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ANALYSIS OF ANTIBIOTIC CONSUMPTION IN BAMAKO HOSPITAL CENTERS WHOSE EFFLUENTS END UP IN THE NIGER RIVER

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ABSTRACT

The consumption of antibiotics in hospitals in Mali is remarkable. The large hospitals at the top of the country's health pyramid are at the heart of this problem. The objective of this study remains the analysis of antibiotic consumption in five large hospitals in Bamako during 2018-2020 and to measure the concentration of antibiotics in the Niger River through hospital effluent discharges. The penetration index was chosen as a tool to measure antibiotic exposure. It takes into account the total amount in grams of antibiotics divided by the Defined Daily Dose established by the WHO. Liquid chromatography in tandem with a mass spectrometer was used to detect and measure the concentration of antibiotics in the effluent in the environment. Three families of antibiotics, including beta-lactam (69%), fluoroquinolones (22%) and macrolides (17%), have brought hospitals together to prescribe antibiotics, in this case amoxicillin (157.6 DD/1000), ciprofloxacin (128.8 DD/1000) and erythromycin (222.4 DD/1000). Effluent concentrations averaged 6.06 µg/L of amoxicillin, 24.9 µg/L of ciprofloxacin and 1.38 µg/L of erythromycin. The occurrence of antibiotic detection was on average (> 70%).About 20% of the total antibiotic load through hospital effluent was sent directly into the Niger River; 50% via sewage systems and the rest through runoff and infiltration. Optimizing antibiotic prescribing and setting up a national network for monitoring and analyzing antimicrobial consumption are necessary to rationalize antibiotic consumption.

Keywords: Antibiotics, prescription, consumption, hospitals, Niger River.

1. INTRODUCTION

The consumption of antibiotics around the world is a global concern. The global volume of antibiotic consumption at 40.2 billion of the Defined Daily Dose (DDD) established by the World Health Organization in 2018, an increase of 46% since 2000 [1]. Antibiotic consumption in 2018 varied between high- and low-income countries, with rates of 20.6 DDD and 13.1 DDD per 1000 inhabitants per day. Indeed, in West Africa, the DDJ per 1000 inhabitants has increased from 972 in 2005 to 2,112 in 2015 when all antibiotics sold are considered [2].

Mali is one of the West African countries where antibiotics are quite widely used in hospitals. Several studies have looked at the consumption of antibiotics in hospital care units in Mali [3; 4]. However, these studies have focused on very limited cohorts through the analysis of prescription dispensing [5; 6]. To our knowledge, no study has been published at the same time on the annual consumption of antibiotics in the 5 major hospitals in Bamako that is the subject of this study. The objective of this study is to complete the information on antibiotic consumption in the 5

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hospitals of Bamako during the period 2018-2020. The analysis of antibiotic consumption through data on drug prescriptions collected from hospital pharmacies over the period 2018-2020 will make it possible to further update trends in antibiotic consumption in hospitals in Mali. Consequently, to provide information on the probable presence of antibiotic residues in the Niger River through hospital effluent discharges.

2. METHODES

2.1. Data collection

The data were collected from the pharmacies of 5 major hospitals: the Gabriel Touré Hospital (HGT), the Point G Hospital (HPG), the Mali Hospital (HM), the National Center for Odontostomatology (CNOS) and the Golden Life Hospital (HGL) in Bamako over the period 2018 – 2020.

2.2. Consumption of antibiotics

The penetration index was chosen as a tool to measure antibiotic exposure. It takes into account the total quantity in grams of antibiotics divided by the DDJ, which is the average daily dosage administered to a 70 kg adult for a specialty used in its main indication divided by the number of days of hospitalization carried out (reflecting the activity of the health care services).

2.3. Link of antibiotic consumption with the Niger River

The environmental disposal of processed products of drugs consumed in hospitals was examined. This was done by tracing the path of wastewater from hospitals to the final points of discharge into the environment.

2.4. Occurrence of antibiotics in the Niger River

The occurrence of antibiotics in the environment was observed through the concentrations measured in hospital effluents sent to the Niger River. High-pressure liquid chromatography (HPLC) in tandem with a mass spectrometer was used to detect and measure the concentration of antibiotics in effluent at the environmental discharge endpoint.

3.RESULTS AND DISCUSSIONS

3.1. ATC classes of the most prescribed molecules

According to the Anatomical Therapeutic Chemical (ATC) classification, between 2018-2020, the drugs used for anti-infectives for systemic use, those for the nervous system, those for the musculoskeletal system, those for antiparasitics and finally those for the cardiovascular system of the classification (ATC level I) were the therapeutic classes most prescribed and consumed by patients in the five large hospitals in the study (Figure 1).

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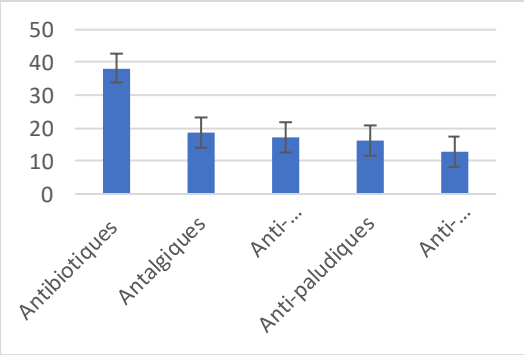

Figure 1. Average percentages of the most prescribed therapeutic classes in the five major hospitals in Bamako in the period 2018-2020.

Pharmaceutical products (PPs) in the class of anti-infectives for systemic use stood out with (38.2%) and those of the nervous system (18.6%), i.e. more than half in the representativeness ratio. They are followed by those of the musculoskeletal system (17.2%), antiparasitics (16.25%) and last and last and last drugs for the cardiovascular system (12.75%).

3.2. Most commonly prescribed antibiotic families

The prescription of antibiotics is subdivided into three main families: beta-lactams,fluoroquinolones and macrolides. The beta-lactam family (69%) was the most prescribed during the 2018-2020 period (Table 1). In similar studies, beta-lactam (55.3%), imidazole (14.9%), aminoglycosides (14.9%), quinolones (7.9%) and macrolides with 7% were prescribed at the CHU-Antananarivo [7]. In the Democratic Republic of Congo (DRC), the prevalence of antibiotic use was 54.8% in health centres in Kisantu [8].

Table 1. Antibiotic Prescribing by Therapeutic Family

Hôp.	% Bêta-lactamines	% Macrolides	% Fluoroquinolones
CNOS	30	2	5
HGL*	5	5	3
HGT	5	4	4
HPG	20	4	5
HM	9	2	5
Total	69	17	22

* 2020 data

3.3. Mapping of antibiotic contamination of the Niger River in the 5 hospitals

From the geographical coordinates of the water outlet points at the hospital (P0) and final discharge (PF) levels and by following the flow paths, it was possible to trace the wastewater routes of the 5 hospitals. This made it possible to generate the map of contamination of the Niger River by the effluents of these hospitals in Bamako at a scale of 1:50,000.

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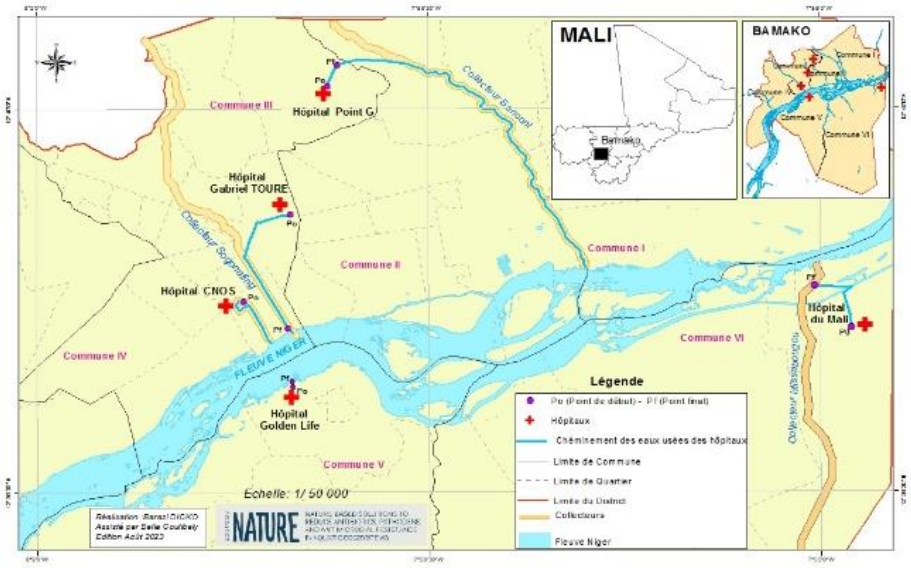

Figure 2. Map of the flow of effluents from hospitals to the Niger River in Bamako.

3.4. Environmental dynamics of antibiotics.

At the final point of discharge of effluents into the environment, in three days of sampling, three antibiotic products belonging to different therapeutic families, namely amoxicillin, beta-lactams, ciprofloxacin, fluoroquinolones and erythromycin, macrolides. Metabolites such as metronidazole* (4 µg/L) and metronidazole-hydroxy (42.66 µg/L) were detected through effluents. The occurrence of antibiotic detections in the environment was on average (> 70%).

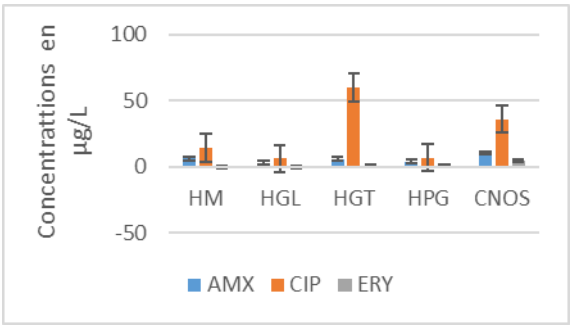

Figure 3. Concentrations of antibiotics detected in effluent at the environmental landfill in 2022.

Similar results have been achieved around the world. Ciprofloxacin has been observed in river water through the discharge of hospital effluents in France at an average concentration of 97 ng/L [9]. Amoxicillin and erythromycin were detected in the effluent of the Point G hospital in Bamako, Mali, at concentrations of 0.066 ± 0.08 µg/L and 0.04 ± 0.0 µg/L, respectively [10].

3.5. Risks associated with the presence of antibiotics in the Niger River.

Specific studies have not been conducted in this study to assess the effect of antibiotics on the fauna and flora of the Niger River.

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However, they cannot be exempt from potential risks. Indeed, the continuous spillage and the level of occurrence of antibiotics in the Niger River remain in favor of this problem. In just three consecutive days of sampling, the five major hospitals in Bamako returned to the environmental environment an average concentration of 6.06 µg/L of amoxicillin; 24.9 µg/L of ciprofloxacin; 1.38 µg/L of erythromycin.

Certainly, the phenomena of self-purification of the river are in favor of reducing the concentrations of these antibiotic products like any other pharmaceutical product intended for consumption, however, drugs are biologically active compounds, selected for their specific action(s) on the body. Exposure outside of the medical or veterinary setting can lead to unintended effects (toxic or disruptive effects) on living beings [11].

The phenomenon of photosensitization can be caused by the occurrence of antibiotics in the water. Indeed, since the Niger River is under the permanent influence of sunlight, the intensity of solar irradiation with the presence of antibiotics could generate free radicals such as OH-; NO3- etc. toxic to the aquatic environment. Growth inhibitions have been reported in single-celled algae from 100µg/L after 72 hours, and in rare cases, from 2µg/L following exposure to PP (ciprofloxacin) [12]. This sufficiently demonstrates a risk of the presence of antibiotics in the environment in Mali. In addition, the continuous discharge of drug residues, particularly antibiotics, into the water of the Niger River could lead to bioconcentration and bioaccumulation of these in the organisms of species in the aquatic environment and subsequently their presence in the food chain. As a result, a path towards antibiotic resistance. Fluoroquinolones have been reported in China in living organisms at concentrations up to 68,000 ng/g, with a frequency of 39% [13].

4. CONCLUSION

Three families of antibiotics have brought together hospitals in the prescription of antibiotics, beta-lactam (69%), fluoroquinolones (22%) and macrolides (17%) and consumed respectively on average through amoxicillin (757 DDD/1000), ciprofloxacin (587 DD/1000) and erythromycin (418 DD/1000) within the 5 hospitals of Bamako during the period 2018-2020.

During the 2022 period, in just three consecutive days of detections, the total concentrations of antibiotic residues sent to the environment from effluent discharges from the five major hospitals in Bamako averaged 6.06 µg/L for amoxicillin; 24.9 µg/L for ciprofloxacin and 1.38 µg/L for erythromycin. About 20% of the total load of antibiotic residues through hospital effluents was sent directly into the Niger River in Bamako; 50% through the city's sewer systems and the rest through the runoff process.

These results should encourage the optimization of antibiotic prescribing and the establishment of a national network for monitoring and analyzing the consumption of these antimicrobials.

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