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Antibiotics Susceptibility of *Salmonella* spp and *Shigella* spp Strains Isolated from Stools Culture at the Centre Hospitalier Universitaire Pédiatrique Charles De Gaulle from 2018 to 2022, Ouagadougou, Burkina Faso

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A B S T R A C T

Salmonella spp and *Shigella spp* are implicated in gastroenteritis. The increasing antibiotic resistance of these pathogenic bacteria is a public health problem in Burkina Faso. The aim of this study was to investigate the antibiotic susceptibility profile of Salmonella spp and Shigella spp strains isolated from coprocultures at the Centre Hospitalier Universitaire Pédiatrique Charles De Gaulle (CHUP-CDG). This was a descriptive cross-sectional study. Data were collected from 1 January 2018 to 30 April 2022 from patients in whom Salmonella spp and Shigella spp strains were identified from coprocultures at the biomedical analysis laboratory. The study population consisted of patients whose stool culture samples were received and analysed during the study period with complete data. Five thousand four hundred and eighty-seven (5487) coprocultures were performed during the study period, of which 1.6% (87/5487) were positive for *Salmonella spp* and *Shigella spp* 45.97% of the patients were aged between 1 and 29 months. Also, 54.02% were male, giving a sex ratio of 1.18 in favour of males. *Salmonella spp* and *Shigella spp* were susceptible to ceftriaxone (82.5%), imipenem (70.84%), ciprofloxacin (64.17%), chloramphenicol (63.33%), gentamicin (62.5%) and cefepime (57.5%). This study revealed a wide variety of *Salmonella spp* and *Shigella spp* serotypes circulating at the CHUP-CDG. As a result, the most commonly used and affordable antibiotics no longer appear to be effective against these strains.

Keywords

Salmonella, Shigella, sensitivity, antibiotics, CHUP, CDG

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Introduction

Diarrhoeal diseases and gastroenteritis are a major health problem worldwide, especially in developing countries where they are endemic (Dupeyron, 1997). The second leading cause of death in children under five, diarrhoea is responsible for 760,000 child deaths a year, with 1.7 billion cases of diarrhoea recorded each year worldwide (OMS, 2017). Bacteria of the *Salmonella* and *Shigella* genera are among the most common aetiological agents. They are the main contributors to acute enteric and diarrhoeal infections (Abu *et al.,* 2008).

The common route of infection for these pathogens is ingestion of contaminated food and/or drink (Switaj *et al.,* 2015). According to the WHO, there are an estimated 11 to 21 million cases of typhoid fever worldwide, with around 140,000 deaths annually (OMS, 2018). The majority of cases occur in South-East Asia, South Asia and sub-Saharan Africa (OMS, 2018). Burkina Faso is an endemic country for typhoid fever. According to the 'Global Burden of Diseases' study in 2019, 80,672 cases of typhoid fever were reported in Burkina Faso, with 356 cases per 100,000 inhabitants (OMS, 2022).

Shigellosis is widespread in all regions of the world, but is endemic in intertropical regions (South-East Asia, Equatorial, East and West Africa and Central America). According to the WHO, around 165 million cases of bacillary dysentery are reported each year, 162 million of them in developing countries, resulting in 1.1 million deaths, mainly among children under the age of 5 (Navia *et al.,* 1999). In Burkina Faso, *Shigella spp* infections are a major cause of gastroenteritis and diarrhoea, accounting for 42% of all cases. They are observed in patients of all ages, with a particular focus on children under five (Bonfiglio *et al.,* 2002).

Antibiotic resistance in a bacterium is defined as the absence of effect of an antibiotic to which the bacterial species is naturally sensitive, i.e. for which a therapeutic effect is expected during treatment at the usual dose by the general route (Waglechner and Wright, 2017). Some bacteria are resistant to several antibiotics and are known as multi-resistant. Resistance to antibiotics can be natural or acquired. Antimicrobial resistance (AMR) is increasingly recognised as a global public health problem, leading to high levels of morbidity and mortality (Ferri *et al.,* 2017; Opatowski, 2020). By 2050, global mortality attributed to AMR could reach 10 million per year, posing a significant threat to the global economy if measures are not taken to contain the problem (O'Neill, 2016). Recent AMR data collected from two million patients in 66 countries show high rates of resistance among antimicrobials commonly used to treat common bacterial infections (WHO, 2020).

In West African countries, the endemicity of respiratory infections, bacterial meningitis, diarrhoea and other infectious diseases has increased the consumption of antibiotics for both symptomatic treatment and prophylaxis (Ouedraogo *et al.,* 2017). Up-to-date data on bacterial resistance is particularly crucial for practitioners in countries such as Burkina Faso, where over-the-counter antimicrobial use and antibiotic abuse are widespread (Somda, 2014).

It was in light of this situation that this study was undertaken to estimate the prevalence of salmonellosis and shigellosis and their antibiotic susceptibility profile in coprocultures at the CHUP-CDG in order to improve patient management.

Materials and Methods

This work was carried out in the biomedical analysis laboratory, specifically in the bacteriology-virology unit of the CHUP-CDG in Ouagadougou. It was a descriptive cross-sectional study conducted from 1 January 2018 to 30 April 2022 on *Salmonella spp* and *Shigella spp* strains isolated from coprocultures. The study population consisted of inpatients and outpatients of any age who had undergone a stool culture at the CHUP-CDG biomedical analysis laboratory during the study period.

All patients whose stool cultures were received at the biomedical analysis laboratory, were positive for *Salmonella spp* and *Shigella spp* strains, had an antibiotic susceptibility test performed and provided complete data were included in the study. Sampling was systematic and exhaustive, and involved only patients who met the inclusion criteria.

We used an individual and anonymous data collection form for each positive result for *Salmonella spp* and *Shigella spp* strains, including the following variables: sampling period; patient identity (age, sex); patient status (inpatient or outpatient); bacterial strain isolated (*Salmonella spp* or *Shigella spp* strains) and antibiogram. The data sources were the coproculture registers of the biomedical analysis laboratory of the bacteriology-virology unit of the CHUP-CDG from 1 January 2018 to 30 April 2022. The sociodemographic variables considered were age, sex and patient status. Biological variables included pathogens isolated and their susceptibility to antibiotics tested. The data were recorded on a microcomputer and then analysed using Epi info software (French version 7.2.2.16). Graphs and tables were produced using Excel 2019. Antibiotic susceptibility testing is carried out at the CHUP-CDG using the Kirby-Bauër agar diffusion method, which classifies a pathogenic strain as sensitive (S), intermediate (I) or resistant (R), rather than as a 'moderately sensitive' therapeutic class. Its aim is to determine the sensitivity of a bacterial strain to various antibiotics and to guide clinicians in their choice of antibiotic to treat a bacterial infection. For each microbial strain, sensitivity or resistance to an antibiotic is different. We used Muëller Hinton (MH) agar for the antibiotic susceptibility test. Pure colonies in the growth phase on MH media, i.e. 24-hour-old colonies, were used to prepare the inoculum. A colony was removed from the agar and crushed in physiological water (0.85% NaCl). The bacterial suspension was homogenised and standardised at Mac Farland 0.5. The inoculum was inoculated onto the MH medium within 10 minutes of preparation using a sterile swab. The MH agar was first dried in an oven at 37°C and identified according to the sample number before handling. Using a dry sterile swab, the inoculum was taken and streaked over the entire surface of the agar three times, rotating the plate at 60°C after each application. La boîte a été séchée 5 minutes avant le dépôt des disques. The dish was dried for 5 minutes before placing the discs. The antibiotic discs were applied to the MH medium using sterile bacteriological forceps, pressing lightly on each disc. The distance between a disc and the wall of the Petri dish should be 1.5 cm and between two discs 3 cm. The whole set was then incubated at 37°C for 24 hours. After incubation, the inhibition diameters were measured. The susceptibility profile of each bacterium to the antibiotics tested was determined by reference to a reading table in accordance with CA-SFM (Comité de l'Antibiogramme de la Société Française de Microbiologie/ EUCAST (European Committee on Antimicrobial Susceptibility Testing). The study protocol was submitted to the CHUP-CDG administrative authorities for approval. The data were processed anonymously and in the strictest confidence for the patients.

Results and Discussion

During this study, 5487 stool cultures were performed with 87 samples positive for *Salmonella* and *Shigella*, representing 1.6% (95% CI: 0.68 - 2.52) of the total stool cultures received. Of the 87 strains isolated, 87.35% (95% CI: 78.50-93.51) were *Salmonella* and 12.65 % (95% CI: 6.48-21.50) were *Shigella*. Patients ranged in age from 2 to 780 months. Of a total of 87 patients with positive stool cultures for *Salmonella* and *Shigella*, 40 (45.97%) were infants. Figure 1 shows the distribution of patients according age groups.

Of the 87 patients whose samples were positive for *Salmonella* and *Shigella* strains, 54.02% were male, giving a sex ratio of 1.18. Of all the positive cases, 12.6% (11/87) were hospitalised and 87.4% (76/87) were outpatients. Most of in-patients came from the medical emergency department. Table 1 shows the distribution of patients according to whether they were hospitalised or not and the department from which they came.

Frequencies of pathogens identified according to gender. Table 2 shows the frequency of pathogens isolated according gender.

Frequencies of isolation of *Salmonella* and *Shigella* strains**:** *Salmonella* and *Shigella* strains isolated from stool cultures are shown in Table 3.

Salmonella spp and *Shigella flexneri* were the two species most frequently found, with stool frequencies of 68.97% and 5.75% respectively.

Trends in the prevalence of salmonellosis and shigellosis

Figure 2 shows changes in the prevalence of salmonellosis and shigellosis during the study period.

We note an increase in cases of *Salmonella spp* from 2019 onwards, with a slight decrease in 2020 and 2021. On the other hand, there was a decrease in cases of *Shigella spp* in 2019, 2020 and 2021.

Susceptibility of *Salmonella spp* strains to antibiotics

The sensitivity of *Salmonella spp* strains to antibiotics is shown in Table 4 below.

Salmonella spp were sensitive to ciprofloxacin (78.33%), gentamicin (75.00%), imipenem (66.67%), cefepime plus ceftriaxone (65.00%) and cotrimoxazole (60.00%).

Susceptibility of Shigella to antibiotics

Susceptibility of *Shigella flexneri* to antibiotics

The sensitivity of *S. flexneri* to antibiotics is shown in Table 5 below.

S. flexneri strains were 100.00% resistant to ampicillin, ciprofloxacin and co-trimoxazole. However, they were sensitive to imipenem (80.00%), gentamicin and chloramphenicol (60.00%).

Susceptibility of *Shigella spp* to antibiotics

The susceptibility of *Shigella spp* to antibiotics is shown in Table 6 below.

Shigella spp was sensitive to ceftriaxone (100.00%), imipenem (75.00%) and chloramphenicol (75.00%).

This section will be divided into three parts: socio-demographic characteristics, frequency of isolation of *Salmonella* and *Shigella* species in coprocultures, and susceptibility of *Salmonella* and *Shigella* strains to antibiotics.

According to the socio-demographic characteristics of the patients

The age group of 1 to 29 months was most represented with a frequency of 45.97%. Our results differ from those of Sawadogo (2020) in Burkina Faso, who found in 2020 that the age group of 180 to 960 months was the most affected, with a frequency of 57.50% (17).

On the other hand, they corroborate those of Leting *et al.,* (2022) during a cross-sectional study carried out in Kenya, who found that the 1-29 month age group was the most represented, with a frequency of 77.60% (18).

Such findings in our results could be explained by the study site (a paediatric hospital), the immaturity of the immune system, poor hygiene conditions and the impossibility for children in this age group to observe hygiene measures. In addition, the early weaning of children, the diversification of their diet, and the low level of awareness and information among childminders about hygiene measures increased the risk of infection with *Salmonella spp* and *Shigella spp*. Of 87 positive cases of salmonella and shigella, we found a frequency of 54.02% in men, with a sex ratio of 1.18.

Our results are similar to those of Leting *et al.,* (2022), who found a frequency of 51.50% for *Salmonella* and *Shigella* in men in a cross-sectional study conducted in Kenya in 2022. In 2021, Abera *et al.,* (2021) also found a frequency of isolation of *Salmonella* and *Shigella* of 54.30% in men in Ethiopia (Gebreegziabher *et al.,* 2018). Gebreegziabher *et al.,* in 2019 at Mekelle hospital in Ethiopia Ameya *et al.,* (2018) at Arba Minch in southern Ethiopia found *Salmonella* and *Shigella* isolation frequencies of 55.80% and 56.90% respectively in men.

This predominance of the frequency of isolation of salmonella and shigella in males could be explained by the high number of males in our sample. What's more, salmonellosis and shigellosis are diseases of dirty hands; men are the most exposed, since they are much more likely to frequent fast food outlets and collective restaurants where hygiene is questionable. Male children also tend to be more active and boisterous, which puts them at greater risk of *Salmonella spp* and *Shigella spp* infections.

According to the frequency of isolation of *Salmonella* and *Shigella* species in the coproculture

During this study, 87 samples were positive for *Salmonella spp* and *Shigella spp* strains in coprocultures. Of 87 isolated strains, 87.35% (76/87) were *Salmonella spp* and 12.65% (11/87) were *Shigella spp*.

Of *Salmonella* strains isolated, 68.97% (60/87) were *Salmonella spp*, i.e. These results corroborate those of Kompaore (2017) in Burkina Faso in 2017 who found that *Salmonella spp* was the most represented with a frequency of 72.22%(16).

However, these results differ from those of Somda in 2014 in Burkina Faso who found Salmonella paratyphi B to be the most isolated species with a frequency of 54.30% (Somda, 2014).

Table.1 Breakdown of patients by status and referring department

Patient status	Service de provenance	Frequencies (n)	Percentages (%)
Out-patients	Medical emergencies	76.0	87.4
In-patients		7.0	8
	Infants	4.0	4.6
Total		87.0	100.0

Table.2 Frequencies of identified pathogens according gender

Pathogens identified	Gender		Total n(%)
	Women n (%)	Men n (%)	
***Salmonella* du groupe C**	0 (0.0)	1 (2.13)	**1 (1.15)**
***Salmonella* du groupe A**	3 (7.5)	1 (2.13)	**4 (4.60)**
***Salmonella* du groupe B**	1 (2.5)	4 (8.51)	**5 (5.75)**
***Salmonella* du groupe D**	3 (7.5)	0 (0.00)	**3 (3,45)**
Salmonella spp	27 (67.5)	33 (70.20)	**60 (68.97)**
Salmonella arizonae	1 (2.5)	2 (4.26)	**3 (3.45)**
Shigella boydii	1 (2.5)	0 (0.00)	**1 (1.15)**
Shigella flexneri	1 (2.5)	4 (8.51)	**5 (5.75)**
Shigella sonnei	1 (2.5)	0 (0.00)	**1 (1.15)**
Shigellla spp	2 (5.0)	2 (4.26)	**4 (4.60)**
Total	**40 (100.0)**	**47 (100.00)**	**87 (100.00)**

Table.3 Frequencies of isolation of *Salmonella* and *Shigella* strains

Pathogens identified	Frequencies	Percentage (%)
***Salmonella* du groupe C**	1	**1.15**
***Salmonella* du groupe A**	4	**4.60**
***Salmonella* du groupe B**	5	**5.75**
***Salmonella* du groupe D**	3	**3.45**
Salmonella spp	60	**68.97**
Salmonella arizonae	3	**3.45**
Shigella boydii	1	**1.15**
Shigella flexneri	5	**5.75**
Shigella sonnei	1	**1.15**
Shigellla spp	4	**4.60**
Total	**87**	**100.00**

Table.4 Susceptibility of *Salmonella spp* strains (n = 60) to antibiotics

Antibiotics	Susceptibility		Resistant	
	Frequencies (n)	percentage (%)	Frequencies (n)	percentage (%)
Ampicillin	20	33.33	40	66.67
Amoxiclav	32	53.33	28	46.67
Cefepim	39	65.00	21	35.00
Ceftriaxon	39	65.00	21	35.00
Ciprofloxacin	47	78.33	13	21.67
Cotrimoxazol	36	60.00	24	40.00
Chloramphenicol	31	51.67	29	48.33
Gentamicin	45	75.00	15	25.00
Imipenem	40	66.67	20	33.33

Table.5 Susceptibility of *S. flexneri* (n=5) to antibiotics

Antibiotique	Susceptible		Resistant	
	Effectif (n)	Fréquence	Effectif (n)	Fréquence
Ampicilline	0	0	5	**5/5**
Amoxiclav	1	1/5	4	**4/5**
Cefepime	1	1/5	4	**4/5**
Ceftriaxone	2	2/5	3	**3/5**
Ciprofloxacine	0	0	5	**5/5**
Cotrimoxazole	0	0	5	**5/5**
Chloramphénicol	3	3/5	2	**2/5**
Gentamicine	3	3/5	2	**2/5**
Imipenème	**4**	**4/5**	**1**	**1/5**

Figure.1 Breakdown of patients by age group

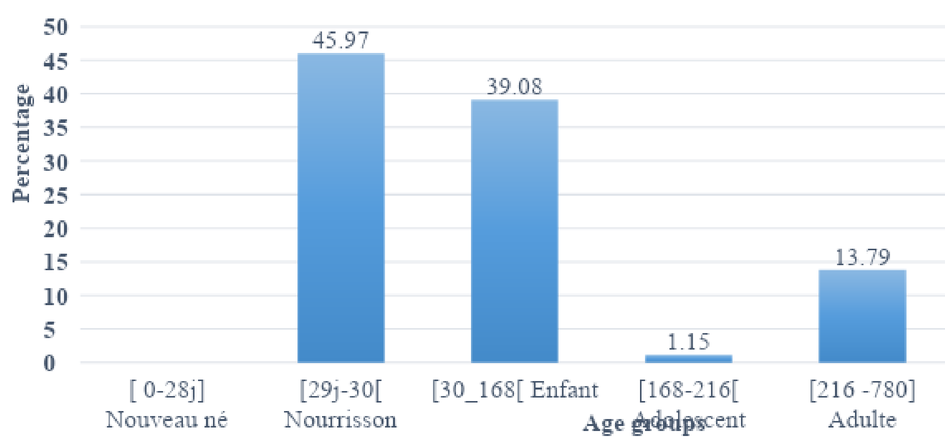
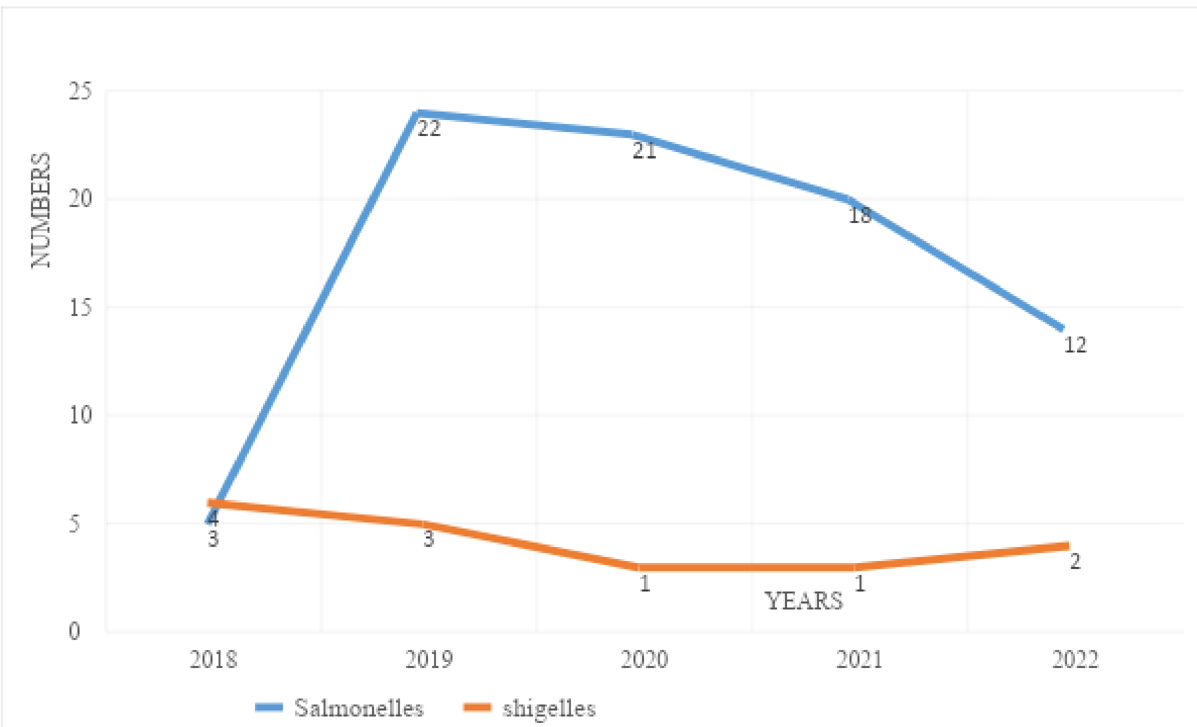


Table.6 Susceptibility of *Shigella spp* (n=4) to antibiotics

Antibiotiques	Susceptibility		Resistant	
	N	Frequencies	N	Frequencies
Ampicilline	1	1/4	3	**3/4**
Amoxiclav	2	2/4	2	**2/4**
Cefepime	2	2/4	2	**2/4**
Ceftriaxone	4	4/4	0	**0**
Ciprofloxacine	2	2/4	2	**2/4**
Cotrimoxazole	1	1/4	3	**3/4**
Chloramphénicol	3	3/4	1	**1/4**
Gentamicine	2	2/4	2	**2/4**
Imipenème	**3**	**3/4**	**1**	**1/4**

Figure.2 Trends in cases of salmonella and shigella over the study period



Our results could be explained by the non-availability of all the antisera for the identification of the different Salmonella serogroups and groups at the CHUP-CDG biomedical analysis laboratory. Among the Shigella strains, *S. flexneri* was the most isolated of the 11 Shigella strains, which confirms the data from several studies indicating that it is the most common of the 4 Shigella species in developing countries (Yang *et al.,* 2005). Mandomando *et al.,* in 2009 in Mozambique, Bonkoungou *et al.,* in 2013 in Burkina Faso and Tosisa *et al.,* in 2020 in Ethiopia also reported the same results.

According to the sensitivity of Salmonella and shigella strains to antibiotics

This study showed that Salmonella spp was sensitive to Ciprofloxacin (78.33%), Gentami-cine (75.00%), Imipenem (66.67%), Ceftriaxone and Cefepime

(65.00%) and co-trimoxazole (60.00%). Our results differ from those of Mengist *et al.,* (2018) in north-west Ethiopia in 2018 who found a sensitivity of 100% to ciprofloxacin and gentamicin, 75% to chloramphenicol and 62.50% to co-trimoxazole. Our results also differ from those of Somda in 2014 in Burkina Faso who found 100% sensitivity to ceftriaxone and cefepime, 97.56% to gentamycin and ciprofloxacin, 73.17% to chloramphenicol, cotrimoxazole and amoxicillin + clavulanic acid and 70.73% to imipenem. Another study conducted by Tadesse *et al.,* in 2019 in eastern Ethiopia also found different results to ours, with 100% sensitivity to gentamicin and ciprofloxacin and 76.90 to ceftriaxone and cotrimoxazole. This low frequency of sensitivity of salmonella strains to the antibiotics tested in our study can be explained by the overuse of antibiotics by humans in the face of the various diseases caused by salmonella. In developing countries such as Burkina Faso, people tend to self-medicate and use prohibited medicines sold on the street, because of their low standard of living. What's more, the poor use of drugs in the antimicrobial treatment of animals confers resistance to bacteria. When these same strains reach humans through food, already resistant to antibiotics, it will be difficult to eliminate them by antibiotic treatment (Somda, 2014). These practices contribute to the reduced sensitivity of *Salmonella spp* strains to antibiotics and to the rapid spread of antibiotic resistance.

This work also showed a high level of resistance in *S. flexneri* to ampicillin, ciprofloxacin and cotrimoxazole (100%); to amoxicillin + clavulanic acid and cefepime (80.00%) and to ceftriaxone (60.00%). However, it was sensitive to imipenem (80.00%), gentamicin and chloramphenicol (60.00%). A study conducted by Zhang *et al.,* in 2014 in China also found a high rate of antibiotic resistance in *S. flexneri* to ampicillin (100%), cotrimoxazole (74.1%), ciprofloxacin (74.1%) and cefepime (58.6%). Anandan *et al.,* in 2017 in South India and Beyene and Tasew in 2014 in South East Jimma, Ethiopia, also found 100% resistance to ampicillin and cotrimoxazole in *S. flexneri*. Also, *Shigella spp* was susceptible to ceftriaxone (100.00%), imipenem (75.00%) and chloramphenicol (75.00%). Our results are similar to those of Hayamo *et al.,* in 2021 in southern Ethiopia, who found a sensitivity of 100.00% for ceftriaxone; however, they differ for ciprofloxacin (77.8%) and gentamicin (55.6%). Mama and Alemu, in 2016 in southern Ethiopia found different results to ours with a sensitivity of 100.00% to gentamicin, ceftriaxone, chloramphenicol, ceftriaxone and a sensitivity of 60.00% to amoxicillin + clavulanic acid (Mama and Alemu, 2016). On the other hand, Shigella spp was resistant to ampicillin and cotrimoxazole with a frequency of 75.00%. Just like Marodi *et al.,* (2021) then Karimi-Yazdi *et al.,* (2020) in Iran with a respective frequency of 100.00% and 96.00% (Marodi *et al.,* 2021; Karimi-Yazdi *et al.,* 2020). This low frequency of sensitivity and the increase in resistance of shigella to antibiotics could be due to the irrational use of these molecules through self-medication before even going to the care center, the prescription of antibiotics particularly in outpatient medicine without first performing a culture to confirm the etiology and then performing an antibiogram. Anything that could help control the taking of inactive antibiotics (Somda, 2014).

In short, antibiotics could lose their effectiveness to different degrees due to these irrational uses. This phenomenon complicates the treatment of bacterial infections and promotes the emergence of multi-resistant strains.

This study was carried out at the biomedical analysis laboratory of the CHUP-CDG in the bacteriology-virology unit. Its objective was to study the antibiotic sensitivity profile of Salmonella spp and Shigella spp strains isolated from stool cultures from January 2018 to April 2022. This was a cross-sectional study with a descriptive aim relating to the data from the above period on Salmonella spp and Shigella spp strains. From this study, we found that men were the most affected with a frequency of 54.02%. As for the antibiogram, it made it possible to determine the sensitivity profile of salmonella and shigella to the antibiotics used in our context. Thus, salmonellae showed greater sensitivity to ciprofloxacin, gentamicin, imipenem, ceftriaxone and cefepime, respectively. Shigellae showed greater sensitivity to ceftriaxone, imipenem and chlororamphenicol. Knowledge of the sensitivity of *Salmonella spp* and *Shigella spp* to antibiotics allows us to better understand the problem of antibiotic resistance in our health context. It would be wise to rationalize the use of antibiotics both in hospital and outpatient settings and to be rigorous in the dispensing of antibiotics in pharmacies for efficient management of salmonellosis and shigella. Also, we should sound the alarm to denounce the resistance of certain strains of Salmonella spp and *Shigella spp* to the antibiotics most used in our context such as ampicillin and cotrimoxazole.

Limitations and constraints of the study

During the completion of this work, we encountered a certain number of difficulties. This mainly involved breakdowns in antisera for the identification of the different serogroups and groups of *Salmonella spp* and *Shigella spp*. The same is true for the rupture of antibiotic discs. Nevertheless, despite these shortcomings, we managed to obtain results which will serve as a basis for work for future times.

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Author Contributions

Kambiré Dinanibè: Investigation, formal analysis, writing—original draft. Ouédraogo Oumarou: Validation, methodology, writing—reviewing. Tondé Issa:—Formal analysis, writing—review and editing. Sankara Francine, Tamboura Mamadou: Investigation, writing—reviewing. Paré Raoul: Resources, investigation writing—reviewing. Zouré Adou-Azaque: Validation, formal analysis, writing—reviewing. Sagna Tani: Conceptualization, methodology, data curation, supervision, writing—reviewing the final version of the manuscript. Compaoré T. Rebeca: Investigation, formal analysis, writing—original draft. Soubeiga Serge Théophile: Validation, methodology, writing—reviewing. Paré Jean Eudes Saïdou:—Formal analysis, writing—review and editing. Barro Lassina: Investigation, writing—reviewing. Kpoda Dissinviel Stéphane: Resources, investigation writing—reviewing. Savadogo Stanislas: Validation, formal analysis, writing—reviewing. Zoungrana Arouna: Conceptualization, methodology, data curation, supervision, writing—reviewing the final version of the manuscript. Ouédraogo Henri Gautier: Investigation, formal analysis, writing—original draft. Sangaré Lassina: Validation, methodology, writing—reviewing. Sanou Idrissa:—Formal analysis, writing—review and editing. Diagbouga Serge: Investigation, writing—reviewing. Kouanda Seni: Resources, investigation writing—reviewing. Ouédraogo/Traoré Rasmata: Validation, formal analysis, writing—reviewing. Sanou Mahamoudou: Conceptualization, methodology, data curation, supervision, writing—reviewing the final version of the manuscript.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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