per 1000
< 12 months old (infant)	*115*	*39*	*339.13*
Male	65	22	338.46
Female	50	17	340.00
12–35 months old (toddler)	*211*	*27*	*127.962*
Male	119	16	134.45
Female	92	11	119.56
3–5 years old (preschool)	*366*	*16*	*43.716*
Male	188	7	37.23
Female	178	9	50.56
6–10 years old (primary school age)	*669*	*12*	*17.937*
Male	340	10	29.41
Female	329	2	6.07

[a]Percentage of the children number in school per age group

number, household members number) independently associated with child mortality (dependent variable) in this study. The model included one independent sociodemographic variable at a time that was tested as a potential predictor of child mortality. Second, odds ratios analysis determined the risk of child mortality for an exposed group versus a non-exposed group (noted as the reference group). For example, odds ratio analysis was used to determine whether family structure (multiple family versus nuclear family- reference group) affected the risk of child mortality (no mortality versus mortality). Results are considered statistically significant at 5% levels of significance ($p < 0.050$).

3 Results

3.1 Respondents' demographics

A general summary of the respondents' demographics is outlined in Table 1 and a summary of respondents' sociodemographic characteristics per quartier is presented in Table 2. This study's data analysis uses information from 517 respondents, including 81% males and 19% females. Most of the household heads are males. The predominant age of respondents is 40–59 years old, mainly from the Nangtchéré group, and are Christians. A third of them have secondary level education but 21% have no formal education. The overall mean number of years spent in education is 7.9. The surveyed households are nuclear families and have an average number of household members of approximately 7 (6.4–6.9 95% CI), with agriculture and business being the top primary and secondary professions, respectively.

House standard and components are used as local indicators of socioeconomic status and summaries of their observations are reported in Tables 1 and 2. Over half of the surveyed houses are of medium standard. The highest portions of low standard houses are found in Bangar, medium standard houses are in Nergue Bakya, and high standard houses mainly in Béré Mission 1.

3.2 Sources of health advice and information

Most of the respondents (91%) receive health advice from CHWs or TBAs, with at least 59% of the residents in each quartier being informed mainly by CHWs, except for Béré Bornou and Singuir. More than half (62%) of the respondents were also advised by TBAs during the last year.

Table 2 Predominant respondents' sociodemographic characteristics by quartier

Respondent characteristics	Quartiers										
	Bangar	Bolo	Béré Bornou	Béré Mission 1	Béré Mission 2	Béré Mouraye	Béré Poste	Cotton-Tchad	Dole	Ivergue Touichiroue	Kobtcha
Household with child mortality	12.7%	5%	50.0%	6.7%	14.3%	21.4%	0%	17.1%	29.3%	0%	5%
Education level	Secondary	Primary/Secondary	Primary	Secondary	Secondary	Primary	Secondary	Secondary	Secondary	Primary	Secondary
No education	24%	40%	50%	16%	17%	36%	40%	20%	12%	17%	25%
Occupation (Primary/Secondary)	Agriculture/ Business	Agriculture/ Agriculture	Agriculture/ Business	Agriculture/ Business	Agriculture/ Business	Agriculture/ Business	Agriculture/ Education	Agriculture/ Business	Agriculture/ Business	Agriculture/ Business	Agriculture/ Business
Unemployment	0%	5.6%	0%	8.3%	5.6%	19.4%	16.7%	0%	0%	0%	16.7%
Household members (mean)	6.2 ± 2.7	7.6 ± 3.2	9.3 ± 2.1	7.1 ± 3.2	6.1 ± 1.6	6.3 ± 1.6	7.1 ± 4.2	7.8 ± 4.8	7.1 ± 4.2	6.2 ± 2.5	7.4 ± 3.6
House standard	Medium	Medium	Medium	Medium/ High	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Children in school	49%	62%	52%	57%	68%	40%	29%	59%	60%	61%	71%
Number of children (mean)	3.8 ± 2.6	5.5 ± 3.3	6.0 ± 2.5	4.8 ± 2.7	3.9 ± 2.9	4.3 ± 1.7	3.9 ± 2.4	5.6 ± 4.7	4.6 ± 3.1	4.1 ± 2.3	4.4 ± 2.6
Health advice source	TBA	CHW	CHW/TBA	CHW/TBA	CHW	CHW	CHW	CHW/TBA	CHW	CHW	CHW

Respondent characteristics	Quartiers									
	Nergue Annah	Nergue Bakya	Nergue-Goudjba	Singuir	Tcha-Asse	Tchamangue	Tchouroue-Yendei	Toupadjer Ngolo	Toupadjre Mbassea	Yendei
Household with child mortality	15.4%	60%	14.6%	18.5%	7.1%	50%	10.0%	2.9%	16.7%	11.8%
Education level	Secondary	Primary/Secondary	Primary	Primary	Secondary	Primary	Secondary	Primary/Secondary	Primary	Secondary
No education	19%	20%	8%	26%	14%	25%	40%	18%	17%	12%
Occupation (Primary/Secondary)	Agriculture/ Business	Agriculture/ Business, Education	Agriculture/ Business	Agriculture/ Business	Agriculture/ Business	Agriculture/ Business	Agriculture/ Business	Agriculture/ Business	Agriculture/ Business	Agriculture/Business
Unemployment	0%	5.6%	0%	13.9%	0%	0%	2.8%	5.6%	0%	0%
Household members (mean)	5.0 ± 3.0	6.9 ± 2.8	6.6 ± 3.8	6.7 ± 3.3	6.1 ± 2.4	9.0 ± 6.9	6.1 ± 2.8	6.0 ± 2.9	4.8 ± 2.4	5.6 ± 2.6

Table 2 (continued)

Respondent characteristics	Quartiers									
	Nergue Annah	Nergue Bakya	Nergue-Goud-jba	Singuir	Tcha-Asse	Tchamangue	Tchouroue-Yendei	Toupadjer Ngolo	Toupadjre Mbassea	Yendei
House standard	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Children in school	78%	60%	44%	46%	54%	59%	63%	55%	47%	58%
Number of children (mean)	2.7 ± 2.1	4.2 ± 2.2	4.5 ± 3.5	4.3 ± 2.2	3.5 ± 1.8	6.7 ± 5.7	4.0 ± 2.6	3.8 ± 2.4	2.8 ± 2.4	3.6 ± 2.4
Health advice source	CHW	CHW	CHW	TBA	CHW	TBA	CHW	CHW	CHW	CHW

3.3 Children demographics

The respondents report of children demographics is shown in Tables 1 and 2. The largest children age group is 6 to 10 years old. The gender distribution of the children in the age groups is similar for boys and girls. Seventy-one percent of primary school-aged children and twenty two percent of preschool-aged children were reported to attend school. Fourteen percent of respondents reported child mortality within the last twelve months. Infant mortality rate is the highest (339.13 deaths/1000) and the mortality rate for children up to 5 years old is 118.50 deaths/1000. Child mortality rates generally decrease with age. Mortality is higher in males (58.5%) for all age groups, except for the 3 to 5 years old.

3.4 Child mortality associations and risk factors

This study uses two strategies for understanding: (a) factors associated with or predictors of child mortality using simple linear regression, and (b) risk of child mortality using odds ratios (see Table 3). The simple linear regression model reveals that respondents' child mortality is statistically significantly associated with the number of children in the household ($B = 0.876$; $r = 0.44$; $p < 0.001$).

Also, the factors that affect the risks of child mortality were identified with odds ratios analysis (see Table 3). The wide confidence interval observed with some odds ratios analyses reflect a smaller number of respondents. Our results show that child age is a determinant of child mortality in this study. Child mortality odds ratios significantly decrease with child age, with the infants' odds ratio being the highest [OR = 7.583; 95% CI (4.886–12.080)] and that of children aged 6 to 10 years old being the lowest [OR = 0.151; 95% CI (0.081–0.280)]. Further, child gender and household location (quartier) are determinants of the risks of mortality for all studied children's groups, with three quartiers (Béré Mouraye, Dole, Singuir) showing statistically significant risks of child mortality. Significant risks of infant mortality in males are in Singuir and Béré–Mouraye, with the highest being in Béré-Mouraye [OR = 5.073 (1.047–24.57)]. The quartier with the highest risks of child mortality per older age group and gender is Dole.

Family structure is also a determinant of child mortality risk. Multiple families are slightly less likely to experience mortality in male toddlers compared to nuclear families [OR = 0.98 (0.97–0.99)].

In addition, the reception of health advice from TBAs in the household within the last twelve months affects infant mortality risk. Households that received health advice from TBAs within the last twelve months are almost four times less likely to experience infant mortality [OR = 0.25 (0.065–0.997)] in females. Therefore, receiving health advice from TBAs has a protective effect on the life of female infants.

3.5 Covariate analysis

Additional analyses were conducted to determine if relationships exist between covariates. Chi-square tests of independence evaluating relationships between categorical covariates show significant associations between respondents religion and educational level ($\chi^2(24, N = 517) = 55.96$; $p < 0.001$), ethnicity and educational level ($\chi^2(16, N = 517) = 55.51$; $p < 0.001$), gender and educational level ($\chi^2(4, N = 517) = 45.11$; $p < 0.001$), age and religion ($\chi^2(24, N = 517) = 46.94$; $p < 0.001$), age and educational level ($\chi^2(16, N = 517) = 47.34$; $p < 0.001$).

4 Discussion

Chad displays a high child mortality rate, especially in the Southern region where Béré is located, and some child mortality factors are sociodemographic [8, 10]. This study is the first of its kind for Béré and provides valuable information on the sociodemographic context and child mortality in Béré, including age-specific child mortality rates, associations between child mortality and sociodemographic factors, and risks factors of child mortality.

First, our study reveals the sociodemographic context of Béré. The study shows that the city has predominant patriarchal household leadership, evangelical religion, agriculture profession, habitations with mud walls indicating low socioeconomic status, education prioritized in males up to primary and secondary levels, but also a Northern portion of Béré with residents with no formal education, creating a 'formal uneducated belt'. Our results agree with previous reports that the highest levels of education (mainly primary and secondary levels) are pursued and observed in males, and that agricultural professional outcomes are associated with lower levels of education [9, 25–27]. The

Table 3 Statistically significant odds ratios for factors of reported child mortality

Mortality factor	Odds ratio	Confidence interval (95%)	
		Lower	Upper
AGE GROUP			
< 12 months old			
No (Ref)[a]	1.000	–	–
Yes	7.583	4.886	12.080
12–35 months old			
No (Ref)	1.000	–	–
Yes	2.196	1.372	3.515
3–5 years old			
No (Ref)	1.000	–	–
Yes	0.557	0.321	0.967
6–10 years old			
No (Ref)	1.000	–	–
Yes	0.151	0.081	0.280
LOCATION			
< 12 months old male			
Singuir			
No (Ref)	1.000	–	–
Yes	3.958	1.073	14.607
Béré Mouraye			
No (Ref)	1.000	–	–
Yes	5.073	1.047	24.57
12–35 months old male:			
Dole			
No (Ref)	1.000	–	–
Yes	5.610	1.649	19.085
12–35 months old female:			
Dole			
No (Ref)	1.000	–	–
Yes	5.289	1.314	21.286
3–5 years old female:			
Dole			
No (Ref)	1.000	–	–
Yes	9.316	2.011	43.151
6–10 years old male:			
Dole			
No (Ref)	1.000	-	-
Yes	6.184	1.488	25.707
FAMILY STRUCTURE			
3–5 years old male:			
Single family (Ref)	1.000	–	–
Multiple family	0.985	0.973	0.997
SOURCE OF HEALTH ADVICE			
< 12 months old female:			
Traditional Birth Assistant			
No (Ref)	1.000	–	–
Yes	0.255	0.065	0.997

[a](Ref): Reference category

educational context of children estimated by school attendance is better in this study than the national one for preschoolers and primary school aged children [7]. Also, the respondents' demographic findings for our study fit with the national patriarchal pattern, rural culture and most previous reports on Chad and rural communities, except for Nangtchéré being the dominant ethnicity and Evangelicals being the top religion [9, 27, 28].

In addition, our results show the mortality rate in Béré is a little higher than the national average for under-five years old, decreases with age, and is notably worse in infants and toddlers. These findings are close to the ones from the recent demographic Chadian study and agree with previous reports [3, 6, 7, 9]. The reported infant mortality rate in Béré is almost five times higher than the national one, which is of concern [3, 6]. In addition, risks of mortality are noticeably higher in infants and toddlers and follow previous reports [7, 9]. Also, our study indicates that child mortality was influenced by gender, where mortality level was higher in male than in female children, except in the 3 to 5 years old group. Although the specific reasons for this outcome are not known yet, it is noteworthy that comparable results are found in previous studies and may provide possible explanations. Biological reasons for these results included increased susceptibility to infections in neonates, premature births, and delivery complications, and social probable causes included neglect [10]. These findings indicate that infant and toddler mortality are significant child health issues in Béré and that plans for health interventions addressing these issues should be considered. Also, further investigations should be done to identify the determinants of infant and toddler mortality in Béré.

Further, this study shows that, household location is a determinant of child mortality risk in Béré. Child mortality risks are particularly found in three quartiers: Béré Mouraye, Dole, and Singuir for certain age groups and gender. Although further investigation is required to gain an adequate understanding of the factors contributing to these outcomes, based on past findings in Chad, it is possible that infectious diseases, and factors related to poverty such as poor water quality, sanitation and hygiene practices may play a role [9]. A previous Chadian study also confirms that child mortality varies with location, emphasizing the importance of including location-specific health programs when planning public health interventions in Chad [10]. Based on our results, Béré Mouraye, Dole, and Singuir must be prioritized when designing future health interventions for children in Béré.

Moreover, our findings show that CHWs and TBAs are major sources of health information, and that health advice from TBAs decreases the risk of mortality in female infants. These results agree with previous studies and strengthen the importance of health information provided by TBAs before and after childbirth, educating mothers for postnatal care and healthy child development throughout the growth of the child (e.g. nutrition, hygiene), and promoting better children survival and health [10, 29, 30]. Our study also reports that CHWs educate more than half of the population in all the quartiers. This finding indicates that the training of community members to become CHWs through Project 21 initiatives is a useful tool for health education in Béré and that the program should be continued. Collectively, the above findings emphasize the role of health volunteers and simple media devices in health education in rural locations, as observed in previous studies [31–37]. These findings also suggest that future health programs must reinforce CHWs and TBAs training and involvement in health interventions, to maximize impact and promote child health outcomes.

Lastly, this study reveals that the number of children in households is a predictor of child mortality. This finding is not surprising considering the reported average number of children per household in the study (approximately four), the observed general household low socioeconomic status, and dominant agricultural work that takes long hours, compromising the availability of adequate child-rearing resources and childcare. Our results match previous reports from low-income countries such as Chad, where child mortality was associated with the number of children in households, the proportion of children among all household members, the family socioeconomic status and size, and the mother's education [38–40]. Therefore, it is recommended that interventions incorporating education on reproductive health, wealth building, and childcare are carried out in all the quartiers to promote child health in Béré.

4.1 Limitations of the study

Although the authors were careful to design a strong study, it has some limitations. The latter include a potential for reporting bias, due to inaccurate recall of respondents, misunderstanding of the questions, respondents trying to give answers they think would be pleasing to interviewers, interviewers making mistakes in data entry, and variations in the number of respondents from each quartier. Also, some quartiers had a lower number of respondents compared to others, which may have affected the width of the confidence intervals for the odds ratio analyses done by quartiers. Additionally, although the final findings may be considered as indications for other rural areas, they may be limited to the location of Béré.

4.2 Conclusion

Taken together, this study provides new valuable baseline data on the sociodemographic and child mortality context of Béré, a rural city in Chad for which official up-to-date and reliable health records are not available. The significant infant mortality rate and risks are of concern. The number of children in the household is a predictor of child mortality and child age and gender, household location, family structure and reception of TBA health advice are determinants of child mortality risk. Infants' and toddlers' mortality risk is worse in the Béré Mouraye, Dole, and Singuir quartiers, and lower when TBAs health advice is received. Therefore, based on our results, the recommendations for Project 21 to promote child health in Béré include: (a) implement health programs to decrease mortality in children up to five years old, giving priority to infants and toddlers, and the quartiers of Béré Mouraye, Dole, and Singuir; (b) strengthen CHW and TBA training and involvement to promote the dissemination of health advice in the community; (c) investigate further the determinants of infant and toddlers mortality, targeting nutrition, infectious diseases, water quality, hygiene and sanitation, some of the main known risk factors in Sub-Saharan countries.

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Data availability The dataset generated by the survey research during and/or analyzed during the current study is available in the Zenodo repository "https://doi.org/10.5281/zenodo.11215482".

Code availability Not applicable.

Declarations

Ethics approval and consent to participate All experimental protocols were approved by Loma Linda University's institutional review board (IRB approval #5150151). All experiments were performed in accordance with relevant guidelines and regulations.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

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