



# Study of Factors Influencing the Intestinal Microbiota in Children from 0 to 3 Months at the Mother and Child Hospital of Bingerville, Ivory Coast during 2023

Grace Kemsol Miedjim <sup>a,b\*</sup>, Gbonon Mbengue Valérie <sup>a</sup>,  
Akaffou Adja Evelyne <sup>c</sup>, Ndôh Ngrabé Nodje-Assal <sup>d</sup>,  
Ndri Kouamé Mathias <sup>a</sup>, Guede Cataud Marius <sup>a</sup>,  
Assohoun Egomli Stanislas <sup>a,e</sup>, Marcelle Money Ettien <sup>a</sup>,  
Franck Djéda Gnahoré <sup>a,f</sup>, Ambroise Kouamé Kintossou <sup>a</sup>,  
Kouamé Clarisse <sup>a</sup>, Kangah Tatiana <sup>a</sup>, Afran Sidjè Arlette <sup>a,f</sup>,  
Diplo Flore <sup>a</sup>, Setchi Luc Olivier <sup>a</sup>, Koffi Stéphane <sup>a</sup>  
and Dosso Mireille <sup>a</sup>

<sup>a</sup> Institut Pasteur de Côte d'Ivoire, Côte d'Ivoire.

<sup>b</sup> UFR Medical Science, University Félix Houphouet Boigny, Côte d'Ivoire.

<sup>c</sup> Hôpital Mère et Enfant de Bingerville, Côte d'Ivoire.

<sup>d</sup> CHU « la Renaissance » of Chad, Chad.

<sup>e</sup> University Jean Lorougnon Guédé, Côte d'Ivoire.

<sup>f</sup> UFR Biosciences, University Félix Houphouet Boigny, Côte d'Ivoire.

## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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\*Corresponding author: E-mail: [gracekemsolmied@yahoo.fr](mailto:gracekemsolmied@yahoo.fr);

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## ABSTRACT

**Introduction:** Every human being builds a symbiosis with a diverse ecosystem of microorganisms: the intestinal microbiota. Its establishment, maturity, and composition evolving throughout life are dynamic processes influenced during their establishment by various factors such as gestational age, birth and feeding modalities, environment, and antibiotic use. The aim of this article is to identify the epidemiological characteristics (factors influencing the establishment and development of the intestinal microbiota) of populations of children from 0 to 3 months studied at the Mother and Child Hospital of Bingerville.

**Methods:** A longitudinal and prospective birth cohort of populations of children from Day 0 to Month 3 was conducted. Epidemiological data were collected from the mother after signing the informed consent form. Data collection tools included the survey form, information sheet, and informed consent form. Statistical analyses were performed using XLSTAT software version 2018. Chi-square test (significance test) was used on variables such as sex and gestational age, mode of delivery, gestational age and birth mode, and birth weight.

**Results:** A total of 52 infants were included. The socio-demographic and clinical characteristics of these newborns and their mothers were examined. Analysis of birth weight distribution according to mode of delivery and feeding mode did not reveal any significant association. Each studied characteristic was then discussed.

**Conclusion:** The objective of the study has been achieved. However, further research is needed to obtain more generalizable results.

*Keywords: Factors influencing; intestinal microbiota; infants 0-3 months; Mother and Child Hospital.*

## 1. INTRODUCTION

The external influences that can affect the behavior of the intestinal microbiota are becoming increasingly clear [1,2,3]. The development of the intestinal microbiota from early life is crucial for an equilibrium that occurs early in life [4,5]. Indeed, the intestinal microbiota plays an important role, especially in nutrient digestion, the immune system, and xenobiotic metabolism. The establishment of the intestinal microbiota is largely influenced at the time of birth, depending on exposure to maternal microorganisms, with significantly higher interaction during vaginal delivery compared to cesarean section [6,7]; This phase of gradual colonization of the intestinal microbiota in children represents a period of vulnerability [8]. Unoccupied intestinal ecological niches leave the immature intestine vulnerable to pathogens. Bacterial imbalances or decreased abundance result in altered functions. This can lead to intestinal dysbiosis, caused by

inadequate or unbalanced diet, infections, medication, stress, etc [9]; Inflammatory diseases, autoimmune diseases, allergies, infectious pathologies, and transit disorders are examples of manifestations of this phenomenon [10,11,12].

Many factors influence the establishment and development of the intestinal microbiota. These factors include, among others, gestational age, mode of delivery, feeding type, child's environment, medication use, and health status [13,14,15].

The acquisition of the intestinal microbiota in children requires special attention. Therefore, the objective of this study is to identify the epidemiological characteristics (factors influencing the establishment and development of the intestinal microbiota) of populations of children from 0 to 3 months studied at the Mother and Child Hospital of Bingerville.

## 2. MATERIALS AND METHODS

### 2.1 Materials

#### 2.1.1 Study setting, period, and population

The study was conducted at the Mother and Child Hospital of Bingerville, located in the autonomous district of Abidjan. It is a large specialized facility where many women and children seek medical care and follow-up. These individuals have varied lifestyles, hence the choice of this study setting. The study period extended from May 23 to June 27, 2023. The population of this study consists of children from Day 0 to 3 months born at the Mother and Child Hospital of Bingerville.

#### 2.1.2 Study type

This is a longitudinal and prospective birth cohort study of populations of children from Day 0 to Month 3.

#### 2.1.3 Inclusion criteria

Included in our study are all children from Day 0 to Day 3 of both sexes born alive at the Mother and Child Hospital of Bingerville, whose parents have agreed to participate in the study.

#### 2.1.4 Exclusion criteria

Excluded from our study are children who were not born at the Mother and Child Hospital of Bingerville, children over 3 days old, and children whose parents have not agreed to participate in the study.

### 2.2 Data Collection Method

Recruitment for this study was done randomly among children meeting the eligibility criteria, whose parents agreed to participate in the study, to answer questionnaires, and to respond to phone calls if necessary.

#### 2.2.1 Method of epidemiological data collection

Epidemiological data were collected from the mother. After childbirth, parents who agreed to participate in the study signed the informed consent form, and then the questionnaire was administered to them. We completed the questionnaire, which includes clinical data, medical history, and pharmacological treatment

prescribed before and after childbirth, from the mothers' medical records.

#### 2.2.2 Data collection tools

The data collection tools included the survey form, information sheet, and informed consent form.

#### 2.2.3 Modes of data entry and analysis

The data were collected using EPI Info™ software (CDC) version 7.2.4.0 to create the database and then exported to Excel. Statistical analyses were performed using XLSTAT software version 2018. Quantitative data were described using mean  $\pm$  standard deviation and median with interquartile range. Qualitative data were described in terms of frequency. Contingency tables (relationship between two quantitative and/or qualitative variables) and the Chi-square test (significance test) were used on variables such as sex and gestational age, mode of delivery, gestational age and birth mode, and birth weight.

## 3. RESULTS

We included fifty-two (52) infants aged from Day 0 to Day 3 for the initial recruitment of this study. Each percentage mentioned in this article was calculated on cohorts of close to 52 due to some missing data. The socio-demographic and clinical characteristics of the newborns and their parents were analyzed. The distribution of birth weights was studied according to mode of delivery and feeding mode, with an evaluation of statistical significance relative to the p-value.

### 3.1 Socio-demographic and Clinical Characteristics of Newborns at the Mother and Child Hospital

There was a significant predominance of full-term births, accounting for 94%, compared to 6% for premature births. Regarding the mode of delivery, newborns born by cesarean section are significantly more numerous than those born vaginally, with a respective frequency of 65% and 35%. Singleton births accounted for 92%, while twin and triplet births each accounted for 4%. Male individuals outnumbered female individuals, representing 71% and 29% respectively, thus establishing a sex ratio (M/F) of 2.45. No newborns had congenital anomalies at birth, and the most common Apgar score was 9/9, with 51%,

followed by 9/10 and 8/9, with 17% each. Overall, 83% of newborns were breastfed within 2 hours of delivery, while 17% were not breastfed within 2 hours of delivery. Mixed feeding was the most common, at 58%, followed by formula feeding only, at 29%. Exclusive breast milk feeding was the least practiced, with 14%.

### 3.2 Socio-demographic and Clinical Characteristics of Parents of Newborns at the Mother and Child Hospital of Bingerville

The results of our study reveal that the majority of parents of newborns have a higher level of education, representing 87% of the sample, followed by those with a secondary level of education, with a frequency of 10%. Individuals with no formal education account for 4% of the sample. This predominance of educated parents suggests a high likelihood that they are well-informed about practices favorable to the optimal growth and development of their newborns, particularly regarding dietary choices and the environment.

However, despite this level of education, the majority of parents are employed in services, representing 67% of the sample, while 21% are unemployed, and 12% are self-employed. This distribution suggests that many newborns could be exposed to mixed feeding due to the rapid

return of mothers to the workforce. It is noteworthy that 94% of mothers were on maternity leave, although 4% had to give birth during their period of employment.

Regarding the geographical distribution, the majority of families of newborns reside in Cocody (44%), followed by Bingerville (27%) and Yopougon (21%). Cocody is mainly inhabited by individuals with a high standard of living, while Bingerville is home to a population with a moderate standard of living. Yopougon, on the other hand, is a popular neighborhood characterized by socio-economic diversity.

Regarding family structure, 79% of parents of newborns live with other people, while only 21% live in a household composed solely of parents and the newborn. Finally, the presence of pets is rare in households, with only 6% of homes owning dogs.

The psychological state of mothers during the gestational period was mainly favorable, with 65% reporting feeling well, 33% feeling fairly well, and only 2% expressing discomfort due to health problems and stress related to concerns about their own health and that of their child. Regarding consumption habits, only 4% of mothers reported smoking cigarettes during pregnancy, while 96% did not consume them. Similarly, 8% reported alcohol consumption during pregnancy, while 92% stated that they did not consume it.

**Table 1. Table of frequency and percentage of socio-demographic characteristics**

Variables		Counts	Frequencies
<b>Gestational Age</b>	Term Birth	49	94%
	Preterm	3	6%
<b>Mode of Delivery</b>	Cesarean Section	34	65%
	Vaginal Delivery	18	35%
<b>Gender</b>	Female	15	29%
	Male	37	71%
<b>Weight</b>	1950g - 2515g	8	15%
	2615g - 2975g	12	23%
	3035g - 3445g	15	29%
	3630g - 4875g	17	33%
<b>Congenital Anomaly</b>	No	52	100%
<b>Breastfeeding Initiation 2 hours after Birth</b>	Yes	43	83%
	No	9	17%
<b>Feeding Mode</b>	Mixed Feeding	30	58%
	Artificial Formula Feeding	15	29 %
	Exclusive Breastfeeding	7	14%

**Table 2. Socio-demographic characteristics of parents of newborns**

Variables		Counts	Frequencies
<b>Level of Education</b>	Not Educated	2	4%
	Secondary	5	10%
	Higher	45	87%
<b>Employment</b>	Self-Employed	6	12%
	Employed	35	67%
	Unemployed	11	21%
<b>On Leave</b>	No	3	6%
	Yes	49	94%
<b>Place of Residence</b>	Adjamé	1	2%
	Bingerville	14	27%
	Cocody	23	44%
	Koumassi	1	2%
	Plateau Dokoui	1	2%
	Port Bouet	1	2%
	Yopougon	11	21%
<b>Married</b>	No	3	6%
	Yes	49	94%
<b>Other Persons</b>	No	11	21%
	Yes	41	79%
<b>Pets</b>	No	49	94%
	Yes	3	6%

**Table 3. Clinical characteristics of parents**

Variables		Counts	Frequencies
<b>Psychological State</b>	Fairly Well	17	33%
	Fairly Poor	1	2%
<b>Tobacco Consumption</b>	Well	34	65%
	Non	50	96%
<b>Alcohol Consumption</b>	Oui	2	4%
	No	48	92%
<b>High Blood Sugar Levels</b>	Yes	4	8%
	Don't Know	5	10%
	No	35	67%
<b>Family History of Diabetes</b>	Yes	12	23%
	Don't Know	5	10%
	No	27	52%
<b>Antibiotic Therapy Before Delivery</b>	Yes	20	39%
	No	35	67%
	Yes	17	33%

**Table 4. Distribution of birth weights according to mode of delivery**

Weight Intervals	Cesarean Section	Vaginal Delivery	Total	P - value
<b>1950 – 3200</b>	26 (74%)	9 (26%)	35 (67%)	> 0,05
<b>3290 – 4875</b>	8 (47%)	9 (53%)	17 (33%)	
<b>Total</b>	34 (65%)	18 (35%)	52 (100%)	

**Table 5. Distribution of birth weights according to feeding mode**

Weight Intervals	Mixed Feeding	Exclusive Breastfeeding	Exclusive Formula Feeding	Total	P - value
1950 – 3200	21 (60%)	2 (6%)	12 (34%)	35(67%)	> 0,05
3290 – 4875	9 (53%)	5 (29%)	3 (18%)	17(33%)	
<b>Total</b>	30 (58%)	7 (13%)	15 (29%)	52(100%)	

The majority of mothers maintained normal blood glucose levels during pregnancy, at 67%, while 23% had elevated levels, and 10% were unaware of their glycemic result either due to the absence of a test or lack of knowledge of the results. Regarding family history of diabetes, 52% of mothers reported no cases in their family, while 39% reported a family history of diabetes. Only 10% were unable to provide information on this topic.

### 3.3 Distribution of Birth Weights According to Mode of Delivery and Feeding Mode

Table 4 reveals that newborns with a birth weight between 1.950 kg and 3.200 kg were mainly born via cesarean section, representing 74%, while 26% were born vaginally. Conversely, newborns exceeding 3.200 kg were predominantly born vaginally, at 53%, while 47% were born via cesarean section. Statistical analysis indicates a p-value greater than 0.05, suggesting no correlation between birth weight and mode of delivery.

Similarly, Table 5 shows that infants with birth weights ranging from 1.950 kg to 3.200 kg were mainly fed with mixed feeding, accounting for 60%, followed by those exclusively fed with formula milk, at 34%. For newborns exceeding 3.200 kg, a majority were also fed with mixed feeding, at 53%, while 29% were exclusively breastfed. Once again, statistical analysis reveals a p-value greater than 0.05, suggesting no correlation between birth weight and feeding mode.

## 4. DISCUSSION

The concept that multiple factors influence a baby's gut bacteria is not novel [16]. In this study, we explored factors related to the socio-demographic and clinical characteristics of newborns and their parents. Gestational age at birth plays a fundamental role in investigations conducted in perinatal and infant health [17]. In this survey, we documented that 94% of births

occurred at term, exceeding 37 weeks of gestation, while 6% were premature. These results are consistent with those of GROSDÉMANGE A., who also noted a predominance of term births (81%) compared to premature births (19%). The method of delivery has a considerable and significant influence on the development of infants' intestinal microbiota. Indeed, the mode of delivery directly influences exposure to maternal microorganisms, with significantly increased contact during vaginal delivery compared to cesarean section [6,7]. Among the subjects included in this study, 65% gave birth by cesarean section, while 35% had a vaginal delivery. These data are consistent with those obtained by KONATE S (Mali), who also observed a cesarean section rate of 64.4% among their participants [18]. MARTA R. et al. (France), in 2019, on their part, obtained 78% of cesarean-delivered infants [19,20]. These high frequencies could be attributed to the fact that most newborns have a birth weight exceeding 3 kg, and some women opt for cesarean section to minimize the pain of childbirth. Additionally, this could be explained by the prevalence of certain conditions such as hypertension among some pregnant women, and even fatigue associated with late pregnancy may be a reason cited for requesting cesarean delivery.

Male individuals outnumber female individuals, representing 71% and 29% respectively, thus establishing a sex ratio (M/F) of 2.45. Our results are comparable to those of SETONDJI G. R. P. (Congo Kinshasa), who obtained similar findings [21].

Birth weight varied from 1950 g to 4875 g, with an average of 3099 g in this study. Several studies confirm that the composition of the microbiota is influenced by birth weight, notably those by Gregory et al. and Sohn et al. [22,23]. Our results are consistent with those of GROSDÉMANGE A. (France), who reported an average of 3319 Grams in his study [19]. The results of this study show a low proportion (7%) of newborns breastfed within the first two hours after birth compared to 22.90% reported by Traoré M. et al. [24]. This result is identical to

that of DIAWARA D. Y. (Bamako, Mali), who obtained 6.8% [25] but significantly lower than the 57.5% reported by the Mali Multiple Indicator Cluster Survey (MICS) in 2010 [26] 48% obtained in Senegal in the 2010-2011 MICS survey [27]. Thus, our result differs from the WHO recommendation, which states that breastfeeding should begin within thirty minutes of birth. Finally, this rate is similar to that found by Al Ghwass and DALIA Ahmed in Egypt, which was 10.4% [28]. However, initiating breastfeeding within 30 minutes after birth has been highlighted as beneficial for the duration of exclusive breastfeeding [29]. This low proportion of breastfeeding within 30 minutes after birth in this study could be explained by the fact that mothers were not informed about the practice of early initiation of breastfeeding. It could also be explained by the fact that there were more cesarean deliveries, and these women took longer to wake up. Consequently, they saw their newborns several hours after delivery.

The mixed feeding mode of the children was 58%, 29% were exclusively formula-fed, and 13% were exclusively breastfed. Our results differ from those in the literature [19]. This could be explained by the fact that most of the mothers recruited have professional occupations. Consequently, they prefer mixed feeding as they will not always be available to exclusively breastfeed their babies.

Occupation and educational level often determine the socio-economic status of patients, which is considered a potential risk factor during pregnancy and childbirth. Women with higher education levels (Baccalaureate +1 to +5) were more represented at 86%, compared to 10% with secondary education and 4% who were unschooled. Our results differ from those of OUSMANE Bé Sao, who found the highest prevalence of 31.1% for secondary education, while higher education had the lowest prevalence at 1.7%, and primary education was at 25.5% [18]. The higher attendance of educated women indicates that despite their occupations and intellectual backgrounds, they find the time to have children.

Most of the parents came from the Cocody district in the city of Abidjan, representing 44%. Yopougon is the second most represented district with 21%. The other districts of Abidjan each accounted for 2%. The city of Bingerville, where the study was conducted, was represented by 27%. This could be explained by

the fact that the city of Abidjan, which has the highest number (38 or 73%), is located right next to Bingerville and has a much larger population than Bingerville (14 or 27%).

Mothers who were in a relationship represented 94% of the cases. This rate was similar to those found by KONATE S (Mali), [18] DIALLO A. S. M. (Mali) [30] and DIAWARA D. F. (Bamako, Mali), [31] with 93.5%, 90.5%, and 98.3% of cases, respectively.

Psychologically, the majority of mothers were in a state of well-being, with 65%. 33% were moderately well, and 2% did not have an easy pregnancy due to being psychologically unstable with a lot of stress. In recent years, accumulated data indicate that the gut microbiota communicates with the central nervous system through endocrine signaling pathways (such as the hypothalamic-pituitary-adrenal axis), neural pathways (the vagus nerve), and immune pathways (cytokines), thus influencing brain function and behavior. These bidirectional communication pathways between the nervous system and the gut are referred to as the gut-microbiota-brain axis [32]. In response to stress, the body initiates an adaptive response that allows it to manage threatening stimuli. In cases of prolonged stress, the stress response fails to restore balance, and the inadequate response may be associated with various pathological conditions [33]. The consumption of tobacco and alcohol was less reported in our study. If this consumption were prevalent during pregnancy, it would constitute a significant risk factor for prenatal and postnatal morbidity and mortality. It is also a risk factor for atypical child development and health issues such as hypertension and diabetes in adulthood [34,35]. The high blood sugar rate during pregnancy in this study was 23%. This result differs from the data in the literature: REGNAULT N. in France with 8% [36] a European study with 2% to 6% [37] VIALA M. in Australia with 4.3%, the Indian subcontinent with 15% [38] LEYE A. in Senegal with 33.1%, [39] and DJOHAN YF in Côte d'Ivoire with 38.8% [40].

Regarding the administration of antibiotics, 33% of mothers received antibiotic treatment just before delivery, while 67% did not. These observations are consistent with the data reported in the scientific literature [19,20].

In conclusion, the distribution of birth weight according to the mode of delivery and the mode

of feeding shows no significant association [41,42].

## 5. CONCLUSION

The various factors influencing the establishment and evolution of the gut microbiota in children at the Mother and Child Hospital (HME) have been explored. The main route of microbiota acquisition in newborns is the mode of delivery. Vaginal delivery is associated with advantages for the infant, particularly due to the influence of the maternal microbiota composition on that of the baby. It is therefore conceivable to prepare for this transmission during pregnancy by considering probiotic supplementation. Additionally, the choice of feeding method plays a crucial role in the diversification of intestinal microorganisms. Breastfeeding, rich in lactobacilli, bifidobacteria, and oligosaccharides, contributes to the balance of the infant's gut microbiota.

Other variables, such as the environment and hygiene practices, must be taken into account. Excessive hygiene or reduced exposure to microorganisms in a sterile environment can also influence the establishment of the gut microbiota.

However, it is essential to conduct this study in multiple hospital settings and on a larger scale to facilitate comparisons and obtain more generalizable results.

## CONSENT

As per international standards, parental written consent has been collected and preserved by the author(s).

## ETHICAL APPROVAL

As per international standards or university standards written ethical approval has been collected and preserved by the author(s).

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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