

Research Article

Factors Associated with Malaria Death in Children Aged 0 to 5 Years at Charles de Gaulle University Pediatric Hospital Center, Burkina Faso, 2018–2022

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Abstract

Introduction: Malaria is one of the leading causes of death among children under 5 years of age worldwide, with more than 90% of these deaths located in Africa. In Burkina Faso, malaria is also highly fatal. It is therefore essential to understand the explanatory factors of these deaths in order to develop effective and efficient preventive strategies. This study aims to identify the factors associated with malaria death in children aged 0 to 5 years at the Charles de Gaulles University Hospital (CHUP-CDG). **Methods:** An analytical cross-sectional study was conducted on a population of children under 5 years of age with malaria who had been hospitalized at the CHUP-CDG. The data were collected from the medical records of the CHUP-CDG care units. The analysis calculated, using SAS® Software version 9.4., the ORs of associations of patient characteristics with death. **Results:** The case fatality rate of malaria was 40.63%. The variables associated with death were rural residence 3.72 [2.48; 12.77], poverty 3:53, [1,10; 11:30], severe malnutrition 3:62, [1,61; 21:51], coma 8:72 [3:15; 24:12], vomiting 2:82 [1:81; 4:12], respiratory distress 5:46 [2:20; 13,58], metabolic acidosis 5,39, [1,79; 16,28], hypoglycemia 3.68 [1.03; 13,21], renal insufficiency 4.91 [1.37; 17.58], having had an indication for transfusion and not having been transfused 308.22 [37.06; 408,66]. **Conclusion:** The need to raise awareness among the population for early use of health facilities, the promotion of universal health coverage and the promotion of a community health policy is necessary in view of the factors identified.

Keywords

Associated Factors, Malaria Death, Charles de Gaulle University Pediatric Hospital Center (CDG-UPHC), Burkina Faso

1. Introduction

Malaria is a serious and potentially fatal human disease caused by a protozoan parasite called Plasmodium, which is prevalent mainly in Africa [1, 2]. It is transmitted to humans through the bite of female mosquitoes of the *anopheles* [3].

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Received: 31 October 2025; Accepted: 23 January 2026; Published: 26 January 2026



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Despite interventions and precautions taken against malaria, the disease remains a major health problem worldwide, particularly in developing countries [2, 4]. It is one of the leading causes of mortality, especially in sub-Saharan African countries (SSA) and the most vulnerable targets are pregnant women and children [2].

In 2017 World Health Organization (WHO), reports that during 2016, about 445,000 deaths out of 216 million malaria cases occurred worldwide, while 70% of deaths occurred in children under five years of age [5]. The 2020 WHO report also states that malaria is endemic in 87 countries worldwide with 229 million cases and 409,000 deaths in 2019 of which 215 million cases and 384,000 deaths occurred in Africa [6].

In 2021, according to WHO, about 95% of malaria cases and 96% of global malaria deaths were recorded in the WHO African Region. Children under 5 years of age accounted for about 80% of all malaria deaths in the Region during the year [1].

In Africa, malaria continues to be one of the main public health concerns. Indeed, the African population is relatively young and the under 15s are the majority, i.e. more than 60% of the total population and the fertility rate being 2.7 children per woman [7]. As a result, the African population is more likely to pay a heavy price for malaria deaths due to its very high proportion of the vulnerable population, such as children and pregnant women. This particularity of the African population means that in sub-Saharan Africa (SSA) the global burden of malaria is disproportionately high. To support this, in 2015, the region accounted for 90% of the world's malaria deaths, with 394,200 deaths [8, 9].

In 2018, sub-Saharan Africa alone accounted for 94% of malaria deaths worldwide, 67% of which were children under five years of age [4]. Malaria contributed to 5% and 18% of under-five deaths globally and in SSA, respectively [10].

In Kenya, in a study of current malaria morbidity and mortality in different transmission settings in western Kenya, Antoine Kapesa et al found that the malaria-related mortality rate was highest in children under 5 years of age, at 60.9 deaths per 1000 malaria admissions [11].

In Burkina Faso, although there has been a sharp reduction in malaria fatality, malaria is still the leading cause of child mortality in the country and therefore remains a public health problem. Indeed, Burkina Faso is one of the eleven most affected countries in the world, with a contribution of 6% of the 94% of malaria deaths recorded in SSA in 2018 [4]. During the same year, malaria was responsible for 66% of deaths among children under five years of age seen in Burkinabe health facilities [12].

In 2019, based on statistical data from the National Health Information System (SNIS), malaria was the main reason for consultation (39.24%), with a proportion of 17.22% of deaths attributed to it in health facilities [13]. Pregnant women and children under 5 were the most vulnerable targets [13].

Faced with this permanent health concern due to the lethality of malaria, Burkina Faso is committed to an active fight

against the disease through a display of political will and a subscription to global initiatives to fight malaria. The country benefits from active surveillance and large-scale interventions to reduce or even eliminate the lethality of malaria through a program governed by the Ministry of Health: the National Malaria Control Program (NMCP).

This program Established in 1991 and restructured in 1995, the aim of the Malaria Mortality and Morbidity Act is to reduce malaria-related mortality and morbidity. The NMCP is responsible for coordinating activities, promoting research activities, ensuring the regular supply of inputs and establishing therapeutic protocols in the fight against malaria. [14].

In addition, Burkina Faso has adopted a number of initiatives for active malaria control.

Indeed, the various initiatives such as the High Burden High Impact Initiative (HBHI), the "Zero Malaria, I Commit" initiative and the Initiative for the Elimination of Malaria in the Sahel (SaME) are among the actions carried out to reduce the incidence of malaria [15, 16].

These initiatives include insecticide spraying in the country's major cities, which has not been successful due to the emergence of insecticide resistance; community-based management of malaria cases; free care at the community level, chemoprevention of seasonal malaria in children with intermittent prophylactic treatment; routine long-lasting impregnated mosquito net (LLIN) coverage with greater attention to LLIN coverage in children under 5 years of age.

Despite all these efforts; Malaria remains one of the major health concerns in Burkina Faso and the young part of the population, especially those under 5 years old, are the main victims of this disease. In addition, its lethality of malaria remains high. The present study aims to understand persistent malaria mortality in children under 5 years of age. At the end of our study, we plan to find the factors that potentiate malaria lethality at the level of the CDG-UPHC. We will propose recommendations and public health actions to help achieve the goal set by the World Health Organization (WHO) in 2015 to reduce malaria mortality by 90% by 2030 in Burkina Faso [16].

2. Material et Methods

Study Environment

Burkina Faso's health system is divided into 13 health regions and 71 health districts. The site of our study is located in the central region which is home to 4 public university hospitals center (UHC), namely the Yalgado OUEDRAOGO University Hospital; the CHU of Tengandogo; the Bogodogo University Hospital, the Charles de Gaulle Paediatric University Hospital.

Our study will take place at the Charles de Gaules Paediatric University Hospital center.

This centre, inaugurated on 30 January 2001, is one of the main national paediatric reference hospitals. With a satisfactory technical platform with a capacity of 126 beds, this centre is the national reference for serious cases of various conditions

affecting children.

Type and period of study

This is a cross-sectional study with analytical aims on retrospective data from subjects with malaria covering the period from January 1, 2018 to December 31, 2022.

Study population and sampling

Study population

The study population was all patients under 5 years of age with malaria who visited the CDG-UPHC during our study period.

Inclusion and non-inclusion criteria

Inclusion criteria

All patients under five years of age with confirmed malaria during the study period were included.

Non-inclusion criteria

All malaria patients whose clinical records were not usable and patients whose treatment outcomes were not available were not included.

Sampling

To calculate our sample size, we considered that 22% of deaths are due to malaria in children under 5 years of age in Burkina Faso. We used the Proc Power procedure of the statistical software SAS 9.4 by applying the method of Liu G. Next, we considered:

- 1) An Odd ratio of deaths due to malaria associated with the delay in consultation of 3;
- 2) 95% statistical power;
- 3) A first-class risk of 5%;
- 4) A non-response rate of 10%.

The minimum acceptable total size n calculated was 203 individuals.

The sampling technique used was simple random sampling.

Variables

Malaria "deaths" in children under five years of age were defined based on patient data information in the consultation registry and medical record. The response modalities (outcome of interest) is binary, encoded in Yes/No respectively "deceased" and "alive".

The independent variables that were considered in this study include socioeconomic, demographic, environmental or geographical, clinical, biological, and therapeutic factors.

These variables were also collected through the clinical records of cases and Vivants. In addition to the document review, additional information on missing variables was completed by telephone call from the children's parents.

Statistical analysis

Descriptive analysis

The aim was to describe the characteristics of malaria cases in children under 5 years of age who were included in our study. Quantitative variables were represented as means and standard deviations, while qualitative variables were allocated as proportions and frequency.

Crude associations with malaria lethality at the 20% threshold were sought with our independent variables.

Etiological analysis

For the selection of variables in the full model, univariate logistic regressions were done to explain the occurrence of death by each of the independent variables. In our context, the main independent variable, which is the delay in care and other potential confounding or effect modifying factors such as age and sex, the distance between the place of residence and the CDG-UPHC, the use of the SMC, the area of residence; occupation, mother's highest level of education, clinical anaemia, jaundice, coma, convulsion, prostration, lethargy, hemoglobin level, parasitaemia, transfusion, vomiting, cardiovascular shock or collapse, acute pulmonary edema (OAP), respiratory distress, metabolic acidosis, blood glucose, hemoglobinuria, renal failure, indication for transfusion.

Only the independent variables that were associated with death at the P value threshold $< 20\%$ were retained for the full model.

In addition to these variables, the main independent variable (time to support) had been forced in all models in case its p-value was $> 20\%$. The same would have been true for all the confounding or effect-modifying factors found in the literature, such as the absence of transfusion when it is necessary; poverty, poor nutritional status, parasitaemia above 4%, low level of education of mothers. We have retained these variables as well to force them into the model.

For the reduction of the full model, we followed the top-down step-by-step method, i.e. we removed from the model the independent variable with the highest p-value above 5%. However, when the removal of a variable from the model caused the regression coefficient associated with the time to care to be taken into care to vary by 15%, this variable was considered a confounding factor. As a result, it was forced into the full model.

The final model contained only the independent variables with a P value $< 5\%$. In addition, the variables of the forced literature, confounding factors or modified forced effects were retained in the final model regardless of their P value.

Ethical considerations

First, we submitted our study protocol to the scientific committee of the Ministry of Health and had obtained their approval to conduct the study. Then we obtained a collection authorization signed by the director of medical and technical services before proceeding with the collection. For the telephone interview, we obtained informed consent from the parents after a description of the study. Indeed, we explained to them that this study has a scientific purpose and that the information obtained will not be used for profit but will aim to improve the prevention of factors aggravating the lethality of malaria.

The data we collected was stored in a password-secured computer to prevent any intentional disclosure of patient data. Individual data has been anonymised.

3. Results

Descriptive analysis

Socio-demographic and economic characteristics of the

2018-2022 study population

The sex ratio for the entire sample was 1.1. This sex ratio was 1.1 for deceased children and 1.24 for living children.

The median age was 12 months for deceased children and 19 months for living children.

Children whose family size was [3, 4] members 111 deceased or 43.70% were the most represented among the deceased.

In addition, deceased children, those living in urban areas, were the most represented, i.e. 113 (32.75%). Also, 51.22% and 54.84% of children whose mother or father are illiterate respectively died.

Among the children with poor parents, 51.76% died, i.e. 147 children.

Table 1. Socio-demographic characteristics of live and deceased malaria cases from 2018–2022.

Variable	Deceased (n = 195)	Alive (n = 285)	Pvalue
Age (months)			
Median (Q1 -Q2)	12(9,0-36,00)	19(10,0-48,0)	
Sex			0,1136*
Masculine	93(37,05)	158(62,95)	
Feminine	102(44,54)	127(55,46)	
Ratio M/F	0,91	1,24	
Family size			
<3mbres	Op. 43(34,68)	81(65,32)	0,2438
[3, 5] MBRES	111(43,70)	143(56,30)	
>5mbres	Ref 41(40,20)	61(59,80)	
Type of area of origin			<0.0001*
Rural	82(60,74)	53(39,26)	
Urban	113(32,75)	232(67,25)	
Mother's level of education			
Illiterate	147(51,22)	140(48,78)	<0.0001*
Elementary level	Op. 33(44,59)	Op. 41(55,41)	
High school level	8(10,39)	Spp. 69(89,61)	
University level	Op. 7(16,67)	Op. 35(83,33)	
Father's level of education			
Illiterate	136(54,84)	112(45,16)	<0.0001*
Elementary level	28(34,57)	53(65,43)	
High school level	19(30,16)	Art. 44(69,84)	
University level	Ref 12(13,64)	Op. 76(86,36)	
Distance to home CHUP-CDG			
Near	Ref 85(27,69)	222(72,31)	<0.0001*
Far	Op. 76(70,37)	Op. 32(29,63)	
Very far	Op. 34(52,31)	Op. 31(47,69)	
Quintile of wealth			
Poor	147(51,76)	137(48,24)	<0.0001
Average standard of living	Op. 47(24,35)	146(75,65)	

Variable	Deceased (n = 195)	Alive (n = 285)	Pvalue
Rich	1(33,33)	S2(66,67)	

Clinical characteristics of live and deceased malaria cases from 2018 to 2022

The deceased children with normal nutrition were 129 individuals and those living 236 individuals.

For those who died whose body temperature, exceeded 38 degrees Celsius was 137. Deceased children with clinical anaemia with severe pallor were the most represented: 87 chil-

dren followed by those with moderate pallor with 76 individuals.

The number of deceased children without jaundice was 131 individuals.

Apart from Lethargy (44.74%) Prostration (49.03%).

More than 50% of children who showed signs of complications such as acute edema, coma, convulsion and vomiting, shock or cardiovascular collapse died.

Table 2. Clinical characteristics of live and deceased malaria cases from 2018–2022.

Variable	Deceased (n = 195)	Alive (n = 285)	p
Malnutrition			
Normal	129(35,44)	236(64,56)	0,0004*
Moderate malnutrition	23(60,53)	15(39,47)	
Severe malnutrition	Ref 43(55,84)	Op. 34(44,16)	
Temperature			
Fever ATCD	Ref. 45(21,95)	160(78,05)	<0.0001*
Fever (>38 degrees)	137(54,58)	114(45,42)	
Normal	13(54,17)	11(45,83)	
Clinical anaemia			
Normal	Op. 32(24,24)	100(75,76)	<0.0001*
Moderate pallor	Op. 76(35,85)	136(64,15)	
Severe pallor	Op. 87(63,97)	Ref 49(36,03)	
Jaundice			
Normal	131(37,32)	220(62,68)	0,0322*
Sub-jaundice	Op. 33(54,10)	Art. 28(45,90)	
Jaundice	Op. 31(45,59)	Op. 37(54,41)	
Coma			
Yes	109(77,86)	Op. 31(22,14)	<0.0001*
No	Ref 86(25,29)	254(74,71)	
Convulsion			
Yes	108(62,07)	Ref 66(37,93)	<0.0001*
No	Op. 87(28,43)	219(71,57)	
Lethargy			
Yes	153(44,74)	189(55,26)	0,0039*
No	Art. 42(30,43)	96(69,57)	
Vomit			<0.0001*

Variable	Deceased (n = 195)	Alive (n = 285)	p
Yes	129(50,39)	127(49,61)	
No	Ref. 66(29,46)	158(70,54)	
Prostration			
Yes	176(49,03)	183(50,97)	<0.0001*
No	Ref 19(15,70)	102(84,30)	
Cardiovascular shock or collapse			
Yes	130(60,47)	85(39,53)	<0.0001*
No	Ref 65(24,53)	200(75,47)	
PAO			
Yes	28(71,79)	11(28,21)	<0.0001*
No	167(37,87)	Op. 274(62,13)	
Detresse_respiratoire			
Yes	147(75,38)	Op. 88(37,45)	<0.0001*
No	Op. 48(62,55)	197(80,41)	

Biological characteristics of live and deceased malaria cases from 2018 to 2022

Forty-six point fifty-two percent (46.52%) of children who experienced severe anemia died, the proportion of deaths was 52.63 percent among those who experienced mild anemia. More than 68% of children who presented with metabolic acidosis died, i.e. 103 children.

Of the children who presented with hyperparasitaemia, 48.11% died. Death affected more than 50% of children who presented with hypoglycemia. Children who had hemoglobinuria or renal failure had a case fatality rate of 76.39% and 68.42%, respectively.

Table 3. Distribution of live and deceased malaria cases by biological characteristics from 2018 to 2022.

Variable	Deceased (n = 195)	Alive (n = 285)	Pvalue
Hemoglobin levels			
Normal	18(26,87)	Ref. 49(73,13)	
Mild anemia	30(52,63)	S27(47,37)	0,0042*
Moderate anaemia	Ref. 60(35,50)	109(64,50)	
Severe anemia	Ref 87(46,52)	100(53,48)	
Acidose_methabolique			
Yes	103(68,21)	Ref. 48(31,79)	<0.0001*
No	92(27,96)	237(72,04)	
Parasitemia			
Bass	93(34,70)	175(65,30)	0,0030*
Hyperparasitaemia	102(48,11)	110(51,89)	
Blood sugar			
Hypoglycaemia	122(50,83)	118(49,17)	<0.0001*
Normal	Art. 45(22,61)	154(77,39)	

Variable	Deceased (n = 195)	Alive (n = 285)	Pvalue
Hyperglycaemia	28(68,29)	13(31,71)	
Hemoglobinuria			
Yes	Ref 55(76,39)	Ref. 17(23,61)	<0.0001*
No	140(34,31)	268(65,69)	
Renal impairment			
Yes	Op. 78(68,42)	Op. 36(31,58)	<0.0001*
No	117(31,97)	249(68,03)	

Distribution of live and deceased malaria cases by treatment from 2018 to 2022

The time to consultation had a median of 2 days in all individuals and 3 days in deceased individuals.

The treatment time was similar to the consultation time with a median of 48 hours in all individuals and 72 hours in deceased cases.

The children who had antimalarial chemoprevention but who died were 161 or 48.49%.

Of those who had an indication for transfusion, 48.47% died and 172 individuals, or 48.05% of those who did not receive transfusion, died.

Table 4. distribution of live and deceased malaria cases by treatment characteristics from 2018 to 2022.

Variable	Deceased (n = 195)	Alive (n = 285)	Pvalue
Consultation period (days)			
Median (Q1-Q2)	3(1,0-4,0)	2(1,0-3,0)	
Processing Time (hours)			
Median (Q1-Q2)	72(24,0-336,0)	48(24,0-240,0)	
ATCD_CPS			
Yes	161(41,49)	227(58,51)	0,0146*
No	34(36,96)	Ref. 58(63,04)	
Indication for Transfusion			
Yes	95(48,47)	101(51,53)	0,0045
No	100(35,21)	184(64,79)	
Transfusion			
Transfused	23(18,85)	99(81,15)	<0.0001*
Not transfused	172(48,05)	186(51,95)	

Factors associated with malaria lethality in univariate analysis

The table below summarizes the results of the factors associated with malaria lethality in univariate analysis at the 20%

level. The variables statistically associated with the 20% cut-off (p-value < 0.20) were all variables except the variables: Mother's education Father's education; history of antimalarial chemoprophylaxis.

Table 5. Factors associated with the lethality of malaria in simple conditional regression (univariate analysis) in 480 participants.

Socio-demographic variables	GOLD IC95% ()	Pvalue
Age		0,0231
[36-60 months	1	
[0-12 months]	1,80 [1,10; 2,96]	0,166
[12-36 months]	1,87 [1,16; 3,02]	0,081
Sex		0,0955*
Masculine	1	
Feminine	2,36 [1,24; 2,96]	<0.0001
Family size		<0.0001*
< 3 members	1	
[3; 5] Members	1,46 [1,30; 2,28]	0,8427
> 5 members	1,26 [1,13; 2,17]	0,1620
Type of area of origin		<0.0001*
Urban	1	
Rural	3,17 [2,10; 4,79]	<0.0001
Distance to home CHUP-CDG		<0.0001*
Near	1	
Far	6,20 [3,83; 10,05]	<0.0001
Very far	2,86 [1,66; 4,95]	0,6138
Quintile of wealth		<0.0001*
Average standard of living	1	
Poor	3,33 [2,22; 4,98]	0,1180
Rich	1,55 [0,14; 17,51]	0,8954
Malnutrition		0,0007*
Normal	1	
Moderate acute malnutrition	2,79 [1,41; 5,54]	0,9630
Severe malnutrition	2,30 [1,40; 3,79]	0,9652
Temperature		<0.0001*
Normal	1	
Fever ATCD	2,40 [1,3; 5,70]	<0.0001
Fever (>38 degrees)	2,02 [1,44; 3,36]	0,0040
Clinical anaemia		<0.0001*
Normal	1	
Moderate pallor	1,75 [1,073; 2,84]	0,1287
Severe pallor	5,55 [3,26; 9,43]	<,0001
Jaundice		0,0341*
Normal	1	
Sub-jaundice	1,46 [0,833; 2,38]	0,0771

Socio-demographic variables	GOLD IC95% ()	Pvalue
Jaundice frank vs Normal	1,98 [1,14; 3,43]	0,9996
Coma		<0.0001*
No	1	
Yes	10,39 [6,50; 16,58]	<0.0001
Convulsion		<0.0001*
No	1	
Yes	4,12 [2,78; 6,11]	<0.0001
Lethargy		0,0041*
No	1	
Yes	1,85 [1,21; 2,82]	0,0041
Vomit		<0.0001
No	1	
Yes	2,43 [1,67; 3,55]	<0.0001
Prostration		<0.0001*
No	1	
Yes	5,16 [3,03; 8,79]	<0.0001
Cardiovascular shock or collapse		<0.0001*
No	1	
Yes	4,71 [3,18; 6,96]	<0.0001
PAO		0,0001*
No	1	
Yes	4,18 [2,026; 8,61]	<0.0001
Respiratory distress		<0.0001*
No		
Yes	6,86 [4,54; 10,35]	<0.0001
Hemoglobin levels		0,0048*
No anemia	1	
Mild anemia	3,02 [1,42; 6,40]	0,0182
Moderate anaemia	1,49 [1,30; 2,801]	0,232
Severe anemia	2,36 [2,36; 4,36]	0,075
Acidose_methabolique		<0.0001*
No	1	
Yes	5,52 [3,63; 8,40]	<0.0001
Parasitemia		0,0031*
Bass	1	
Hyperparasitaemia	1,74 [1,20; 2,52]	0,0031
Blood sugar		<0.0001*
Normal	1	
Hypoglycaemia	3,54 [2,33; 5,37]	<0.0001

Socio-demographic variables	GOLD IC95% ()	Pvalue
Hyperglycaemia	7,37 [3,53; 15,40]	<0.0001
Hemoglobinuria		<0.0001*
No	1	
Yes	6,19 [3,46; 11,07]	<0.0001
Renal impairment		<0.0001*
No		
Yes	4,61 [2,93; 7,24]	<0.0001
Processing Time (hours)		0,0049*
<24h	1	
[24-48h]	0,99 [0,53; 1,86]	0,4890
[48h-72h]	1,88 [4,6; 1,69]	0,2012
72 hours and more	1,88 [1,11; 3,18]	0,0004
Indication for Transfusion		0,0038*
No	1	
Yes	1,73 [1,19; 2,51]	0,0038
Transfusion		<0.0001*
Not transfused	1	
Transfused	3,98 [2,42; 6,55]	<0.0001

Etiological analyses

Factors associated with malaria lethality, in multivariate analysis.

Multivariate analysis identified **17** statistically significant association factors out of the 27 detected in the simple conditional logistic regression analysis as risk factors for malaria lethality:

First of all, our main explanatory variable, which is the time of consultation, is a risk factor for malaria lethality:

For a delay in taking antimalarial treatment of 72 hours or more, the chance of dying from malaria was multiplied by 3.12 [1.30; 3.41] also for a treatment time with a value between [48h-72h], the risk of death was multiplied by 2.17 [2.04; 2.80].

In addition, the covariates present are associated with malaria lethality at the 5% threshold are listed in the table with their association score.

Table 6. Factors Influencing Malaria Lethality: Multiple Conditional Logistic Regression Analysis in 480 Participants.

Variable	aOR [95% CI]	p-value
Sex		0.0068
Masculine	1	
Feminine	6.11 [2.0; 18.63]	0.0026
Residential setting		0.0002
Urban	1	
Rural	3.72 [2.48; 12.77]	<.0001
Distance from home to the CHUP-CDG		0.0005
Near	1	

Variable	aOR [95% CI]	p-value
Far	4.05 [1.50; 10.92]	<.0001
Very far	0.29 [0.07; 1.20]	0.0083
Quintile_richesse		0.0136
Average standard of living	1	
Poor	3.53 [1.10; 11.30]	0.0060
Rich	0.02 [0.01; 0.792]	0.0423
Malnutrition		0.0020
Normal	1	
Moderate malnutrition	0.43 [0.08; 2.04]	0.0834
Severe malnutrition	3.62 [1.61; 21.51]	0.047
Temperature		0.0040
Normal	1	
Fever ATCD	0.33 [0.06; 1.85]	0.0126
Fever (>38 degrees)	2.24 [1.23; 6.59]	0.1470
Coma		<.0001
No	1	
Yes	8.72 [3.15; 24.12]	<.0001
Vomit		0.0297
No	1	
Yes	2.82 [1.81; 4.12]	0.0533
Respiratory distress		0.0003
No		
Yes	5.46 [2.20; 13.58]	0.0002
Prostration		0.0001
No	1	
Yes	2.64 [1.91; 7.70]	0.0934
Acidose_methabolique		0.0001
No	1	
Yes	5.39 [1.79; 16.28]	0.0014
Blood sugar		0.0005
Normal		
Hypoglycaemia	3.68 [1.03; 13.21]	0.0433
Hyperglycaemia	1.36 [0.52; 3.56]	0.0740
Insuffisance_r_nale		0.0355
No		
Yes	4.91 [1.37; 17.58]	0.0144
Transfusion indication		<.0001
No		
Yes	27.40 [3.475,216.19]	<.0001

Variable	aOR [95% CI]	p-value
Transfusion		<.0001
Transfused	1	
Not transfused	308.22 [37.06; 408.66]	<.0001
Therapeutic time		0.0085
< 24 hours	1	
[24-48h]	0.44 [0.12; 1.61]	0.5211
[48h-72h]	2.17 [2.04; 2.80]	0.1184
72 hours and more	3.12 [1.30; 3.41]	0.0223

4. Discussion

This study allowed us to identify seventeen (17) factors associated with the lethality of malaria in the Charles De Gaulle University Hospital from 2018 to 2022.

The strengths of our study were:

- 1) The right sample size which allowed for good accuracy.
- 2) The absence of missing data which prevented a loss of subjects during the univariate and multivariate analysis.

All of these results reinforce the reliability of the study's results. The results will be discussed according to the groups of factors studied.

Sociodemographic and economic factors associated with malaria lethality

We noted a predominance of children living in urban areas, i.e. 63.96% of children. This urban majority could be explained by the fact that the study took place in a university hospital located in an urban environment. In addition, 52.92% of the children and 78.74% of the deaths were from the Centre region where the Burkinabe capital is located. This region, although it has rural peripheral districts, it is mostly urban [17]. Nevertheless, living in a rural area multiplied the risk of death by 3.72. Timohy Musumbu Mukanda et al in the Kasai province of the Democratic Republic of Congo found a risk factor for malaria related to rural areas of 3.2 times compared to urban populations [18]. Our similar results could be explained by the fact that the rural African population has a risky health behavior, which is the delay in consultation. Indeed, the rural environment meets certain conditions that delay consultation and care in a health center, namely poverty, impassable roads, especially in the rainy season, also in the majority of rural areas which are villages, the inhabitants are more accustomed to treating themselves with medicinal plants which are often ineffective because of increasingly resistant parasites, This means that simple malaria that could have been successfully treated, presents itself in the complication phase in the hospital, thus predisposing the child to the risk of death.

Coming from a poor family would potentiate the risk of dying from malaria by 3.53 times more than a rich one. Fla KOUETA, Diarra YE et al had found in Ouagadougou at the CHUP-CDG in 2008 that a low socio-economic level increased the chance of dying from malaria by 5.4 times. Our results are substantially similar and this could be justified by the fact that the study site is the same. Poverty is also one of the major obstacles to access to healthcare. Although in Burkina Faso there is a policy of free education for children under 5 years of age, it is clear that on the ground this policy is struggling to be effective due to the government's lack of funds to finance this free education. The citizen finds himself obliged to honor his own ordinances; This is done in a context where the majority of the population lives above the poverty line, which would partly explain why the mortality rate is linked to poverty [19].

Clinical factors associated with malaria lethality

Severe malnutrition is thought to increase the risk of death from malaria by 3.62 times compared to those who are not malnourished. This same observation was made by A. S. Ouermi, et al in the Regional University Hospital of Ouahigouya (Burkina Faso) who reported a risk of death of 2.42 times compared to normal for malnourished children; Fla KOUETA et al in Burkina Faso also found that poor nutritional status increased the risk of death by 7.9 times [19, 20]. This association is physiologically explainable because malnutrition is a field of immunosuppression and weakened, which means that a lesser infection such as malaria can quickly become complicated by signs of severity and therefore lead to death in a short period of time compared to children who are not malnourished.

Fever (>38 degrees) was statistically associated with death from malaria and increased the risk of death by 2.24 times. This is justified by the fact that fever is the main sign of the disease and the more it rises, the more it testifies to the importance of malaria infection. Also, according to the literature, hyperthermia considerably reduces therapeutic efficacy, and therefore in turn exacerbates the mortality rate [21-23].

Children who presented signs of clinical severity such as

coma, respiratory distress had a risk factor multiplied by 2.

Andria Moussa et al on data from Ovid, MEDLINE and Embase from 10 East African countries found that cerebral malaria respiratory distress syndrome increased the risk of death by 2.42 and 4.09 times, respectively [24]. N. Fall, N. Lakhe et al in the National University Hospital of Fann (University Hospital of Fann) in Dakar also found a significant association of death with certain signs of severity. Thus, they were able to show that the main predictive factors deaths from severe malaria included: the presence of a disorder of consciousness (aOR=74.2); respiratory distress (aOR=18.2) [25]. A. S. Ouermi et al found in Burkina Faso that disorders of consciousness (aOR = 1.73) [20]. This could be explained by the fact that at the stage of severity, we have a polyvisceral attack which exposes the child more to death.

Biological factors associated with malaria lethality

Among children who experienced metabolic acidosis, 68.2% died, 50.83% of people who experienced hypoglycemia died, and 68.42% of children who experienced kidney failure died.

Moreover, having one of these three biological signs increased the risk of death by 2 times more than children who did not have any biological repercussions. A. S. Ouermi et al found in Burkina Faso that a haemoglobin level < 5 g/dl (OR = 1.81), hypoglycemia (aOR = 2.14), renal failure (aOR = 17.40) were factors associated with death [20]. This association could be explained by the fact that the metabolic disorders present in certain severe forms of malaria act in a vicious circle with multi-organ damage, thus increasing the risk of death.

Finally, children who presented with anaemia requiring transfusion and who had not been transfused had a 308.22-fold increased risk of death. Kevin Marsh et al had found a risk factor of 1.4 related to severe anaemia in the Kilifi Hospital district of Kenya [26]. Our higher risk figures could be justified by the fact that our study hospital is critically short of labile blood product, so the diagnosis of severe anemia without transfusion exacerbates the risk of death.

Indeed, malaria causes anemia by blood plunder, this causes the child with malaria to quickly find himself anaemic and in cases of severe anemia, this leads to hypovolemic insufficiency and a deficiency in oxygen. It will therefore be a cardiac repercussion leading to shock or cardiovascular collapse, a renal repercussion and also an impact on the respiratory system that can even cause acute edema of the lung. The final stage of this polyvisceral repercussions is cardiorespiratory arrest.

Therapeutic factors associated with malaria lethality

The median therapeutic delay was 48 hours. Children who had a treatment delay of more than 48 hours were 2.17 times more likely to die from malaria than those who consulted in less than 24 hours; this risk was increased as the treatment time increased. Indeed, for a therapeutic delay of more than 72 hours, the risk of dying was multiplied by 3.12. This observation was made by Andria Moussa et al on data from Ovid MEDLINE and Embase from 10 East African countries where

they found that a delayed treatment of 72 hours or more increased the risk of respiratory complications or neuromalaria by 5.6 times, 4.09 times respectively [24]. Fla Koueta et al found in 2008 in Burkina Faso that delayed treatment increased the risk of death by 15.5 times [19]. This association could be justified by the fact that children under 5 years of age are a fringe susceptible to malaria. They are more prone to severe forms with early complications during malaria infections. Also, given the anorexia that malaria causes, an infected child will quickly develop a metabolic and biological disorder if the intake of treatment is delayed because the lack of intake thus potentiates the lethal effect of malaria. So the longer the treatment is delayed, the higher the risk of death [27]. Mono Alasane et al had found an association between treatment delay and death (aOR=0.5). Our difference in association with this last study could lie in the fact that they considered an age range of 0 to 15 years. Indeed, children over 5 years of age are not included in populations vulnerable to malaria, and therefore less exposed to death from malaria.

5. Conclusion

This study confirmed that hospital lethality of malaria remains a reality in Burkina Faso. The main factors associated with malaria lethality were: delay in treatment the female sex, the rural place of residence, a residence located far or very far from the CHU, poverty, having one of the following signs or complications: severe malnutrition, fever (>38 degrees), coma, vomiting, respiratory distress, prostration, metabolic acidosis, hypoglycemia, kidney failure, having had an indication for transfusion and not being transfused. These results show the need to strengthen health education for behaviour change with a view to early use of health structures in case of fever, to revitalize community-based interventions, and to strengthen the technical platforms of health structures. Universal health coverage to fight poverty. Also, a new policy by the authorities to increase the availability of labile blood products through awareness-raising could help prevent deaths due to lack of transfusion in Burkina Faso.

Abbreviations

CDG-UPHC	Charles de Gaulle University Pediatric Hospital Center
WHO	World Health Organization
SSA	sub-Saharan Africa
NHIS	National Health Information System
NMCP	National Malaria Control Program
HBHI	High Burden High Impact Initiative
SaME	Elimination of Malaria in the Sahel
LLIN	Long-lasting Impregnated Mosquito Net
aOR	Adjusted Odds Ratio

Acknowledgments

The authors would like to acknowledge the chief physician of the Bogodogo health district and the heads of the various health facilities all their staff study for their due cooperation and involvement during the survey.

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Funding

This work is not supported by any external funding.

Data Availability Statement

The data is available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

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