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Risk Factors for Surgical Site Infections in Patients Operated at the University Clinic of Traumatology-Orthopedics and Restorative Surgery of the National Hospital and University Center Hubert Koutoukou Maga in Cotonou

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Abstract

Background: Operative site infections (ISO) are typically nosocomial. According to the WHO the incidence of ISO varies from 0.5% to 15% and exceeds 25% in developing countries. They result from the combined action of several factors and represent a concern for public health. To study the contributing factors of surgical site infections in patients operated at the University Clinic of Orthopedic Traumatology of CNHU-HKM of Cotonou. **Method:** This was an analytical cross-sectional study that involved 35 operated patients and ten nurses. Were included in our study: 1) All patients, without distinction of sex or age, having been operated on in the university clinic of orthopedic traumatology, during the survey period; 2) Patients hospitalized for post-operative care during the survey period; 3) The nursing staff on duty during our study period. The usual statistical measures were used according to the type of variables: means, standard deviations, percentages. Data analysis first involved calculating percentages for the qualitative variables and means followed by their standard deviations for the quantitative variables. Next, the Pearson Chi-square test was used to test the association between the dependent variable and the independent variables of interest. The significance level is set at $p < 0.05$. **Results:** The prevalence of surgical site infections was 28.58%. The main factors contributing to the occurrence of SSIs that were found were the patient's level of education ($p = 0.003$) and the reuse of ban-

dages used for dressing (p = 0.004). Other potential factors such as the economic status of the patient, the poor quality of technical dressings, and the preoperative stay were also highlighted. **Conclusion:** Surgical site infections remain a global concern. Risk factors were found on both the patient and nurse sides. It is urgent to address these various factors to minimize the occurrence of surgical site infections.

Keywords

Surgical Site Infection, Nosocomial Infections, Risk Factors, Patient, Benin

1. Introduction

Nosocomial Infections (NIs) are known worldwide and occur in both low- and middle-income countries as well as in high-income countries. These infections acquired in healthcare facilities are among the leading causes of patient morbidity and death. Surgical Site Infections (SSIs) are NIs that occur in the direct (30 days) or distant aftermath of surgery and are directly related to it. Statistics on the prevalence of NIs rank SSIs second only to Urinary Tract Infections (UTIs). They account for 2% of surgical interventions in developed countries [1]. SSIs remain a leading concern for health care facilities, despite the availability of antibiotics, improved anesthesia techniques, and advances in preventive measures [2].

Healthcare-Associated Infection (HCAIs) is a reflection of the quality of care delivery in a healthcare system [3]. The prevention of HCAIs is a requirement for the quality of care offered to populations [4]. The safety of care requires the strict application of hospital hygiene guidelines. There is a significant association between poor hospital hygiene and the occurrence of HCAIs [1].

The prevalence of such infections reveals the weakness of the health system in ensuring the safety of patient care [4]. The epidemiology of NIs complies with the main principles of communicable diseases. Studies conducted between 2005 and 2008 in developed countries in Europe and the United States revealed that the prevalence of HCAIs ranged from 5% to 15% among hospitalized patients. They can affect 9% to 37% of patients admitted to intensive care units, with a mortality rate from 12% to 80% [5] [6]. In France, a study conducted in 2006 reported that the prevalence of NIs was 5.38% [7]. In 2008, a study involving 55 hospitals in 14 countries showed that, on average, 8.7% of hospitalized patients were affected by Nis [1]. In Africa, various studies have highlighted the prevalence of HCAIs. In Morocco, the prevalence of HCAIs was 6.7% in 2007 [8]. Surveys in Tunisia in 2004 and Morocco from 1994 to 1995 (Ibn Rochd hospital in Casablanca) reported a prevalence of 6.5% and 2.03% [9] [10] [11]. Since 2006 in Benin, efforts have been made to control HCAIs, but data on the issue are not always available [4]. A study in 2012, conducted at the National Hospital and University Center Hubert Koutoukou Maga (CNHU-HKM), but in the operat-

ing theaters, reported a prevalence of NIs of 6.17% [12]. According to a study conducted in orthopedic trauma surgery at the CNHU-HKM in Cotonou, the prevalence of SSIs was 9.59% with a predominance of deep infections (85.2%) [13]. A recent study conducted in 2015 in the same center reported a prevalence of 9.84% [4]. Accepting to take charge of a patient implies the obligation for the health care staff to implement all means of preventing SSI. There is a great need for research on the prevalence and risk factors involved in the occurrence of SSI.

This study aimed to highlight the risk factors for SSIs in patients operated on at the University Clinic of Traumatology-Orthopedics and Restorative Surgery of the CNHU-HKM in Cotonou.

2. Materials and Methods

2.1. Study Area

This study took place at the University Clinic of Traumatology-Orthopedics and Restorative Surgery (CUTO-CR) of the CNHU-HKM. The CNHU-HKM offers reference care that cannot be provided in other health centers and is also the main health facility in Benin. It is a center for care, research, and training of health workers. It also carries out social actions. Within the CNHU-HKM, there is the University Clinic of Hospital Hygiene (CUHH). The CUHH is transversal to the visceral surgery, urology, and traumatology departments to improve their quality in terms of hygiene.

2.2. Study Design and Sampling

It was an analytical cross-sectional study that took place in 2019. The primary targets were patients who had been receiving surgery in the CUTO-CR during the study period. The secondary targets were the nurses on duty during the study period at the CUTO-CR. The sample size was 35 surgical patients and ten nurses.

2.3. Study Variables

The dependent variable was the occurrence of SSIs. SSI referred to:

- a purulent discharge from a surgical wound or surgical drain,
- a discharge from a wound or surgical drain with a positive or negative microbiological culture,
- a wound requiring reopening,
- and/or a diagnosis of infection by the surgeon.

The independent variables were:

- the patient's level of education,
- the patient's hospitalization category,
- the number of days spent in the department before the intervention,
- having a shower before the procedure,
- having shaved the area where the procedure will take place before the block,
- having received antibiotics before the procedure,

- using the same bandage strip that was applied for the dressing,
- having the financial means to purchase dressing materials each time and the frequency with which the hospital bed sheet is washed.

2.4. Data Collection and Analysis

We collected data through a document review, interviews, a questionnaire survey, and observations. Data analysis was conducted using SPSS 21. We first described the study variables by presenting the frequencies and percentages or the means and standard deviations. A Chi-square test was used to assess the associations between the dependent variable and each of the independent variables. The level of statistical significance was set at $p < 0.05$.

3. Results

3.1. Characteristics of the Nursing Staff

The mean age of nurses was 40.6, with a minimum of 35 and a maximum of 50. The nursing staff at CUTO-CR was equally divided between men and women. Only one nurse in ten was a specialized State Registered Nurse, compared to four who were health action controllers. The mean professional experience of the nurses was 16.4, with a minimum of 10 and a maximum of 24. Only 3 out of 10 nurses had professional experience of 5 years or more. More than half of the nurses (7/10) said they had received additional training in hospital hygiene guidelines.

3.2. Characteristics of Patients

The majority of patients surveyed (74.29%) were male. Nearly half (40%) of the patients were between 29 and 39 years old compared to 20% who were over 50 years old. Most of the patients (74.28%) were in a couple versus 22.86% who were single. Twenty percent of the patients were traders, 14.29% were civil servants, and 8.57% were artisans. Besides, 74.28% of the patients had a high level of education against 17.14% who had no formal education.

3.3. Process for Preventing Surgical Site Infections

All the nurses had reported having done the patient's hygiene, shaving, and disinfection of the operating site before each operation, *i.e.* the day before the operation. All nurses reported handwashing before and after each wound dressing. Most of the nurses (9/10) said that they had provided nursing care to patients undergoing surgery in the department.

3.4. Nurses' Perception of Factors that Promote Surgical Site Infections

According to the nurses, the multiple patient visits and the bringing of luggage to the hospital wards would favor the occurrence of SSIs. Five out of ten nurses indicated that wounds with external fixators would be at greater risk of SSIs,

compared to three nurses who said that wounds with drains would be at greater risk. The majority of nurses (8/10) reported that surgical wound dressing equipment was not adequate and nine out of ten nurses reported having defective dressing clips. Most of nurses highlight using sterile gloves and examination gloves when dressing. This situation reflects the lack of standardization of protocols when nurses perform dressing procedures on the ward. More than half of the nurses (7 out of 10) said that sterilization of dressing materials would not be adequate. All nurses surveyed pointed out that all dressing boxes on the ward are incomplete. This situation would influence the occurrence of SSIs, especially as the standards require a complete box in the production of dressings, in addition to those for surgery. More than half of the nurses (6/10) claimed that the ward is cleaned once a week. This could increase the accumulation of microorganisms in the ward environment, given that most patients are in common rooms.

3.5. Clinical and Therapeutic Patient Data

Table 1 presents the clinical and therapeutic data of the patients operated on. Almost all patients (94.29%) were admitted to the clinic because of a road traffic injury and were hospitalized in a common ward. We note that 48.57% of the patients had spent less than two days in the ward before the intervention, and about 45% of patients had spent 2 to 7 days. The majority of patients (71.43%) reported showering before the intervention. Notably, 54.29% of patients said shaving at the pre-block area of the intervention. Most patients (51.43%) pointed out that they had not received antibiotics before the intervention. The majority of patients (65.71%) said using Betadine (polyvidone-iodine) as their dressing, compared to 20% of those who reported using hydrogen peroxide, and only 2.86% reported using saline for their dressing. Besides, 11.43% of patients claimed they would re-use the same bandage again for dressing. Of the patients, 28.57% reported infection in their surgical wounds. Nearly half of the patients (48.57%) said they washed their sheets once every three days, compared with 34.29% who washed their sheets once a day. The majority of the patients surveyed (80%) reported that nurses did not perform nursing.

Factors associated with the occurrence of surgical site infection.

Among those operated on, 26.8% developed a surgical site infection. The analysis of Table 2 showed that there was a statistically significant association between the level of education of the patient ($p = 0.03$), the reuse of the same tape that was used for the dressing ($p = 0.004$) and the wound infection.

We note that 66.67% of patients who have no level of study have their wound which has been infected and 100% of patients who have reused the same strip which was used for the dressing declared that their wound has been infected.

There was no relationship between the patient's category of hospitalization, the number of days spent in the service, the fact of having had a shower before the intervention, the fact of having had the part where will take place the intervention before the block, the fact of having received antibiotics before the intervention, the fact of having financial means the fact of having financial means

Table 1. Distribution of patients according to clinical and therapeutic data of patients.

Variables	Frequency	%
Reason for entry		
Road accidents	33	94.29
Victim of armed robbery	1	2.86
Free fall	1	2.86
Category of hospitalisation		
Common room	33	94.29
Cabin	2	5.71
Number of days spent in the service		
before the operation		
Less than 2 days	17	48.57
2 to 7 days	16	45.71
More than a week	2	5.71
Shower before the operation		
Yes	25	71.43
No	10	28.57
Shaving of the intervention site		
Yes	19	54.29
No	16	45.71
Antibiotics received before the operation		
Yes	17	48.57
No	18	51.43
Type of antiseptic used during the dressing process		
Betadine	23	65.71
Hydrogen peroxide	7	20.0
Dakin	4	11.43
Salt serum	1	2.86
Re-use of the same bandage for the dressing		
Yes	4	11.43
No	31	88.57
Surgical wound infection		
Yes	10	28.57
No	25	71.43
Frequency of sheet washing		
Once a day	12	34.29

Continued

Once every 3 days	17	48.57
Once a week	6	17.14
Nursing provided by nursing staff		
Yes	7	20.00
No	28	80.00

Table 2. Factors associated with the occurrence of surgical site infection

Variables	Total (n = 35)	Surgical site infection		p-value
		Yes (%)	No (%)	
Level of education				
None	6	4 (66.67)	2 (33.33)	
Primary	3	0 (0)	3 (100.0)	0.03*
Secondary	13	1 (7.69)	12 (92.31)	
Superior	13	5 (38.46)	8 (61.54)	
Category of hospitalisation				
Common room	33	9 (27.27)	24 (72.73)	0.50
Cabin	2	1 (50.0)	1 (50.0)	
Number of days spent in the department before the intervention				
Less than 2 days	17	6 (35.29)	11 (64.71)	
2 to 7 days	16	3 (18.75)	13 (81.25)	0.39
More than a week	2	1 (50.0)	1 (50.0)	
Shower before the operation				
Yes	25	7 (28.0)	18 (72.0)	1
No	10	3 (30.0)	7 (70.0)	
Shaving done				
Yes	19	5 (26.32)	14 (73.68)	1
No	16	5 (31.25)	11 (68.75)	
Antibiotics received before the operation				
Yes	17	4 (23.53)	13 (76.47)	0.71
No	18	6 (33.33)	12 (66.67)	
Re-use of the same bandage that was applied for the dressing				
Yes	4	4 (100.0)	0	0.004*
No	31	6 (19.35)	25 (80.65)	
Existence of means to buy dressing material each time				
Yes	24	5 (20.83)	19 (79.17)	0.23
No	11	5 (45.45)	6 (54.55)	

Continued

Frequency of sheet washing				
Once a day	12	3 (25.0)	9 (75.0)	0.48
Once every 3 days	17	4 (23.53)	13 (76.47)	
Once a week	6	3 (50.0)	3 (50.0)	

and wound infection ($p > 0.05$).

4. Discussion

The prevalence of SSIs in the CUTO-CR at the CNHU HKM was 28.57%. In Tunisia, Latifa *et al.* (2018) reported a prevalence of 19.1% of SSIs in General and Visceral Surgery and 14.8% in Orthopedic [14]. Our study showed that the occurrence of SSIs is the result of the combined actions of factors related to patients and health care staff. Nearly half of the patients in our study were between 29 and 39 years old. El Rhazi *et al.* (2008) reported in their study that the mean age of patients was 35.25 ± 21 years. Our sample was composed of as many men as women [8]. Only one nurse was a specialist. The mean age of the nurses was 40.6 with a minimum of 35 and a maximum of 50. These data corroborate with the results found by Souli in 2017 in Burkina Faso (Souli 2017) [15]. On the other hand, (Yaouba 2014) found that 60% of the nursing staff were female, and the mean age of respondents was 35.85 years [15].

In our study, we did not find a significant association between the duration of the number of days spent in the department before the intervention and the occurrence of SSIs. There is no link between the category of hospitalization and SSIs. We have explored patient-specific factors that may directly or indirectly contribute to the occurrence of SSIs. These were the patient's level of education and re-use of dressing strips. These results are consistent with those of Yaouba in 2014, which showed that 91% of patients who used previous dressing strips and accessories developed SSI [16]. Our study did not reveal a significant association between having the financial means to purchase the material each time and wound infection. Laurence in 2012 also found that patients were blamed by the nursing staff for the occurrence of care-associated infections. All nurses reported the unavailability of good medical technical equipment in the ward. The equipment is obsolete and unsuitable, which would have a significant influence on the occurrence of SSIs. Laurence in 2012 found a similar discourse of nurses who denounced a lack of adequate equipment to take care of patients [17].

This situation is not conducive to the prevention of SSIs because, as Lucet and Birgand point out in 2016, the availability of material resources plays an important role in the effective application of infection control (Birgand and Lucet 2016) [18]. All nurses suggested increasing the number of staff to reduce the workload per person. To this end, the high workload is perceived by nurses as a factor that may contribute to the occurrence of SSI. The nurses of the difficulties in providing care in large numbers while meeting hospital hygiene requirements.

Amiel in 2005 highlighted the constraints faced by healthcare professionals who are concerned about the need to provide care over time, but also the risk of exposing themselves or the patient to infections [19].

The same perceptions were found among health care staff by Carricaburu *et al.* (2008), who pointed out that high workloads were associated with the occurrence of HCAIs. In our study, shaving was not associated with the occurrence of SSI. Our results are in contrast to those in the literature which reported that preoperative shaving influences surgical risk [20]. These studies reported that patients who did not have a preoperative shave were at greater risk of surgical site infection than those who had a shave (Haidara 2008) [21].

Several studies have shown an increased risk when hair was removed with a hand-held razor compared to an electric razor or epilation. Also, when a hand-held razor was used, the risk was double when shaving was done within 24 hours before surgery compared to shaving immediately before surgery. SSIs increased the length of the postoperative stay. The longer the postoperative stay, the greater the risk of site infection (Chadli *et al.* 2005; Garba *et al.* 2018) [22] [23]. Also, it should be noted that factors such as the number of preoperative days performed in the ward, the patient's economic situation, and the frequency of sheet washing could have a significant influence on the occurrence of SSIs.

Among the nursing staff, potential factors lead to SSIs were the lack of nurses specialized in trauma and orthopedic surgery in the department (one nurse out of ten); the problem related to the performance of nursing in the patient department. Other factors were noted such as the poor quality of the technical equipment used to make dressings, the inadequacy of the sterilization of equipment in the ward with boxes of dressings that were incomplete and filled with defective and obsolete clamps. All of the above could significantly influence the occurrence of SSIs. Strict adherence to the current standards for the prevention of SSIs is based on standard protocols that should be applied in all care facilities, especially in the surgical sector. In our study, it was found that the nursing staff was experienced in countering the threat of SSIs (70% of the nurses had received at least one continuous training course in hospital hygiene). Thus, the preparation of the patient for the operating room was essentially done by the nurses. According to their statements, they were responsible for 100% of body hygiene on the day before surgery, depilation of patients followed by disinfection of the operating site, preparation of the patient on the day of surgery, and nursing for the new patient. Besides, the majority of the operations were performed according to a well-defined and known schedule (32 out of 35 scheduled operations), so the staff had time to fine-tune the preparation. The gestures and procedures were not uniform and or in conformity with the standards.

Ten out of thirty-five patients reported not receiving a shower before going to the operating room, while sixteen out of thirty-five patients hammered at not being shaved before the procedure. Of the nineteen patients in whom hair removal was performed, a hair clipper was used in only one case vs. a blade for the others; this is in direct contravention of the provisions in force. The postpone-

ment of surgery due to infection was not negligible (41.67%), but paradoxically 51.43% of the patients operated on reported not receiving antibiotic prophylaxis before to surgery. The nurses responsible for 94.29% of the dressings in the ward, who were real workers in the management of surgical wounds, mostly used Polyvidone Iodine dressings (65.71% of the dressings), which made the majority of surgical wounds previously dry but not oozing. All these data lead us to say that the process of preparation for the operating theatre as well as the level of observance of hygiene rules would be insufficient and would not be regulated by a fixed protocol applicable in the ward.

The ISO prevention policy is centered on the combined action of the different actors in the system, including the patients themselves. Awareness among patients would be a considerable asset in the fight against the factors favoring SSIs. These patients would have information on SSIs and it is for this reason that they develop actions to counteract the factors.

5. Conclusion

The results we obtained show that the occurrence of SSIs in CUTO-CR is linked to the re-use of tapes from previous runs by patients, the patient's level of education who do not apprehend most of the time the consequences of SSIs. Among the personnel, potential factors were noted. Notably, there are the glaring lack of nurses specialized in trauma and orthopedic surgery in the department, the problems related to the nursing in the department for operated patients, the poor quality of the technical equipment used for the production of dressings, the inadequacy of the sterilization of the equipment in the department with boxes of dressings that are incomplete and filled with defective and obsolete clamps.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Questionnaire Pour Le Personnel

Dans le cadre de notre recherche sur les **Facteurs favorisants des infections du site opératoire chez les patients opérés à la clinique universitaire de Traumatologie Orthopédique du CHNU HKM de Cotonou."**

INFORMATIONS GENERALES

1-Age /____/_____/ ans

2-Sexe Masculin ☐ Féminin ☐

3-Qualification professionnelle: CAS/IDE ☐ IS/Infirmier Breveté ☐

IDE Spécialisé ☐ IAS/IDE ☐

4-Ancienneté professionnelle /____/_____/ ans

5-Ancienneté dans le service: moins de 5 ans ☐ ≥5 ans ☐

6-Faites-vous la toilette corporelle du patient a la veille des interventions? OUI ☐ NON ☐

7-Faites-vous le rasage a la veille des interventions? OUI ☐ NON ☐

8-Procéder vous a la désinfection du site opératoire a la veille des interventions? OUI ☐ NON ☐

9-Faites-vous le nursing au patient opérés? OUI ☐ NON ☐

10-Avez-vous suivis une fois une formation sur les mesures d'hygiènes hospitalières? OUI ☐ NON ☐

11-Faites-vous le lavage des mains avant et après chaque pansement? OUI ☐ NON ☐

12-selon vous, quels sont les comportements des patients qui favorisent les infections du site opératoire?

Beaucoup de visite ☐ Défaut d'hygiène corporelle ☐ Apport des bagages dans les salles ☐

13-Quels sont selon vous les types de plaies qui sont sujet aux infections du site opératoire

Plaies avec fixateur externe ☐ Plaies avec drain ☐

Autre à préciser----------

14-Disposez-vous du matériel adéquat pour le pansement OUI ☐ NON ☐

15-utilisez-vous toujours lors des pansements des: Gants stérile ☐ Gants d'examen ☐

16-Pensez-vous que le matériel de pansement est-il bien stérilisé? OUI ☐ NON ☐

17-à quel rythme se fait le nettoyage des locaux dans le service

Une fois par semaine ☐ une fois par mois ☐

18-Avez-vous des pinces en bon état? OUI ☐ NON ☐

19-Disposez-vous des boites a pansement au complet? OUI ☐ NON ☐

20-Quelles suggestions faites-vous pour éviter la survenue des infections du site opératoire?

Merci d'avoir répondu à nos questions

QUESTIONNAIRE POUR LES PATIENTS

Fiche N°……. Date de collecte: ……/…….

Dans le cadre de notre recherche sur les **"Facteurs favorisants des infections du site opératoire chez les patients opérés à la clinique universitaire de Traumatologie Orthopédique du CHNU HKM de Cotonou.**

A/IDENTIFICATION DU PATIENT

Nom et prénoms du malade……

1-Catégorie d'hospitalisation Salle commune ☐ Cabine ☐

2-Sexe M ☐, F ☐

3-Age: 18 à 28 ans ☐, 28 à 38 ans ☐, 38 à 48 ans ☐ 48 ans à plus ☐

4-Quelle est votre profession……

5-Situation Matrimoniale……

6-Quelle est votre nationalité: Béninoise ☐ Autres à préciser----------

7-Quel est votre niveau d'étude a) Illettré; b) primaire; c) secondaire; d) supérieure

8-Quel est votre motif d'entré……..

9-Date d'admission ……

10-Combient de jours avez-vous passé dans le service avant votre intervention …….. Jours

11-Avez-vous subi une douche avant votre intervention? OUI ☐ NON ☐

12-a-t-on rasé la partie où se déroulera l'intervention avant le bloc? OUI ☐ NON ☐

Si OUI, par quel matériel: Une tondeuse ☐ Une lame ☐

13-avez-vous reçu des antibiotiques avant l'intervention OUI ☐ NON ☐

Si oui pendant combien de jours----------

14-Votre intervention a-t-elle été reportée une fois? OUI ☐ NON ☐

Si oui cela est due à: Une infection ☐, indisponibilité du matériel ☐

manque de moyen financier ☐

15-votre intervention est-elle: programmée ☐ ou en urgence ☐

16-quel est le site de votre intervention? ----------

17-Quel est l'état de votre plaie actuellement: Plaie humide ☐ plaie sèche ☐

18-avec quoi votre pansement est-il réalisé? Bétadine ☐, Eau oxygéné ☐,

Dakin ☐, Autres à préciser----------

19-qui sont ceux qui se chargent de la réalisation de votre pansement?

Infirmier ☐ médecin ☐ aide-soignant ☐

20-Réutilisez-vous la même bande qui a servi pour le pansement? OUI ☐ NON ☐

21-Votre plaie a-t-elle été infectée? OUI ☐ NON ☐

22-Avez-vous les moyens pour acheter le matériel de pansement chaque fois? OUI ☐ NON ☐

23-Comment faites-vous la gestion des bandes: Eliminer ☐ Recycler ☐

24-A quelle fréquence votre drap est lavé?

25-le personnel infirmier vous assure-t-il le nursing? OUI ☐ NON ☐

26-Avez-vous été repris pour une nouvelle intervention? OUI ☐ NON ☐

27-Comment éviter l'infection des plaies opératoires selon vous?

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Retrospective Epidemiological Analysis of Colles' Fracture in Patients Admitted in Fernandes Távora Hospital

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Abstract

Background: Colles' fracture is a type of fracture of the distal third of the radius and its most common cause is falling from patient's own height and, epidemiologically, it is more common in the elderly. **Objectives:** The main objective of this study is to analyze the epidemiology of Colles' fracture retrospectively, in patients admitted to Fernandes Távora Hospital. **Materials and Methods:** This retrospective study conducted at the Fernandes Távora Hospital used 1030 radiographic images of patients with wrist fractures. **Results:** (After a careful analysis) It was found that this type of fracture occurred with a greater frequency in age groups of 50 to 69, 60 to 69, and 40 to 49 years old, which corresponds to 59.5% of patients and the most affected sex were females (51.1%). **Conclusion:** The study concluded that this type of bone injury is more common in people aged 40 to 69 years old, especially in women, because of their geometry and bone composition. It is evident that Colles' fracture impacts the life of the affected person, therefore, an adequate diagnosis and treatment having utmost importance.

Keywords

Fracture, Colles' Fracture, Epidemiology

1. Introduction

Colles' fracture is defined as a fracture of the distal third of the radius, in which the fragment moves posteriorly without extending to the articular surface. It was named after the Irish surgeon Abraham Colles who, even before the advent of radiography, in 1814, described the fracture for the first time.

The most common cause of injury is falling from one's own height, where the individual rests on the flattened hand. This causes the distal end of the radius to absorb the impact [1].

According to large-scale epidemiological studies conducted in the United States, Colles' fracture tends to be distributed in a bimodal manner, affecting mainly young people in puberty, during sports, as well as the elderly, especially women over 50 with osteoporosis [2].

This disease, despite not being the result of major complications for the affected younger population, has special relevance in the loss of quality of life in the elderly population [2], which has gained attention and deserved specialized studies, since the global demographic trend shows an increase in the number of this population [3].

The present study aims to elucidate the epidemiological characteristics of this fracture in a tertiary hospital in the capital of Ceará, in order to elucidate the local epidemiology and, consequently, provide data for health professionals and technical support for local public policies.

2. Methods and Materials

2.1. Study Design

2.1.1. Location

A retrospective study was carried out at Hospital Fernandes Távora, a hospital complex founded more than 50 years ago, located at Avenida Francisco Sá, 5445-Álvaro Weyne, zip code: 60335-195, in Fortaleza, Ceará. The images for the analysis were collected from the hospital's surgical center database from April 2022 to June 2022.

2.1.2. Sample

For the study, 1030 radiographic images of fractures of patients admitted to the hospital from June 2021 to June 2022 were collected in both Posterior-Anterior (PA) and Anteroposterior (AP) views, in addition to profile view, using the descriptors "wrist" and "forearm" in the *software* that stores the patients' radiographic images, in order to have a higher prevalence of Colles' fractures.

2.2. Inclusion and Exclusion Criteria

To select the images from the hospital database, some inclusion and exclusion criteria were used in order to determine the most reliable sample possible made up only of Colles' fractures.

2.2.1. Exclusion Criteria

Radiographic images of patients with only a single radiographic view in PA or

AP were discarded, because these views alone by themselves make it impossible to classify the types of distal radius fractures.

Smith's and Barton's fractures were disregarded, because even though they involve fracturing the distal third of the radius, they do not fit the characteristics of Colles' fracture.

Galeazzi and Monteggia fractures were also disregarded because they are not restricted only to distal fractures of the radius, and can occur in the radius diaphysis and ulna extension.

Additionally, repeat images of the same patient were excluded, also excluded radiographs of the same patient from both limbs.

2.2.2. Inclusion Criteria

We considered all the radiographic images of patients that have only a single incidence, provided that this is the profile, because with this incidence it was possible to identify Colles' fracture.

All radiographic images of patients with more than one radiographic image (profile, AP and/or PA) were considered, as they enable the identification of this type of fracture.

All radiographic images registered as "wrist" and "forearm" that have features of Colles' fracture will be included.

2.3. Proposed Methodology

After approval by the ethics and research committee, the researchers surveyed the radiographic images and then selected the images meeting with the characteristics of Colles' fracture, following the inclusion and exclusion criteria presented in item 2.2.

After this selection, based on age and gender, the patients were allocated to the previously defined age groups to trace the epidemiological profile. Then, the data were quantified and illustrated by statistical analysis.

2.4. Risks and Benefits

In the research, there was no risk to the patients because their radiographic images were only used for the epidemiological analysis of the study. The results obtained from the research will bring scientific contribution since there is scarce epidemiological information on this subject in the consulted databases. Furthermore, given the epidemiological importance of the topic, the approach will enable a better and faster diagnosis of Colles' fracture due to improved clinical reasoning.

2.5. Outcomes

2.5.1. Primary Endpoint

To determine the epidemiological groups most affected by Colles' fracture at Fernandes Távora Hospital, defining priority and risk groups for clinical analysis and hospital service improvement.

2.5.2. Secondary Endpoint

To differentiate the types of distal third fracture, quantify the patients affected by Colles' fracture at the Fernandes Távora Hospital, thus outlining an epidemiological profile.

2.6. Ethical Aspects

The research is indirectly involving human beings and is committed to treating them in their dignity, respecting their autonomy and defending them in their vulnerability, obeying the ethical principles of beneficence, non-maleficence, justice and equity.

All patient data contained in the radiographs were used solely and exclusively for the research, and the confidentiality of such information was fully preserved.

This research has not and will not cause any harm to the patients whose images will be used in the analysis.

2.7. Data Analysis Methodology

The data obtained from the collection of radiological images with the diagnosis of Colles' fracture were tabulated and analyzed using GraphPad Prism 8 software. Comparisons with a p-value up to 0.05 were considered significant. Exactly 1030 radiographic images were collected for this study with the descriptors "wrist" and "forearm" fracture from the hospital software. After applying the inclusion and exclusion criteria, 230 images were selected and classified as Colles' fracture, and the 800 excluded images were of other fracture types. All records were stored in a virtual cloud by using the application Google Docs.

3. Results

After a thorough evaluation of the images of patients affected by Colles' fracture, the age groups were divided, and consequently, the allocation of patients who fit into the age groups was performed. Graph 1 represents the number of fractures for each group of patients within their respective allocated ages affected by the Colles' fracture.

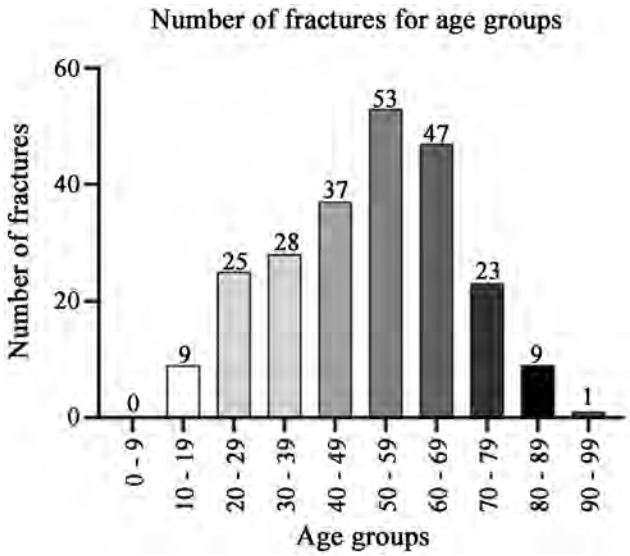
According to Graph 1, the group from 0 to 9 years old had no patients affected by Colles' fracture. In the group from 10 to 19 years old, it reached 9 patients. In the 20 to 29 age group, it affected 25 patients, 28 patients were in the 30 to 39 age group, and 37 patients were in the 40 to 49 age group. In the 50 to 59 age group it reached 53 patients. In the 60 to 69 age group, it reached 47 patients. In the 70 to 79, 80 to 89, and 90 to 99 age groups it reached 23, 9, and 1 patients, respectively.

It can be observed that, according to Graph 1, the group of patients who were most affected by Colles' fracture were those aged 50 to 59 years old with 53 patients, followed by the group aged 60 to 69 years old with 47 patients, and then the group aged 40 to 49 years old with 37 patients affected by Colles' fracture. If the three age groups are added together, the total reaches 137 patients affected

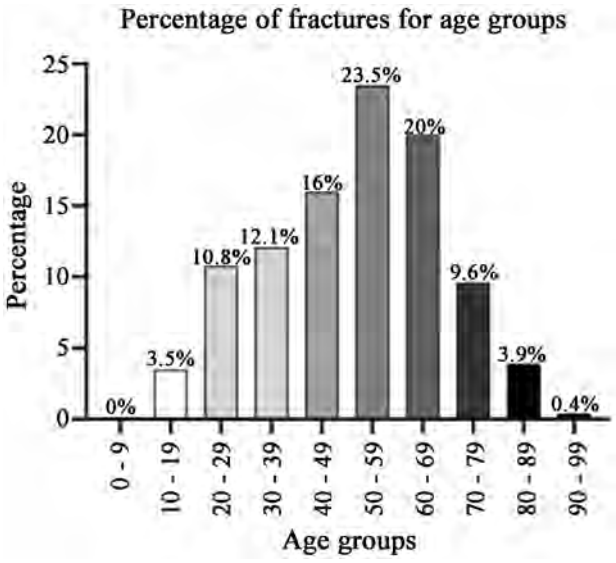
by Colles' fracture out of 232 patients brought to this study, corresponding to approximately 59.5% of the patients.

According to Graph 2, the group from 0 to 9 years old had no patients affected by Colles' fracture, and consequently reached 0%. In the group from 10 to 19 years old, it reached 3.5% of patients. In the 20 to 29 age group it reached 10.8% of patients, 12.1% of patients were in the 30 to 39 age group, and 16% of patients were in the 40 to 49 age group. In the 50 to 59 age group it reached 23.5% of the patients. In the 60 to 69 age group, it reached 20% of the patients. In the 70 to 79, 80 to 89, and 90 to 99 age groups, it reached 9.6%, 3.9%, and 0.4% of the patients, respectively.

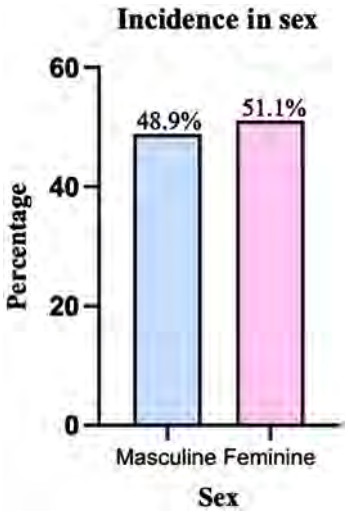
It can be observed that, according to Graph 2, the group of patients that most affected by Colles' fracture was those aged 50 to 59 years old with 23.5% of the



Graph 1. Number of Colles' fractures by age group.



Graph 2. Percentage of Colles' fractures by age group.



Graph 3. Incidence of Colles' fractures by gender.

patients, followed by the group aged 60 to 69 years old with 20% of the patients, and then the group aged 40 to 49 years old with 16% of the patients affected with Colles' fracture.

According to Graph 3, the female group has a slight predominance in the number of patients affected by Colles' fracture with 51.1%.

These sex differences were expected to occur due to osteoporotic and osteopenic conditions that preferentially affect women.

4. Discussion

Fractures can impact the patient's social life because of limited mobility that compromises social activity [1]. The predominantly female gender of most populations indicates that these were generally representative of people who suffer these injuries in industrialized societies [2].

Our study shows prevalence of Colles' fracture mostly between 40 and 79 years and slightly bigger prevalence in women, which differs from another researches that suggest a bi-modal distribution for Colles' fracture, mainly in the pediatric sport practicant population and women over 50 [3].

This difference in the pediatric population may be due the absence of more violent or radical sports which are more common in developed countries, that proportion more opportunities for fracture's then soccer, the most popular sport in Brazil's pediatric population [4]. Although there are a few epidemiological studies on Colles' fracture in the pediatric population in Brazil to confirm these hypotheses.

The incidence of a distal radius fracture in patients older than 50 years old was 77/10,000 person-years among women in 2005 and 63/10,000 person-years in 2013. The incidence of a distal radius fracture in men in the same age group was 18/10,000 person-years in 2005 and 14/10,000 in 2013 [5].

This higher incidence found in older people is related to the increased progression of the incidence of osteopenia in this population group, contributing to

the increased prevalence of osteoporotic fractures [6]. Because of this relation with osteoporosis, its prevention is linked to a lower risk of distal radius fractures [3].

The most common trauma mechanisms for this type of fracture in young adults come from high-energy trauma with intra-articular components. In the geriatric population, the most common fracture pattern is extra-articular [7].

In another study, the mean age of the cohort was 51.5 years and was slightly female dominant (51.5%), with demographic data on the main fractures. Most patients were classified as coming from urban areas (81.9%; rural 16.2%) [8].

For distal radius fractures and multiple radial and ulnar fractures, the highest proportion of fractures occurred in the 51 - 65 age group. Distal radius fractures were more prevalent in females at 73.3% [8].

Another study shows that distal radius fractures were by far the most common wrist fractures, with over 16,000 cases in the 51 to 65 age group. There were more cases in females through all age groups, although the difference was small in the 18 to 40 year age category and became highly sex-differentiated in the older age groups, such as the 51 to 65 year age group (12,615 females versus 3759 males) [8].

In a case-control study, it was observed that postmenopausal women who had been diagnosed with Colles' fracture had a lower bone mineral density than the control group and that the incidence of osteoporosis was higher in the group with fractures. Women have high risks of fracture due to their geometry and bone composition [9].

At age 50, there is a large increase in the amount of distal radius fractures in women when compared to men, although the population contains very similar numbers of men and women at this age [8]. The results of the present study corroborate the data already published in the literature.

5. Limitations

During the study, limitations were found, among them the presence of a single radiological view in PA or AP, which made the analysis difficult, as it is only possible to classify the types of distal radius fractures with the use of both views.

Another difficulty was the presence of other types of fractures, such as Smith's and Barton's fractures, which were disregarded, because even though they involve a fracture of the distal third of the radius, they do not fit Colles' fractures.

Galeazzi and Monteggia fractures were also excluded from the study, as they are not restricted only to the distal portions of the radius, and may affect the radius diaphysis and ulna extension. Finally, all repeated radiographs of the same patient were excluded from the study.

6. Conclusion

From this study, we conclude that Colles' Fracture is very clinically relevant and has a prevalence among people aged 40 to 69 years, especially females (51.1%).

In this analysis, the results obtained validate the data already exposed in the literature. Thus, it is evident that Colles' Fracture impacts the patient's social life and mobility, making its diagnosis and adequate treatment essential, with the inclusion of radiographs in two views (anteroposterior and profile) for a better wrist evaluation.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Assessing School-Based Water, Sanitation and Hygiene (WASH) Facilities in Peri-Urban Settings of Kinshasa, DR Congo

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Abstract

Background: Kinshasa's peri-urban settings have a low rate of water access, which has significant consequences for the WASH infrastructures in schools and preventative measures against the spread of waterborne diseases and pathogens. This study aimed to assess the availability, functionality, and gender sensitivity of WASH infrastructures of Kinshasa's peri-urban schools. **Methods:** A cross-sectional study was performed in three of the four educational provinces of Kinshasa, targeting 165 peri-urban schools. Data were collected using a questionnaire and an observation grid. **Results:** An overall proportion of 10.9% of schools possessed a water point, and therefore time-consuming water chores are a necessity in 89.1% of schools. Girl students provided 30% of the labor collecting water during punishments. A total of 98.2% of schools had functional latrines of which 3.6% were found hygienic, associated with water reserve next to the latrines ($P = 0.040$). Only 2.4% of schools displayed posters raising awareness of latrine hygiene, and 3.6% displayed posters on hand hygiene. The ratios of latrines units for girls were 58:1 for toilets and 115:1 for urinals, justifying open defecation and urination reported in 62.4% of schools. Also, 43% of schools had hand-washing facilities whose functionality was significantly associated with the presence of water points in the school's inner courtyard ($P = 0.032$), with water ($P < 0.001$), and with soap availability ($P < 0.001$). In total, 2.4% of schools had laundries for menstrual hygiene management. **Conclusion:** The majority of schools had limited drinking water services, which negatively impact the functionality and gender sensitivity of other WASH provisions. The current evidence as a public health concern would raise government and school authorities' attention to address these environmental threats.

Keywords

Water Access, Latrine Hygiene, Hand Hygiene, Gender Sensitivity, Schooled Girl Students

1. Background

Water, sanitation, and hygiene (WASH) services are essential for promoting population health, especially in the current context of the COVID-19 pandemic where frequent handwashing is an essential preventative measure against the spread of pathogens [1]. WASH services are vital for schools to promote the achievement of their primary mission of ensuring quality education for young people in a healthy environment. A dirty physical environment, poor water quality, and inadequate hygiene practices can have significant consequences on school children's health and well-being [2] [3].

Based on improved and adapted WASH infrastructure, schools can improve health, education, gender equality, and the prevention of gender-based violence (GBV), while using consistent WASH facilities [4] [5] [6]. To achieve this, schools need to be equipped with services that meet the minimum quality requirements for WASH programmes [1] that ensure sustainable provision of water of sufficient quantity and quality, provide sanitation services that enable school community members to dispose of excreta without risk to health and the environment as well as providing menstrual and personal hygiene programmes and equipment for girls [7] [8]. Availability, functionality, and access without structural barriers to WASH facilities for all students should therefore be guaranteed and sustained. It is also important that schools should be provided with gender-specific, or gender-sensitive facilities, meeting WHO standards related to gender-segregated use, and the number of students per latrine and urinal [9] [10].

WHO has estimated that most schools around the world lack water, sanitation, and hygiene facilities [11]. In 2016, 69% of schools worldwide had a basic drinking water service, while 12% had a limited drinking water service (no access to drinking water within 30 minutes of water collection). Nineteen percent of these schools did not even have a supply of drinking water [12].

In sub-Saharan Africa, a third of schools lack toilets and less than half have sanitation facilities [12]. In terms of gender, 335 million girls worldwide attended schools without essentials to ensure menstrual hygiene management [12].

A previous assessment conducted by UNICEF in 49 resource-limited countries reported that only 51% of schools had adequate access to water, and 45% had adequate toilets [3] [13]. The results of these studies suggested that various gender and socio-sanitary consequences are likely to occur as a result of little attention to WASH-related issues. Thus waterborne and dirty-hands diseases such as cholera, salmonellosis, shigellosis, and helminthiasis can emerge and lead to negative impacts on health as well as physical, mental, social well-being, learning

abilities, school attendance, school achievements, and can also increase the inequality between girls and boys [14] [15] [16] [17].

In the DRC, access to WASH infrastructures in rural and peri-urban settings is supported by the National Rural Water Service, and the government partners such as UNICEF, USAID, UKaid, Oxfam through the National Healthy School and Villages Program (PNEVA), a joint programme of the National Ministries of Health and Education.

In the city of Kinshasa, the supply and access to drinking water are characterized by many disparities, and inequalities based on a non-sufficient connection to the industrial water distribution network in the central areas, while the peri-urban areas remain weakly connected to the water distribution network.

This low proportion of water access in peri-urban settings of Kinshasa negatively impacts access to water in most social welfare services such as schools, exposing school communities to the duty of fetching water, which undoubtedly has significant consequences for other WASH infrastructures and services as well as on girl students' school attendance [18].

While peri-urban households bear the brunt of these disparities and inequalities in access to water, the PNEVA, is reportedly struggling to extend its coverage rate to schools, implying that these schools failing to meet the WASH school community's needs, and the WASH access criteria of WHO or DRC WASH standards [10] [19].

To date, there are no studies that document these gaps by providing an overview of WASH infrastructures in peri-urban schools of Kinshasa (PUSK), as well as describing the level of access to water, and other WASH infrastructure, especially for girl students as a part of PNEVA coverage efforts.

Evidence providing an improved understanding of WASH facilities, including a gender component in the schools through the Educational Provinces (EPs), which mostly operate in an undocumented water access context, would be very helpful for guiding and adapting interventions to address potential gaps. Leading to such understanding requires structured and extensive studies which are presently lacking to document the whole WASH and gender-related situation in these schools in the Kinshasa EPs.

Based on interviews and observations performed in the three studied EPs, this study aims to fill the gap in WASH data by painting a picture of peri-urban schools' WASH facilities in the EPs compared to each other as well as the experience of girl students with WASH facilities. Subsequently, the study applies a SWOT analysis to determine the strengths, weaknesses, opportunities, and threats of these WASH facilities.

2. Methods

2.1. Study Site

Kinshasa, the capital of the DRC is divided into four Educational Provinces (EP) including, Funa (FN), Tshangu, Mont-Amba, and Lukunga. Each EP is further

divided into educational sub-provinces (ESP).

2.2. Study Design

We performed a cross-sectional study using analytical and observational approaches on WASH infrastructures, including their gender sensitivity, in schools from the ESPs belonging to three of the four EPs.

1) Study population, sampling procedures, and sample size determination

This study was preceded by another first study carried out at the household level targeting school-going adolescent girls (SGAG) in the same EPs. The population of this second study consisted of SGAGs' school WASH facilities in three EPs: Tshangu, Mont-Amba, and Lukunga.

The SGAGs targeted during the first study were randomly selected during a household survey using the multistage sampling method. The first study applied a 5-degree random sampling that successively performed a selection of 6 out of 12 peri-urban health zones (PUHZ) followed by a selection of 24 health areas in 6 PUHZ. Thereafter we selected 120 streets from 24 health areas. Finally, 858 households were randomly selected based on the criteria of having at least one SGAG. Thus 858 SGAGs were selected of whom 174 were excluded as they did not meet the selection criteria to participate in the survey (Mukiese, JM *et al.*, *in press*). Hence, during the first study 684 SGAGs meeting, the inclusion criteria were interviewed about access to water and WASH facilities as well as in their households and their schools. The 684 SGAGs questioned at the household level stated about the WASH issues in their schools. Subsequently, the first study listed the indicated schools attended by SGAGs in the three study EPs.

Thereafter, this second study has been implemented to establish links between the SGAGs and their cited schools to investigate WASH issues as stated by SGAGs at the household level.

Eligibility criteria

The schools that met the major inclusion criteria (to be cited and attended by a SGAG surveyed at the household level, to be located in one of the three previously studied EPs including Mont Amba, Tshangu, and Lukunga as well as the acceptance of the study by school authorities and availability of a person from the school to complete the study questionnaire) were selected to participate in this school WASH infrastructure assessment survey.

Given the fact that the schools to be investigated were those mentioned by the 684 SGAGs investigated at the household level, their number was determined progressively as they were indicated as schools attended by the SGAGs previously interviewed. A total of 187 schools were mentioned by SGAGs at the household level, of which 165 (88.2%) met the study criteria. The 165 schools selected to be surveyed represented more than a third of the 433 schools listed in the three studied EPs meeting the eligibility criteria.

2) Data collection

Data for this study were collected from March to December 2019. The quanti-

tative data displayed in Table 1 were obtained through interviews with school authorities. The qualitative data recorded on a grid were collected by interviewers using observations on the school WASH infrastructure.

Table 1 shows that half of the schools surveyed were in Lukunga, 60% were in the private sector, and almost all the schools were mixed-level schools and not beneficiaries of PNEVA interventions. On average, there were more girl students than boys in the surveyed schools.

3) Study variables

Socio-demographic variables

We collected information about the status of the schools, the level of the schools, and their PNEVA intervention status.

Variables related to gender sensitivity of WASH infrastructure, and GBV.

The gender sensitivity of the infrastructure was assessed by whether or not latrines, urinals and laundry facilities were used separately for girls and boys, and whether handwashing facilities were located next to girls' latrines and urinals. We also observed whether the schools dispensed modules on gender, GBV, teacher awareness or training on gender. The privacy and safety of the girls using the latrines were assessed by the presence of wooden or metal doors that could

Table 1. Characteristics of schools surveyed in Kinshasa peri-urban settings.

Variables assessed (n = 165)	Frequency	%	Minimum-Maximum
Study district			
Lukunga	83	50.3	
Mont-Amba	43	26.1	
Tshangu	39	23.6	
Status of the school			
Private school	104	63.0	
Denominational school	50	30.3	
Public school	11	6.7	
Type of school			
Mixed school	158	95.8	
High school	4	2.4	
College	3	1.8	
PNEVA status of schools			
Non-beneficiaries of the interventions	156	94.5	
Beneficiaries of the interventions	9	5.5	
Average number of students in schools			
Number of students	214.93 ± 185.590		14 - 987
Number of girls	114.95 ± 109.243		2 - 600
Number of boys	99.88 ± 93.885		1 - 534

be locked from the inside with a key or lock; GBV related to WASH facilities were assessed by the existence of policies on GBV, the Presence of posters raising awareness of GBV, and Denunciation of GBV in the use of WASH facilities.

Variables related to the availability of WASH infrastructure and programmes

The presence of water points, latrines, urinals, laundries and handwashing facilities (HWF) were both observed.

Variables related to the functionality of WASH infrastructure and programmes

The functionality of a water point was measured by the availability of water on the day of the survey, and the functionality of latrines, urinals, and laundry facilities was measured by their use by students on the day of the survey. The hygienic character of the latrines was assessed using an observation grid checking the absence of excreta, soiled toilet paper scattered on the internal and external surfaces; the absence of smell, flies, and other vectors. The functionality of HWF was measured by their use and the availability of water and soap or ash in the facilities on the day of the survey. Awareness-raising activities on WASH issues were assessed by their inclusion in school curricula as well as by statements from school authorities. The WASH club in schools to supervise WASH activities was checked too.

Temporo-spatial variables for water points located outside schools

The physical distance between the school and the water point was measured in metres using a measuring wheel. The time spent per day collecting water was estimated from interviews with the school authorities.

4) Patient and public involvement statement

There were no patients involved in our research. Participants aged 18 or over were recruited not as patients, but as stakeholders in the school system, as users of WASH services, and as members of the school community.

Thus, the development of the research question and outcome measures were not informed by the patients' priorities, experiences, and preferences. Therefore patients were not involved in the research design or in the recruitment to and conduct of the study. In addition, our study is not clinical research or a randomized clinical trial.

5) Data analysis

Data collected were analysed with SPSS software (Version 26.0). The normality of quantitative variables was checked with the Kolmogorov-Smirnov and Shapiro-Wilk tests [20] [21]. Descriptive statistical analysis was used to describe the existing WASH facilities in schools. Relations between main variables, differences in proportions and means between EPs, and subgroups were checked using the Student t-test, Fisher-Irwin Chi-square. The difference was considered significant for $P < 0.05$ [22]. Associations between nominal variables were verified with Pearson Chi-square tests of independence, and Cramer's V was used to measure the strength of associations when $P < 0.05$. A result less than 0.010 was considered to be a negligible association; from 0.10 and 0.20 a weak association;

from 0.20 to 0.40, a moderate association; 0.40 and under 0.60 as a strong association; 0.60 and under 0.80 as a relatively strong association; and 0.80 and under 1.00 as a very strong association [23].

The strengths, weaknesses, opportunities, and threats (SWOT) related to the WASH infrastructures and their gender sensitivity were identified using SWOT analysis [24] [25].

3. Results

The data collected from 165 PUSK on WASH infrastructure and related components are displayed as follows:

3.1. Availability of WASH Infrastructures in PUSK

Table 2 shows first, the proportion of peri-urban schools possessing water points, which is 10.9%. This low coverage rate is not significantly different among the three EPs surveyed ($P > 0.05$). Second, the overall latrine coverage was 98.2%, and of these, 3.6% of latrines were considered hygienic, with no significant difference among the three EPs ($P > 0.05$). Third, the overall coverage of schools with urinals was 13.9% with no significant difference between the three Eps ($P > 0.05$). However, the difference was significant when comparing the proportion of 23.1% of urinals at Tshangu and 7.2% of urinals at Lukunga ($P = 0.0130$). The proportion of schools that had laundries for MHM was 2.4%, and 7.2% had alternative spaces for girls to manage menstrual hygiene, both with no significant differences between the three EPs ($P > 0.05$). Finally, the overall coverage of HWF was 43%, and there was no significant difference when we compared proportions from the three EPs ($P > 0.05$).

3.2. Water Access in Schools without Water Points

3.2.1. Distance from Schools to Water Points

In the absence of a water point in their inner courtyard, 89.1% of the schools visited

Table 2. Availability of WASH infrastructure in PUSK.

Types of WASH infrastructure available in schools ($n = 165$)	Educational province (%)				*P*-value
	Set $n = 165$	Lukunga $n = 83$	Mont-Amba $n = 43$	Tshangu $n = 39$	
Water points	10.9	13.3	4.7	12.8	0.1347
Latrines	98.2	98.8	97.7	97.4	0.5726
Hygienic latrines	3.6	3.6	2.3	5.1	0.5011
Urinals	13.9	7.2	18.6	23.1	**0.0130***
Laundries for MHM	2.4	0.0	2.3	7.7	0.2594
Alternative space for MHM	7.2	4.2	3.0	0.0	0.7391
Handwashing facility/device	43.0	23.0	12.7	7.3	0.1680

*: Statically significant. $P < 0.05$.

were supplied with water from outside. The average distance travelled to collect water was 479.99 ± 381.724 m with extremes ranging from 50 to 2000 m. Pupils from Tshangu travelled an average distance of 423.77 ± 315.703 m, which was not significantly different from 413 ± 280.307 m at Mont-Amba ($P = 0.8796$) and 598.57 ± 520.858 m at Lukunga ($P = 0.0556$). However, with an average of 598.57 ± 520.858 m, school communities in Lukunga travel significantly further than the average of 413 ± 280.307 m in Mont-Amba ($P = 0.0322$).

3.2.2. Time Spent in Water Collection

The average time spent on water collection in schools was 59.68 ± 63.488 minutes with times ranging from 2 to 300 minutes. The average time of 80.71 ± 80.67 minutes spent in Lukunga was significantly higher than 31.27 ± 31.484 minutes spent in Tshangu ($P = 0.0004$), and 41.30 ± 40.988 minutes in Mont Amba ($P = 0.0033$).

3.2.3. People Involved in Water Collection in Schools

This study showed that more than 50% of the water collectors were school workers and nearly 30% were girl students. In addition, in 52.5% of cases, water collection in schools occurs during punishments, which frequently deprived girl students of participation in class lessons.

3.3. Types of Water Points in Schools

The data from this study indicates that of the 10.9% of water points, 89% were "improved", of which 50% of water points in schools were standpipes, followed by 22.5% of unimproved boreholes, and improved boreholes which accounted for 16.5% of water points, with no significant differences among the three EPs ($P > 0.05$).

3.4. Functionality of WASH Infrastructures

3.4.1. Water Points

This study showed that 15 (83.3%) out of 18 available water points were functional. All of the water points in the Mont-Amba schools were functional, significantly higher than 66.7% at Tshangu ($P < 0.0001$). The proportion of functional water points in Lukunga was significantly higher than in Tshangu ($P = 0.0003$).

3.4.2. Latrines

Overall, 130 (80.2%) of 162 latrines visited were functional on the day of our survey, with no significant difference in the functionality rate among the three EPs ($P > 0.05$).

3.4.3. Separate Use of Latrines by Gender

A total of 67.3% of the schools had latrines that were used separately by girls and boys, with no significant difference among the three EPs ($P > 0.05$).

3.4.4. Protection of Privacy and Safety in Latrines and Urinals

Overall, 48.5% of the toilets visited provide privacy to female student users, with

no significant difference in the proportion among the three EPs ($P > 0.05$). In total, 14 (60.9%) of the 23 peri-urban school urinals were used separately by gender, with no significant difference among the three EPs ($P > 0.05$). Of these urinals visited, 22.2% offered safety and privacy for girl users. However, a significantly higher proportion (66.7%) of urinals in Lukunga were safe compared to 14.3% at Tshangu ($P < 0.0001$) and 12.5% at Mont-Amba ($P < 0.0001$).

3.5. Latrines in Peri-Urban Schools

3.5.1. Types of Latrines

Two types of latrines were prevalent in the schools studied: 35.2% had improved latrines with roof, door, and lock, and 26% had pit latrines (ordinary) made of sack or sheet metal walls with neither roof nor door. There was no significant difference among the three EPs in the proportions of latrine types.

3.5.2. Characteristics of Latrines in Schools

A total of 80.2% of the latrines visited in 162 possessing latrines were functional, characterized by the presence of foul smells and 59.3% were characterized by the presence of scattered human excreta, with no significant difference among the three EPs ($P > 0.05$). On the other hand, 54.9% of the latrines had a significantly higher presence of flies, insects, and rodents at Tshangu compared to Mont-Amba and Lukunga ($P = 0.0231$).

3.5.3. Ratio of Latrine Units Rate for Girls in Schools

The median number of latrines used by girl students was two latrines and one urinal per school. Overall, the toilet and urinal ratios for girl students were 58:1 and 115:1 respectively, with no significant difference between these ratios in different EPs ($P > 0.05$).

3.5.4. Queues in Front of School Latrines and Urinals

In the 162 schools with latrines, the presence of queues in front of toilets and urinals, particularly during recess was noted. Queues for toilets with an average number of 4.5 ± 1.3 girl students were observed with no significant difference among the three EPs ($P > 0.05$). A median of 5.22 ± 2.01 girl students was observed queuing for urinals with significantly longer queues in Mont-Amba compared to other EPs ($P = 0.0330$).

3.5.5. Open Defecation and Urination

This study reported that in 62.4% of the schools surveyed, girl students were observed urinating and/or defecating next to or behind toilets. In 37.5% of schools, girl students were observed urinating or defecating next to or behind urinals. Overall, open defecation and urination were observed significantly more often next to and behind toilets than urinals used by girl students ($P = 0.0233$).

3.6. School WASH Clubs

This study reported 4.8% of schools ($n = 165$) that had a school WASH club with

a significantly higher proportion in Mont Amba schools ($P = 0.0206$). In terms of representativeness, with an average of 5.88 ± 6.256 boys versus 3.88 ± 4.42 girls, there were significantly more boys than girl students in these WASH clubs ($P < 0.0001$).

3.7. Actions to Support WASH, and Gender Sensitivity in PUSK

Table 3 summarises data on the availability of WASH and gender issues support actions, as well as the availability of WASH awareness posters in schools. The data reveal that most of these actions were not statistically different among the three EPs studied. However, the data reveal that schools from Lukunga were more likely to monitor pupils' handwashing regularly ($P = 0.0313$), had a clearer policy on gender equality ($P = 0.0019$), and had a higher reporting rate on GBV

Table 3. Actions developed in support of WASH in schools.

Availability of support actions ($n = 165$)	Set $n = 165$	Educational provinces (EP)			*P*-value
		Lukunga $n = 83$	Mont-Amba $n = 43$	Tshangu $n = 39$	
Hygiene and the fight against dirty hands diseases					
Mass awareness on hand hygiene	86.7	90,4	86.0	79.5	0.0973
Presence of hand hygiene awareness posters	3.6	4,8	0.0	5.1	0.9431
Monitoring of regular handwashing by students	23.0	33.7	14.0	10.3	**0.0313***
Mass awareness on drinking water hygiene	67.3	63.9	67.4	74.4	0.4893
Presence of posters raising awareness on water hygiene	1.2	2.4	0.0	0.0	0.3313
Mass awareness on latrine hygiene	74.5	77.1	74.4	69.2	0.3520
Presence of posters raising awareness on latrine hygiene	2.4	3.6	0.0	2.6	0.7733
Mass helminth deworming activities at school	66.7	62.7	60.5	82.1	**0.0316***
Allocation of funds for WASH infrastructure maintenance	24.9	16.4	8.5	0.0	0.2411
Gender sensitivity and menstrual management					
Awareness of students on the body and genital hygiene	71.5	65.1	76.7	79.5	0.1080
Menstrual hygiene management (MHM) awareness	66.7	53.0	76.7	84.6	**0.0008***
Presence of a clear policy on MHM in schools	7.3	9.6	7.0	2.6	0.6372
Presence of posters raising awareness of the MHM	0.6	1.2	0.0	0.0	0.4939
Free distribution of towels for the MHM	11.5	14.5	14.0	2.6	0.6143
Teacher training on gender and the gender approach	11.5	13.3	11.6	7.7	0.3680
Raising awareness of students on the gender approach	6.7	9.6	7.0	0.0	0.6250
Clear policy on gender equality in schools	30.3	41.1	25.6	12.8	**0.0019***
Presence of posters raising awareness of SGBV	1.2	1.2	0.0	2.6	0.5726
Denunciation of SGBV in the use of WASH facilities	44.8	50.6	48.8	28.2	**0.0204***

*: Statically significant. $P < 0.05$.

occurring in WASH facilities than the other EPs (P = 0.0204). On the other hand, activities on menstrual hygiene management (P = 0.0008) and mass helminth deworming in schools (P = 0.0316) were significantly higher in Tshangu compared with the other EPs.

3.8. Association between Variables Studied

The data in Table 4 indicate that the hygienic condition of latrines in schools is associated with the availability of reserve water next to the latrines for maintenance purposes, even if this is a weak dependence (P = 0.040; Cramer's V = 0.162). The presence of a water point in the school's inner courtyard as well as the availability of water next to the latrine has been found to have protective effects. Otherwise, they increase the likelihood of the latrines being kept clean and hygienic and of the HWFs being usable by the school community members. However, the functionality of handwashing facilities was weakly associated with the presence of a water point in the school's inner courtyard (P = 0.032; Cramer's V = 0.167), while there was a strong association with the availability of water in the HWF (P < 0.001; Cramer's V = 0.322), and soap next to the HWF (P < 0.001; Cramer's V = 0.672). Hence, the soap availability next to the HWF as

Table 4. Predictors of latrine hygiene and functionality of handwashing facilities in peri-urban schools in the city of Kinshasa, using Chi-square tests of independence.

Factors	χ^2	AOR (95% CI)	*P*-value	Cramer's V
Hygienic latrines				
Water point possession	0.212	1.671 (0.184 - 15.155)	0.645	
Functionality of water points	0.669	0.889 (0.998 - 1.000)	0.414	
Availability of water next to the latrines	42.30	0.492 (0.329 - 0.738)	**0.040***	0.162
School possession of urinal	0.039	1.245(0.139 - 11.170)	0.844	
Existence of a WASH brigade within schools	0.317	0.950 (0.916 - 1.000)	0.573	
Training of school staff on WASH issues	0.581	0.911 (0.868 - 1.000)	0.446	
Presence of latrine hygiene posters in schools	0.155	0.975 (0.951 - 1.000)	0.694	
Mass raising awareness on latrine hygiene	0.204	0.672 (0.119 - 3.810)	0.652	
Fund allocation to support WASH	0.240	1.538 (0.271 - 8.725)	0.624	
Functional handwashing facilities (HWF)				
Presence of a water point in school	4.604	0.378 (0.149 - 0.957)	**0.032***	0.167
Fund allocation to support WASH	0.831	0.719 (0.353 - 1.463)	0.362	
WASH brigade within the school	1.300	2.298 (0.530 - 9.955)	0.254	
Training of school staff on WASH issues	0.000	1.008 (0.333 - 3.048)	0.989	
Soap availability next to the HWF	17.133	1.203 (1.084 - 1.336)	**<0.001***	0.322
Water availability in the HWF	7.593	2.448 (1.851 - 3.239)	**<0.001***	0.672

*: Statically significant. P < 0.05.

well as the presence of water respectively increase by 20.3% and 44.8% the likelihood for the HWF to be used by the school community members.

3.9. Strengths, Weaknesses, Opportunities, and Threats (SWOT) of WASH Infrastructure

The SWOT analysis data displayed in Table 5 reveals that overall, there are more weaknesses and threats than strengths and unrealized opportunities for WASH infrastructures and items in schools in the study area.

Table 5. WASH infrastructure Strengths, weaknesses, opportunities, and threats.

SWOT analysis matrix	
Gender issues	
Forces	**Weaknesses**
68.5% of latrines and 60.9% of urinals are separated and used by gender	Low gender sensitivity of WASH programmes and infrastructures
44.8% of schools have an SGBV reporting policy	11.5% of teachers trained in gender and gender approach
66.7% of schools raise awareness on menstrual hygiene management	6.7% of schools raise students' awareness of gender issues
	30.3% of schools have a clear policy on gender equality
	Only 1.2% of schools have posters on GBV
	Lack of dedicated toilets and urinals for girls
	Unequal representation of girls in school WASH clubs
	At least 30% of girls draw water on punishments during school hours
Opportunities	**Threats**
Government commitment to gender promotion	Endemic toxic masculinity in peri-urban communities (patriarchy)
Presence of supporting partners (UNICEF, Ministry, USAID) in gender	School environments less sensitive to the gender approach
"Gender" module integrated into the country's school curriculum	Sexual and reproductive health issues
Presence of NGOs, feminist organizations defending the rights of girls	Increased absenteeism and school dropout of girl students
Water	
Strengths	**Weaknesses**
15 out of 18 schools (83.3%) have functional water points	89.1% of schools do not have water points, experiencing water chore
77.5% of schools with water points use improved sources	98.8% of schools lack water awareness posters
67.3 of the schools carry out sensitizations on drinking water hygiene	98% of latrines and 91% of urinals lack water for hygiene
	40.8% of handwashing facilities lack water for hand hygiene
Opportunities	**Threats**
Government's political commitment to the SDGs	Climate change and acts of sabotage by the population

Continued

Presence of the national service of rural hydraulics for water drilling	Student absenteeism, particularly among girls
Presence of technical and financial partners: PNEVA, Unicef, etc.	Risk of the emergence of waterborne and dirty hands diseases
	Increased risk of health, school, and gender impacts of fetching water
Hygiene	
Strengths	**Weaknesses**
86.7% of schools educate students on hand hygiene	43.0% of schools have handwashing facilities
75% of existing hand-washing facilities are functional next to latrines	90.3% of schools lack handwashing facilities next to latrines.
59.2% of handwashing facilities are functional on school grounds	97.2% of schools lack handwashing facilities next to urinals.
Presence of school WASH clubs in some schools	92% of schools lack hand hygiene posters.
	77% of schools do not ensure or monitor handwashing by students
Opportunities	**Threats**
Availability of the PNEVA	The imminent implosion of diarrhoeal and other dirty hands disease
Presence of the hygiene and sanitation module in the school curriculum	Lack of accessible funding for WASH
Presence of handwashing facilities in the market of the city	Covid-19 pandemic in a context of low water availability
	Endemicity of dirty hands and waterborne diseases
Sanitation	
Strengths	**Weaknesses**
98.2% of schools have latrines, of which 35.2% are improved latrines	3.6% of schools have hygienic toilets
52% of latrines have sanitary napkins and papers for intimate hygiene	13.9% of schools have urinals and 2.4% have laundry facilities
74.5% of schools raise awareness on the hygiene of WASH infrastructure	51.5% of toilets and 82.6% of urinals do not provide privacy for girls
Presence of a WASH brigade in some schools	4.8% of schools have a WASH school brigade
	2.4% of schools allocate funds to maintain WASH infrastructure
Opportunities	**Threats**
Presence of the National Healthy Schools and Villages programme	Increased girls' absenteeism in school
Presence of technical support partners: UNICEF, USAID, UKaid, etc.	Increased incidence of diarrhoeal diseases and dirty hands

4. Discussion

4.1. Water Point Coverage Rate

The results of this study demonstrate that fewer schools have water points without significant differences between EPs, and most of them have improved and functional water supply points. Larger holdings of improved water points equivalent to 45% of schools were reported in South Sudan and 57.1% in Uganda

[26]. On the outskirts of Kinshasa, access to drinking water for 9 out of 10 schools involves water collection chores. This poor access can be explained in part by the local context, which is characterized by disparities resulting in the poor water network connection of peri-urban settings, but also by the fact that schools do not take advantage of local opportunities presented by potential partners, such as SHHR, UNICEF, UKaid or different embassies located in Kinshasa.

Consequently, in the schools lacking water in their yards, the average distance travelled and the time spent collecting water exceed the set WHO standards. The patriarchal context has the implication that in the school, girl students are more often used as a workforce to collect water than boy students. In more than half of the cases, girl students collect water during punishment performed during school hours. Such practices have been reported in rural areas of the province of Central Kongo where in consequence, girl students miss lessons and face GBV violence like sexual harassment or rape during water collection [27]. Furthermore, this low access to water could have negative implications on the management and use of other WASH infrastructures' functionality and hygienic status such as latrines, urinals, and handwashing facilities which can lead to the practice of open defecation and urination reported by this study. This is supported by 81.5% of school girls in Ethiopia who stated that the lack of water remains the major challenge to the use of WASH infrastructure in their schools [26], while it has been documented that the availability of water is an essential component associated with supporting hygiene, combatting diarrhoeal diseases and pathogens transmitted by dirty hands [28] [29].

In addition, the lack of funds allocated to the WASH sector as reported in the majority of PUSK could explain a part of this low coverage or its worsening in the study region [30]. For schools with a water point, one of the limitations of this study is that its goal did not include analysing the microbial quality and quantities of water used.

4.2. Availability and Hygiene of School Latrines

With no significant difference between EPs, the majority of the schools surveyed had at least one latrine, of which more than one-third had an improved type of latrine with a door and an internal lock. Among these latrines, nearly 8 out of 10 were functional. This result is similar to the coverage of 83.7% reported from South Sudan [26], 77% from Benin, and 100% from South Africa [31] [32]. However, when this high coverage is normalized to the number of students in peri-urban schools in Kinshasa, specifically for girls, it appears that the ratio of students to toilet units is 58:1. This result is similar to the ratio of 60:1 reported in Ethiopian schools [33]. The latrine ratio for female students in Kinshasa schools was higher than the WHO standards, which recommend an average of 25:1 for girls or 30:1 according to the DRC WASH cluster [10] [19].

These ratios are problematic, given the risk of diarrhoeal diseases, and pathogens transmitted by dirty hands [28] [29], but are also detrimental to the

well-being of users, and would need to be addressed to contribute to the improvement of school attendance, particularly for girls [5] [34]. These ratios contribute to justify the unhygienic status of visited latrines with the presence of human excreta on the surface, several flies, and foul odors. This result qualitatively agrees with research reporting 49% of schools in Zimbabwe, 32.7% in South Sudan, and 33.3% in Ethiopia possessed unhygienic latrines, identified by the presence of human excreta on the surface, several flies and bad smells [26] [33]. In contrast, research from Benin reported that 79% of school latrines were found to be clean and hygienic in the commune of Zè [32].

The high proportion of unhygienic latrines reported in the current study can be explained by various factors, including insufficient coverage of water points in schools, and insufficient allocation of funds for infrastructure maintenance, which also has been reported in other contexts [35] [36]. Other factors studied include the absence of school WASH clubs or their failure to function, the lack of awareness-raising posters on latrine hygiene, and the weakness of mechanisms for monitoring the application of hygiene measures in PUSK as well as the high ratio of students to insufficient or inadequate toilet units reported in PUSK would also affect hygiene and latrine use [33] [36], because of the over-use by several students which can also explain the practice of open defecation and urinating next to toilets as reported repeatedly by studies carried out in other contexts [26] [37]. Likewise, the high ratio of female students to urinals could be taken as an additional factor in the deterioration of latrine hygiene as the toilets were used as an alternative for urination [37].

As such unhygienic latrines are hotbeds for the spread of diarrhoeal pathogens and other hand-transmitted diseases in pupils, it is strongly recommended that multi-faceted interventions targeting WASH to improve the latrine hygiene in these EPs be implemented, to combat the challenges of transmitted diseases as well as student absenteeism, repetition, and dropout in school as reported by other studies. This is especially important for girls, who already face several other factors that affect their schooling [35] [38].

Because of the link between latrine hygiene and multiple other factors [39], the large proportion of unhygienic latrines reported in this study raises concerns about the level of effective students' latrine use and satisfaction, the prevalence of transmitted diseases [37] [40] [41], student absenteeism, school dropout as well as the level of student's knowledge, attitudes, and practices about WASH. In this regard, further studies would be helpful to measure these considerations.

4.3. Handwashing Facilities (HWF) in Schools

The low percentage of schools with HWF is another factor that makes it harder to combat transmissible pathogens in peri-urban schools in Kinshasa. In the three studied EPs, our study has demonstrated a low availability of HWF as well as water and soap for their use. A similar availability of HWF of 46.7% was reported in high schools in the city of Yaoundé in Cameroon [42]. In contrast, a

higher proportion of 93% of schools with HWF, 80% of which contained water and soap, was reported from schools in Bamako [43].

The low availability of HWF in peri-urban schools in Kinshasa could be linked to a lack of interventions targeting WASH items and infrastructures from partners, schools, and governmental authorities as documented in this study. This can also be explained by the lack of school staff training in WASH as well as the low allocation of funds to the management of WASH infrastructure by internal school organizations. A similar situation was reported in schools in Ghana showing a strong association between functional HWF with functional water facilities [30]. The low rate of HWF, their functionality, and their location near latrines reported in this study are also similar to the low rate documented by a study performed in Ethiopian schools [33]. Once detrimental to the control of pathogens, as handwashing practices are highly influenced by the presence of functional HWF, containing water and soap or ash [44] as reported in **Table 4** of this study. We suggest that additional studies be carried out to improve the understanding of the level and determinants of handwashing practice in the communities of PUSK.

4.4. Gender Sensitivity of WASH Infrastructure

From a gender perspective, our study shows that at least 6 out of 10 latrines and urinals may be classified as gender sensitive, as there are separate facilities for boys and girls but not always used separately. This distribution in PUSK remains lower than the 83.8% of schools that offered separate latrine use in Uganda [26]. In the regions studied here, the low hygienic latrine rate could be considered a key factor limiting the optimization of separate latrine use, due to limited choices for students. Likewise, non-separate latrine use was experienced by 22% of girls who reported resorting to open urination in Uganda schools [26].

Of all the facilities visited, almost half of the latrines and urinals did not have doors or had doors without locks that could be closed from the inside for girl users' safety. Such latrines have the potential to become sites where girl students may experience difficulties in ensuring their privacy, and there is also an increased risk of GBV against girls using such latrines as relying upon that safety and dignity are two key components determining latrine use by girl students [36], and if these are lacking, it is possible that girl students will avoid using them and consequently use open defecation and urination as reported in PUSK.

Our study reports a very low proportion of schools in the three studied EPs offering laundry facilities to manage menstrual hygiene for girl students. Among those that do not offer these facilities, only 7.2% offered an alternative space for menstrual hygiene management (MHM). The proportion reported contrasts with the rate mentioned by a study from South Sudan, where 56.6% of the girls interviewed reported lacking spaces for MHM in their schools [26].

The low proportion of MHM facilities noted in our study could be explained

by the low level of gender awareness in schools, inadequate school staff training on gender issues, insufficient funds allocated to the management of WASH infrastructure, the low proportion of school WASH clubs, and the lack of access to water in many schools. Further studies are suggested to clarify the factors associated with the low proportion of MHM facilities and to evaluate the breadth of female students' school impacts resulting in the weakness of menses management mechanisms such as absenteeism reported in other contexts [45]. Given the importance of MHM in the promotion of gender-related interventions is strongly suggested to address these weaknesses in the PUSK to deal with the multiple impacts reported elsewhere as the MHM is a major factor associated with girls' school attendance, and weak school performances [46] [47] [48].

Limitation

The shortcoming of the current study was its cross-sectional status, which is unable to demonstrate correctly the strength of the associations reported.

5. Conclusions

The WASH infrastructure situation remains a public health concern in Kinshasa's peri-urban schools. This study provides a broad picture of the availability, functionality, and gender sensitivity of WASH infrastructures in PUSK, where most of them operate in the context of limited access to water. The results of the SWOT analysis applied to the WASH infrastructure and the gender programme reveal numerous challenges, weaknesses, and threats intersecting on girl students that jeopardize chances of achieving SDGs 3, 4, 5, and 6 related to health, education, gender equality and access to water from their schools.

The current results raise awareness of WASH and gender issues among political and school authorities and could be combined with taking advantage of existing opportunities to strengthen the response to address the current weaknesses and threats identified to improve gender perspective, availability, functionality, and delivery of existing school programmes and WASH facilities.

Further studies assessing the different impacts on students' health and well-being, education, and girls' experiences of safety and dignity, and those assessing the knowledge, opinions, perceptions, and practices of students, particularly female students, are expected to improve understanding of WASH and gender issues in PUSK.

Ethics Approval and Consent to Participate

The study protocol was submitted to the ethics committee of the School of Public Health of the University of Kinshasa. This received approval under the number: ESP/CE/230/2018. Informed consent was obtained from each school staff interviewed. Also, approvals from different authorities of the surveyed EP (Tshangu, Mont-Amba and Lukunga) were previously obtained, and then endorsed by the offices of the ESP and the heads of schools before the data collection process.

Availability of Data and Material

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

Authors' Contributions

JMMN and GMK designed the study and drafted the French and English versions of the manuscript that was revised by JKNN and MKY. All the authors read and approved the final version of the manuscript until submission.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Abbreviations

CI: confidence interval, **DRC**: Democratic Republic of Congo, **EP**: Educational province, **ESP**: Educational sub-province, **HA**: Health area, **HWF**: Handwashing facility, **HZ**: Health zone, **MHM**: Menstrual Hygiene Management, **PNEVA**: Programme National École et Village Assainis, **SDGs**: Sustainable Development Goals, **SGAG**: School-going adolescent girl, **SPSS**: Statistical package for social science, **SWOT**: Strengths, weaknesses, opportunities and threats, **WASH**: Water, sanitation and hygiene, **WHO**: World Health Organization.

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Frequency of B and C Hepatitis Viruses, and Metabolic Profile in Type 2 Diabetics: A Case of the Yaoundé Central Hospital, Cameroon

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Abstract

Poorly controlled type 2 diabetes alters the immune system, increasing the risk of susceptibility to viral infections such as hepatitis B and C infections. This study aimed to determine the frequency of hepatitis B and C and metabolic profiles in type 2 diabetics. This was a cross-sectional study conducted over six months. It was conducted at the National Obesity Center (NOC) of the Yaoundé Central Hospital (YCH), Cameroon. 100 diabetic patients, with a mean age of 58.41 ± 10.74 years were enrolled in the study. The socio-demographic characteristics of the study population and the risk factors for virus transmission were recorded using a pre-established questionnaire. HBsAg and anti-HCV antibodies were revealed by a rapid diagnostic test. Liver function markers' activities were determined. Commercial kits were used to evaluate the patient's serum lipid profile, serum fasting glucose level, urea, creatinine, and albumin. With a sex ratio of 3:1, women outnumbered men. Risk factors for HCV and HBV infections evocated by the population were dental care (50%), followed by alcohol consumption (41%). HBsAg and anti-HCV antibodies frequency was 3% and 8% respectively. No cases of coinfection were found. In general, hypertriglyceridemia with a mean of 1.61 ± 0.46 g/L and hyperglycemia of 1.35 ± 0.45 g/L were noted. A significant difference ($p = 0.028$) was found in HDL-cholesterol values between non-co-affected diabetics and HCV+ diabetics. The effect of the duration of diabetes on biochemical parameters revealed that albumin was the only significant decrease over time ($p = 0.013$). Based on these results, the metabolic profile of patients was altered. It is important to take note of the prevalence of hepatitis seen in type 2 diabetes mellitus since it demonstrates the potential link between both illnesses. Thus, early detection could prevent complications related to B and C

hepatitis infections in type 2 diabetics.

Keywords

Type 2 Diabetes, Hepatitis B, Hepatitis C, Metabolic Profile, Frequency, Cameroon

1. Introduction

Hepatisis B virus (HBV) and hepatisis C virus (HCV) are infections that, according to some studies, are associated with diabetes mellitus (DM) [1] [2] [3]. This association can be considered a major public health problem, due to the numerous complications and metabolic or pathological disorders that these diseases can cause individually or in synergy. Despite the fact that a diabetic is undergoing therapy, these many dysfunctions might still exist.

In a cohort study in China, the relative risk of hepatitis B virus (HBV) infection was 43% higher in type 2 diabetics than in non-diabetic patients [4]. In Brazil, one study reported a prevalence of 15.83% of HBV infection and 1.7% of viral hepatitis C among type 2 diabetics [5]. In Africa, studies on the association between hepatitis B and C, and diabetes have often been cross-sectional [6]. In Morocco, a prevalence of 4.5% of Viral Hepatitis C has been found in patients with type 2 diabetes [7]. In sub-Saharan Africa, 11% - 27% of type 2 diabetics with viral hepatitis C and 5% - 10% with viral hepatitis B were reported [6]. Type 2 diabetics are more prone to developing infections, as diabetes is a cause of immunosuppression [8] [9] [10]. This immunosuppression induced by T2DM makes the body vulnerable to many pathologies, especially viral diseases such as hepatitis B and C [6] [11]. Type 2 diabetes, most often associated with dyslipidemia, is responsible for the accumulation of fat. Viral hepatitis infection weakens the liver and degrades its functioning and integrity. Thus, the coexistence of diabetes and hepatitis could potentiate the risk of developing steatosis and liver fibrosis [12]. This degradation of the functional and anatomical capacities of the liver has multiple metabolic repercussions.

Hepatitis B and C have been the subject of several investigations in Cameroon [13] [14] [15]. These trials were conducted on individuals who also had other illnesses, and as far as we are aware, none of them specifically addressed the hepatitis B or C viruses and type 2 diabetes. We did a study on the relationship between type 2 diabetes and hepatitis B and C to investigate the associations between problems of glucose metabolism, some other biochemical parameters, and hepatotropic viral infection in Cameroon. The comprehension of this association will contribute to the improvement of the management of diabetes mellitus and limit complications due to viral hepatitis B and C in diabetics. In particular, this study sought to ascertain the metabolic profile and prevalence of hepatitis B and C in type 2 diabetics visiting the Central Hospital of Yaoundé, Cameroon.

2. Materials and Methods

2.1. Study Population

From January 2022 to June 2022, a cross-sectional study was conducted on diabetics attending the National Obesity Center of YCH. The sample size was determined based on the prevalence of diabetics in Cameroon, using the Lorentz formula and 100 patients were enrolled in the study. All participants in the study were type 2 diabetics attending the routine health screening exams with YCH.

2.2. Measurements

A standardized self-administered questionnaire was used to collect data from each study's participants on their socio-demographic characteristics, medical history, history of diabetes, usage of medication, and level of education. The age range was categorized as <40, 40 - 60, and >60. BMI was classified as <25, 25 - 30, and >30. Consumption of Alcohol, tobacco, blood transfusion, tattoo, intravenous drug abuse, surgical intervention, and dental care were recorded in patients as the risk of developing hepatitis. Education level was categorized as non-scolarized, primary, secondary, and university level of education. Hospital staff members took anthropometric measurements. Body Mass Index (BMI) was determined (kg/m^2). Anthropometric parameters were measured by hospital staff members. Body Mass Index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m^2).

Blood was drawn from the antecubital vein after subjects had been fasting for at least eight hours. Blood specimens were sampled from the antecubital vein after at least 8 hours of fasting. Afterward, ten milliliters (10 mL) of venous blood were aseptically collected using plain and glucose tubes (5 mL in each tube) for the determination of various analyses. The blood specimen in those tubes was centrifuged at 3000 RPM for 15 minutes. The remaining serum and plasma were kept in the deep refrigerator at −20˚C. Liver enzymes, including aspartate aminotransferase (AST), alanine aminotransferase (ALT), and kidney markers such as urea and creatinine, albumin, lipid profile (Total Cholesterol, Triglycerides, HDL-Cholesterol, and LDL-Cholesterol) were evaluated using Commercial BIO LABO dosing kits. Subjects' fasting blood glucose (FBG) was measured by using a Glucose Oxidase/Peroxidase Kit assay (GLUCOSE liquicolor, Human GmbH, Germany). Diabetes was defined as the presence of a self-reported doctor diagnosis, self-reported usage of insulin or another hypoglycemic medication, or fasting blood glucose levels below 126 mg/dL. HBsAg hepatitis status was determined using a one-step HBsAg test strip (DiaSpot HBsAg; DiaSpot Diagnostics) and anti-HCV of subjects was detected by a rapid diagnostic test (DiaSpot HCV One Step Hepatitis C Virus Test Strip).

2.3. Statistical Analysis

The gathered information was imported into Excel and analyzed by the SPSS statistics version 20.0. At baseline visits, HBsAg and HCV Ab status were com-

pared to demographic traits, liver function profiles, serum fasting glucose level, and fatty liver disease. Numbers (proportions) were used to characterize categorical data, while the mean (with standard deviation) was used to describe continuous variables. Demographic characteristics, liver function profiles, serum fasting glucose level, and fatty liver disease at baseline visits were compared by HBsAg and HCV Ab status. Numbers (proportions) were used to characterize categorical data, while the mean (with standard deviation) or median was used to describe continuous variables. Comparisons were made using Analysis of Ordered Variables (One Way ANOVA), followed by a Chi-square test, and a Student's t-test, as needed, at the statistical significance level of 0.05.

3. Results

HCV and HBV infection frequency observed in diabetics was 8% and 3% respectively.

3.1. Socio-Demographic and Anthropometric Characteristics of the Studied Population

In the present study, the majority of participants (44%) were in the 40 - 60 age group. Female participants (60%) were the most represented with a sex ratio of 3:2. Almost all participants (86%) were married while 10% were widowed and 4% were single. In addition, the majority of participants had a primary level of education (38%) and were employed in the informal sector (35%). The age of participants ranged from 32 to 82 years, with an average of 58.41 ± 10.74 years. Participants' BMI (Body Mass Index) ranged from 17.10 to 56.64 kg/m^2, with an average BMI of 28.70 ± 6.01 kg/m^2 (Table 1).

3.2. Viral Hepatitis Risk Factors in the Study Population

The main risk factors for viral hepatitis reported by participants were dental care, alcohol consumption, and surgical procedures (Table 2).

3.3. Duration of Diabetes and Type of Treatment

The majority of participants had a duration of diabetes less than 5 years (45%) with a mean of 6.86 ± 6.72. Most participants were taking oral antidiabetic drugs (70%). 15% were on insulin and 15% were on oral antidiabetic drugs and insulin.

3.4. Markers of the Hepatic and Kidney Function Level, Fasting Blood Glucose, and Metabolic Profile of the Study Population

These different markers reveal that the liver and kidney of the study population functioned normally, with hypertriglyceridemia and hyperglycemia (Table 3).

3.5. Seroprevalence of HCV in Diabetics Patients According to the Demographic and Clinical Characteristics

Comparisons between HCV+ diabetics patients and HCV– diabetics patients

showed that the difference between age, age range, BMI categories, sex, and risk factors was not significant ($p > 0.05$) (Table 4).

Table 1. Distribution of participants by socio-demographic characteristics.

Characteristics	Frequency	Proportion (%)
Age range		
<40	6	6.0
40 - 60	50	50.0
>60	44	44.0
Sex		
Male	40	40.0
Female	60	60.0
Marital status		
Single	4	4.0
Married	86	86.0
Widower	10	10.0
Education level		
Out of school	4	4.0
Primary	38	38.0
Secondary	34	34.0
University	24	24.0
Profession		
Formal sector	13	13.0
Informal sector	35	35.0
Unemployed	19	19.0
Retired	33	33.0

Table 2. Participants' distribution according to risk factors.

Risk factors	Effective (N = 100)	Proportion (%)
Alcohol	41	41
Tobacco	12	12
Blood transfusion	9	9
Tattoo	2	2
Intravenous drug abuse	1	1
Surgical intervention	23	23
Dental care	50	50
Total	100	100

The data in Table 2 represents the number of participants who mentioned the risk factor.

Table 3. Markers of the hepatic and kidney function level, Fasting Blood Glucose, and metabolic profile of the study population.

Variables	Mean ± SD	Minimum	Maximum
AST (UI/L)	38.79 ± 22.89	18.5	208.4
ALT (UI/L)	25.53 ± 17.27	11.0	147.4
Urea (g/L)	0.48 ± 0.08	0.25	0.75
Creatinine (g/L)	11.77 ± 3.98	4.4	21.8
Albumin (g/L)	43.56 ± 4.74	33.5	64.6
FBG (g/L)	1.35 ± 0.45	0.67	2.80
TC (g/L)	1.66 ± 0.42	1.06	3.17
TG (g/L)	1.61 ± 0.46	1.01	3.10
HDL-C (g/L)	0.45 ± 0.09	0.21	0.66
LDL-C (g/L)	0.89 ± 0.39	0.24	2.18

Legend: FBG: fasting blood glucose; TC: total cholesterol; TG: triglyceride; HDL-C: High-density lipoprotein cholesterol; LDL-C: Low-density lipoprotein.

Table 4. Seroprevalence of HCV in diabetics patients according to the demographic and clinical characteristics.

Variables	Total (N = 100)	HCV+ (N = 8)	HCV− (N = 92)	P-value
Age	58.41 ± 10.74	65.63 ± 8.4	57.78 ± 10.73	0.42
BMI	28.70 ± 6.01	28.44 ± 7.20	28.73 ± 5.94	0.71
Sex				
Male	40 (40)	1 (2.5)	39 (97.5)	0.09
Female	60 (60)	7 (11.7)	53 (88.3)	
Age range				
<40	6 (6)	0	6 (100)	0.17
40 - 60	50 (50)	2 (4)	48 (96)	
>60	44 (44)	6 (13.6)	38 (8.4)	
BMI categories				
<25	22 (22)	3 (13.6)	19 (86.4)	0.53
25 - 30	43 (43)	3 (7.0)	40 (93.0)	
>25	35 (35)	2 (5.7)	33 (94.3)	
Alcohol	41 (41)	2 (4.9)	39 (95.1)	0.34
Tabacco	12 (12)	0	12 (100)	0.28
Blood transfusion	9 (9)	1 (11.1)	8 (88.9)	0.72
Surgical Intervention	23 (23)	2 (8.7)	21 (91.3)	0.89
Dental care	50 (50)	5 (10.0)	45 (90.0)	0.46

Values representing ages and BMI are presented as mean ± standard deviation; Values in brackets are expressed in percentages; N represents the number of diabetics concerned.

3.6. Seroprevalence of HBV in Diabetics Patients According to the Demographic and Clinical Characteristics

Comparisons between these two groups, HBV+ diabetics patients and HBV− diabetics patients showed that the difference between age, age range, BMI, BMI categories, sex, and risk factors was not significant ($p > 0.05$) (Table 5).

3.7. Seroprevalence of HBV and HCV of the Study Population According to the Biological Characteristics

Table 6 shows comparisons between these three groups; Diabetes patients only, HBV+ diabetics patients, and HCV+ diabetics patients. This table revealed that there was a significant difference in High-density lipoprotein cholesterol between Diabetes patients only and HCV+ diabetics patients ($p < 0.05$). Moreover, the difference in High-Density Lipoprotein Cholesterol between diabetes patients only and HBV+ diabetics patients was not significant ($p > 0.05$) (Table 6).

Table 5. Seroprevalence of HBV in diabetics patients according to the demographic and clinical characteristics.

Variables	Total N = 100	HBV+ N = 3	HBV− N = 97	P-value
Age	58.41 ± 10.74	50.67 ± 5.86	58.65 ± 10.79	0.21
BMI	28.70 ± 6.01	27.26 ± 5.71	28.75 ± 6.04	0.13
Sex				
Male	40 (40)	1 (2.5)	39 (97.5)	0.81
Female	60 (60)	2 (3.3)	58 (96.7)	
Age range				
<40	6 (6)	0	6 (100)	0.17
40 - 60	50 (50)	2 (4)	48 (96.7)	
>60	44 (44)	1 (13.6)	38 (86.4)	
BMI categories				
<25	22 (22)	3 (13.6)	19 (86,4)	0.53
25 - 30	43 (43)	3 (7.0)	40 (93.0)	
>25	35 (35)	2 (5.7)	33 (94.3)	
Alcohol	41 (41)	3 (7.3)	38 (92.7)	0.4
Tobacco	12 (12)	1 (8.3)	11 (91.7)	0.25
Blood transfusion	9 (9)	0	9 (100)	0.580
Surgical Intervention	23 (23)	1 (4,3)	22 (95.7)	0.67
Dental care	50 (50)	3 (6.0)	47 (94.0)	0.08

Values representing ages and BMI are presented in mean ± standard deviation; Values in brackets are expressed in percentages; N represents the number of diabetics concerned.

3.8. Effect of the Duration of Diabetes on Biochemical Parameters

Table 7 demonstrates that the amount of albumin drops by 0.013 every year of diabetes duration.

Table 6. Seroprevalence of HBV and HCV of the study population according to the biochemical parameters.

Parameters	Diabetes N = 89	Diabetes + Hepatitis B N = 3	Diabetes + Hepatitis C N = 8	ANOVA P-value
ALT (UI/L)	24.48 ± 17.01	39.10 ± 23.89	32.11 ± 16.52	0.181
AST (UI/L)	37.33 ± 22.36	52.10 ± 21.24	50.06 ± 27.34	0.192
Urea (g/L)	0.49 ± 0.08	0.39 ± 0.12	0.46 ± 0.04	0.056
Creatinine (g/L)	11.82 ± 3.84	10.30 ± 3.93	11.75 ± 5.75	0.812
FBG (g/L)	1.36 ± 0.45	1.44 ± 0.68	1.28 ± 0.35	0.863
TC (g/L)	1.68 ± 0.43	1.60 ± 0.13	1.43 ± 0.20	0.252
HDL-C (g/L)	0.46 ± 0.08[b]	0.48 ± 0.10[a,b]	0.37 ± 0.11[a]	0.0282
LDL-C (g/L)	0.91 ± 0.40	0.78 ± 0.11	0.72 ± 0.25	0.372
TG (g/L)	1.61 ± 0.45	1.71 ± 0.17	1.67 ± 0.55	0.879
Albumin (g/L)	43.90 ± 4.73	39.73 ± 2.54	41.42 ± 4.70	0.134

Legend: [a,b]Represents the statistically significant differences of post hoc test of Tukey after one way Anova; Values are represented as mean ± Standard Deviation; N represents the number of diabetics; FBG: fasting blood glucose; TC: total cholesterol; TG: triglyceride; HDL-C: High-density lipoprotein cholesterol; LDL-C: Low-density lipoprotein.

Table 7. Effect of the duration of diabetes on biochemical parameters.

Biochemical parameters	Coef	T	P-value
FBG (g/L)	0.003	1.00	0.322
AST (UI/L)	−0.003	−0.34	0.735
ALT (UI/L)	0.001	0.06	0.955
TC (g/L)	2.541	1.29	0.200
HDL-C (g/L)	−3.108	−1.40	0.164
LDL-C (g/L)	−2.786	−1.40	0.165
TG (g/L)	−0.365	−0.89	0.376
Urea (g/L)	0.998	0.87	0.389
Creatinine (g/L)	0.034	1.59	0.115
Albumin (g/L)	−0.044	−2.53	0.013

Legend: SE: Standard Error; Coef: Coefficient; T: T-test; FBG: fasting blood glucose; TC: total cholesterol; TG: triglyceride; HDL-C: High-density lipoprotein cholesterol; LDL-C: Low-density lipoprotein.

4. Discussion

We conducted a cross-sectional study whose objective was to determine the frequency of hepatitis B and C and the metabolic profile in patients with type 2 diabetes followed at the National Obesity Center (CNO) of the Central Hospital of Yaoundé (HCY). We included 100 type 2 diabetics in this study with an average age of 58.41 ± 10.74 years.

The included patients had a normal liver function. In addition, we found a prevalence of 11% of hepatitis B and C, 3% for hepatitis B, and 8% for hepatitis C in type 2 diabetics.

The different ages of patients ranged from 32 to 82 years. The majority were in the 40 - 60 age group, this is similar to the one published by Gebrekristos *et al.*, in Ethiopia and that of Ba-Essa *et al.*, in Saudi Arabia who reported the same age group of 46 - 60 years with a respective average age of 45.8 ± 11.8 years and 48.42 ± 13.70 years [16] [17]. This could be explained by the fact that type 2 diabetes affects the elderly much more. Women were the most represented (60%). These results are consistent with other data such as that obtained by Merza, in 2020 in an Iraqi Kurdistan population (Duhok province) and that of Villar *et al.* in 2019 in a Brazilian population, which had a greater representation of women (65.87% and 63.87% respectively) [5] [18]. This result could be justified not only by the high representation of women in society but also by their greater attendance at healthcare facilities. The majority of participants had a primary level of education (38%), this is in line with the study by Gebrekristos *et al.*, in Ethiopia, which reports a proportion of 36.5% of participants with a primary level of education [16]. This justifies the fact that most respondents had heard of hepatitis B and C, but did not know the mode of transmission.

The participants' average BMI was 28.70 ± 6.01 kg/m^2, indicating that they were overweight; more than 90% of type 2 diabetes patients have a BMI of 25 kg/m^2 or above [19]. Similar data were obtained in the Moroccan population [7]. Indeed, it has been shown that being overweight or obese is a risk factor for type 2 diabetes.

In general, patients had normal liver function (AST and ALT: 38.79 ± 22.89 and 25.53 ± 17.27 respectively). Similarly, renal function was normal in the included patients (creatinine: 11.77 ± 3.98; albumin 43.56 ± 4.74). This can be seen as a protective effect for these patients since all of them are under medication. Apart from triglyceride levels (1.61 ± 0.46), other lipid profile parameters were normal in our study population. Triglycerides are fatty acid esters of glycerol and represent the main lipid component of dietary fat and fat depots of animals. Elevated triglycerides level can be considered a lipid metabolism disorder, which can be linked to diabetes or treatment, in particular to insulin which is known to have an anti-lipolytic effect [20].

The treatment frequency with oral antidiabetic drugs was 70%; 15% were on insulin treatment, while 15% were taking oral antidiabetics and insulin. These different treatments taken by most of the patients in this study could partly ex-

plain the results of their metabolic profile. Indeed, metformin (a first-line anti-diabetic drug taken by some patients in the study population) has been shown to have a lipid-lowering effect [21] [22] [23].

Serological tests for hepatitis B and C were performed during this investigation to look for anti-HCV antibodies and HBsAg. Contrary to the prevalence values of hepatitis B (11.2%) [13], and hepatitis C (4.9%) [24] obtained in the general population of Cameroon, we obtained a prevalence of 3% of hepatitis B and 8% of hepatitis C in type 2 diabetics. Because hepatitis B is more frequently linked to sexually transmitted diseases (STDs), which in turn cause an increase in the national incidence of hepatitis B in Cameroon, the low prevalence of hepatitis B in our research population can be attributable to this [25]. In contrast, anti-HCV antibodies are more prevalent in our sample because the average age is of 58.41 ± 10.74 years (which is the third age), meaning that some diabetics would have had pathologies that are likely to have resulted in blood transfusions (the primary cause of hepatitis C contamination) and because there is no effective hepatitis C vaccine for the majority of the population [26]. Bassit, in 2014 recorded in his study in Marrakech a prevalence of 4.5% of hepatitis C and 2.5% of hepatitis B [7]. Villar *et al.* in 2019 in Brazil did a study showing a prevalence of 2.42% of hepatitis C and 0.55% of hepatitis B [5]. These results are consistent with ours, with a low prevalence of HBsAg compared to HCV-Ac. Our results contradict certain studies conducted in Africa [27] [28]. This variation in results can be explained by the type of study population. First, the study population consisted of children co-infected with human immunodeficiency virus type 1 (HIV-1) and viral hepatitis [27]; second, the sample was composed of southeast Nigerian HIV-positive patients co-infected with hepatitis B and C [28].

HCV+ participants had an average age of 65.6 ± 8.4 years and most (6/8) were in the age range > 60 years. This result is consistent with many epidemiological studies that have demonstrated that diabetes people between the ages of 40 and 65 have an increased risk of contracting hepatitis C [29] [30].

In contrast, HBV+ participants had an average age of 50.7 ± 5.9 years, and most (2/3) were in the 40 - 60 age group. This low prevalence of HBV infection and the high frequency in younger patients is thought to be related to the wide vaccination coverage against hepatitis B, lowering the circulation of the virus in the general population. The risk factors for HCV and HBV reported by the study population were dental care (50%), followed by alcohol consumption (41%), surgery (23%), and blood transfusion (9%). However, all these risk factors were comparable in diabetic patients without viral infection and those with HCV+ or HBV serology. Thus, HBV and HCV infection in diabetes patients included in our study would not be linked to these risk factors. Similar results were obtained respectively by Chen *et al.* in 2006 in a Chinese population, Jadoon *et al.* in 2010 in a Pakistani population, and Kombi *et al.* in 2018 in a Congolese population [29] [30] [31].

There was a non-significant increase in AST and ALT values in HCV+ diabetic patients and HBV+ diabetics than in diabetic patients only. These findings

are contrary to the study in an Indian population that reported a significant difference between those two parameters [32]. This could be explained by the type of study population.

Our results showed a significant decrease ($p = 0.028$) in HDL cholesterol levels in HCV+ diabetic patients compared to the other 2 groups (diabetic only and HBV+ diabetic patients). This contradicts the findings of research conducted in Iran, where individuals with hepatitis B had considerably high HDL cholesterol concentrations ($p = 0.04$) [33]. The decreasing level of albumin in the blood may be related to water retention over time related to the effectiveness of antidiabetic treatments.

5. Conclusion

It appears from this study that the included patients had normal liver and kidney functions. Moreover, the lipid profile of the patients was dominated by hypertriglyceridemia. In addition to this, the results revealed that the seroprevalence of hepatitis B and C was 3% and 8%, respectively in type 2 diabetics.

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Data Availability Statement

Data is available from the corresponding authors (N.N).

Authors' Contributions

L.A.F.S, N.N, N.L initiated the project, wrote and corrected the manuscript. L.A.F.S, conducted biological tests. J.L.M.N, F.M.M, conducted statistical analyzes. N.N, J.A, supervised the study. All the authors read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Cross-Sectional Height-Specific Changes in Serum Lipid Concentrations in Cameroon Children

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Abstract

Background: Information on the relationship between height and changes in serum lipids in children is scarce in Cameroon. The aim of this study is to determine prevalence of dyslipidemia with respect to age and gender and assess the association between height increase and serum lipid changes in Cameroon children. **Methods:** This hospital-based cross-sectional analysis included 472 boys and 534 girls between the ages of 5 and 16 years. Body height, weight, and waist circumference (WC) of children were measured and z-scores calculated. Total cholesterol-TC, triglycerides-TG, low density lipoprotein cholesterol-LDL-C and high-density lipoprotein cholesterol-HDL-C concentrations in fasting blood samples were determined by enzymatic method using an automated clinical chemistry analyzer (RX Monaco, UK). Children were divided into increasing quartiles of height z-score. Multiple linear regression analysis was used to compare mean lipid concentrations across quartiles of height z-score after controlling for age, gender, body weight, WC and fasting blood glucose. **Results:** The prevalence of elevated TC and LDL-C were respectively 18.5% and 19.2% higher in girls than boys. Also, the prevalence of elevated TC and TG was highest among younger (5- to 9-year-old) girls and boys respectively. There was a significant decrease in mean TC (168.8 to 127.2 mg/dl; $p < 0.001$), TG (99.0 to 84.1 mg/dl; $p = 0.019$) and LDL-C (91.1 to 69.4 mg/dl; $p = 0.018$) in boys; and a significant decrease in mean TC (171.2 to 144.7 mg/dl; $p = 0.004$) and HDL-C (62.8 to 28.7 mg/dl; $p < 0.001$) in girls with increasing quartiles of height z-score. However, the decrease in HDL-C in boys ($p = 0.053$) and the decrease in TG ($p = 0.211$) and LDL-C ($p = 0.732$) in girls with increasing height were not significant. **Con-**

clusion: Serum lipids decreased with increasing height after controlling for different variables. This study indicates that short children have higher serum lipid concentrations and this may increase the risk of lipid disorders, which may persist into adulthood.

Keywords

Serum Lipids, Dyslipidemia, Height, Children, Cameroon

1. Introduction

Height is an important measure of nutrition status. It is determined by genetic predisposition and other environmental factors and it also reflects chronic disease in children and adults [1]. For instance, a recent study revealed that a one-standard deviation decrease in height (determined genetically) increased the risk of coronary artery disease (CAD) by 13.5% in adults [2]. Also, a systematic review and meta-analysis indicated that short height increased the risk of cardiovascular disease (CVD) mortality and coronary heart disease (CHD) by 1.55 and 1.49 times respectively when compared with the tallest subjects [3]. In another meta-analysis height had an inverse association with risk of stroke and CVD [4]. There is additional evidence from epidemiologic studies indicating that height is also inversely associated with dyslipidemia in both children and adults. In adults, a recent Korean study revealed that height had an inverse association with total cholesterol (TC), triglycerides (TG) and low-density lipoprotein cholesterol (LDL-C) and a positive association with high-density lipoprotein cholesterol (HDL-C) in men and women [5]. Also, a prospective cohort study indicated that a 6.7 cm increase in body height was associated with a 0.12 mmol/l decrease in serum cholesterol [6]. In children, shorter height increased the odds of hypercholesterolemia, hypertriglyceridemia and hyper-LDL-cholesterolemia by 2.3 to 7.0 times in boys, and in girls, only the odds of hyper-LDL-cholesterolemia increased by 3.12 times [5]. Also, a recent study showed that an increase of one standard deviation in body height lowered LDL-C by 0.049 mg/dl [7]. Previously, the Bogalusa Heart Study had shown that height is inversely associated with HDL-C and LDL-C in black and white adolescent males respectively [8]. However, this study did not control for the effect of confounding variables like dietary intake and tanner stage. In addition, studies in Japanese children had shown that height increase over a 3-year period had a negative association with TC, HDL-C [9] and LDL-C during puberty [10]. The decrease in serum lipid concentration during puberty has been attributed to the process of sexual maturation involving an increase in oestradiol and testosterone concentrations in girls and boys respectively [11] [12] [13]. Also, the secretion of growth hormone during this period promotes linear growth, and there is evidence that growth hormone secretion has a negative association with LDL-C [14]. The adverse lipid profile (dyslipidemia) and its association with shorter height from the above

findings constitute a major contributor to the development of CVD and atherosclerosis [15] [16]. Atherosclerosis can start early in life and can persist until adulthood resulting in coronary atherosclerosis [17] [18]. Thus, in order to prevent cardiovascular diseases in adulthood, it is important for serum lipid levels to be checked during childhood and appropriate interventions carried out when necessary [17]. However, there is also evidence that some children can have elevated serum lipid levels that drop to acceptable levels later in life [19]. It can be hypothesized from the above findings that shorter children may tend to have higher levels of serum lipids. Information on this aspect is scarce in Africa and Cameroon in particular. In this study, the aim was to determine the prevalence of lipid disorders with respect to gender and age and assess the changes in serum lipid levels in relation to height-for-age in Cameroon children.

2. Materials and Methods

2.1. Study Design and Study Participants

This cross-sectional study was limited to children between the ages of 5 and 16 years who were recruited in-hospital (Bamenda Regional Hospital—BRH, Cameroon) during consultations from November 2021 to October 2022. The children and their parents/guardians were approached by laboratory technicians involved in data collection as they arrived the outpatient unit of the BRH and were provided with the consent information. Children were included in the study after their parents/guardians had provided informed consent and if the children had fasted overnight for at least twelve hours. Among the 1069 potential participants of the study, those with type 1 diabetes [20] and those with incomplete serum lipid data and anthropometric measurements (n = 63) were excluded. This eventually gave a sample that included 1006 children (472 boys and 534 girls).

2.2. Ethical Considerations

The study protocol was approved by the Ethical Review Committee/Institutional Review Board (IRB) of the Faculty of Health Sciences of The University of Bamenda (Ref. no. 2021/103H/UBa/IRB). Administrative clearance was also obtained from the North West Regional Delegation for Public Health. In addition, hospital clearance was obtained from the BRH. Lastly, all parents/guardians and children provided written informed consent and verbal assent respectively before data was collected.

3. Data Collection

3.1. Anthropometric Measurements

The body height of each participant was measured in bare feet using a portable stadiometer (SECA 213, Germany) to an accuracy of 0.1 cm. Body weight was also measured in bare feet and light clothing using a tetrapolar bioimpedance digital scale (Omron BF 511, Japan) to the nearest 0.1 kg. Body mass index

(BMI) was calculated as weight (kg) divided by the square of the height (m^2). The z-score of body height, weight and BMI were calculated using the WHO growth monitoring software (WHO Anthro) for children between 5 and 19 years [21]. This growth monitoring software makes use of the WHO 2007 child growth standards. The cases were sorted by increasing height z-score and then divided into increasing quartiles of height z-score. Waist circumference (WC) was also measured using a flexible inelastic waist circumference measuring tape (SECA 209, Germany) to the nearest 0.5 cm [22]. The WC readings were also converted to z-scores using LMS Growth software, which employs the UK 1990 growth reference standards as reported by McCarthy *et al.* [22].

3.2. Laboratory Measurements

The biochemical procedures were carried out in the laboratory of the BRH. Fasting veinous blood samples (5 ml) were obtained from the antecubital fossa using a vacutainer by laboratory technicians. The blood collected was allowed to coagulate. Centrifugation was carried at 3000 rpm for three minutes and serum was obtained using a pipette and transferred in to vials for lipid profile determination. The concentrations of TC, TG and HDL-C in serum were determined enzymatically using an automatic chemistry analyzer (Randox Monaco, UK). The instructions of the manufacturer were followed and the Randox Multisera level 2 and 3 were used for daily quality control monitoring. The Friedewald formular was used to calculate the concentration of LDL-C [23]. The study participants with at least one of the following lipid disorders were considered as dyslipidemic according to the Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents: hypo-HDL-cholesterolemia (<35 mg/dl), hyper-LDL-cholesterolemia (≥130 mg/dl), hypercholesterolemia (≥200 mg/dl), hypertriglyceridemia (≥100 mg/dl for children between 0 and 9 years and ≥130 mg/dl for children between 10 and 19 years) [24]. Fasting blood glucose was also determined using a blood glucose meter (Model G-425-3, LabPro Pharma, LLC, Houston, Texas, US).

3.3. Statistical Analysis

All statistical analyses were performed using IBM-SPSS version 21.0 (IBM, 1 New Orchard Road Armonk, New York 10504-1722, US). The distribution of continuous variables was checked for normality using the Kolmogorov Smirnov (*K-S*) test. Comparisons of mean concentrations of serum lipids between boys and girls and also between two age groups (5 - 9 and 10 - 16 years) were carried out using the independent samples *t*-test and data has been reported as mean (minimum - maximum). Also, the proportions of children with abnormal lipid levels were calculated and the data has been presented as % (95% CI). The comparison of proportions was carried out using the Chi square test. In addition, the comparison of means of serum lipid concentrations across increasing quartiles of height z-score was carried out using general linear models. In this analysis, the

serum lipids (TC, TG, LDL-C and HDL-C) were modeled as dependent variables and quartiles of height z-score as the independent variable. The model was adjusted for covariates including; age, gender, body weight, waist circumference and fasting blood glucose. The unadjusted and adjusted mean concentrations of serum lipids across quartiles of height-z-score have been presented with their corresponding standard errors and *p*-values for trend. The cut-off for statistical significance was set at $p < 0.05$.

4. Results

4.1. Summary Characteristics of the Study Population

The summary characteristics of the study population have been presented in Table 1 below. With respect to gender, girls were significantly older ($p < 0.001$) and heavier ($p = 0.008$) than boys. Also, the girls had significantly higher mean serum TC ($p = 0.002$), TG ($p = 0.004$) and LDL-C ($p = 0.003$) concentrations than the boys. The boys had a higher mean HDL-C concentration than girls. However, this difference was not significant ($p = 0.241$). In addition, the mean waist circumference (WC) was significantly higher for girls ($p < 0.001$) than boys. The mean blood glucose was significantly higher in boys ($p < 0.001$) than girls. With respect to age groups, the mean concentrations of serum lipids decreased slightly among children between the ages of 10 and 16 years. However, these differences were not statistically significant ($p > 0.05$) when compared with

Table 1. Summary characteristics of the study population with respect to gender and age group.

Variables	Boys		Girls	
	5 - 9 years	10 - 16 years	5 - 9 years	10 - 16 years
n	240	232	194	340
Height (cm)	134.8 (125.0 - 145.0)	155.5 (133.0 - 178.0)	132.1 (128.0 - 153.0)	154.9 (131.0 - 167.0)
Height z-score	0.5 (−1.8 - 2.6)	−0.4 (−2.1 - 1.2)	0.2 (−0.8 - 2.5)	−0.2 (−2.1 - 1.7)
Weight (kg)	29.3 (22.0 - 38.0)	50.7 (25.0 - 76.0)	29.6 (22.0 - 38.0)	51.5 (25.0 - 87.0)
Weight z-score	0.3 (−1.2 - 1.7)	0.2 (−2.2 - 2.5)	0.2 (−2.0 - 1.5)	0.3 (−2.9 - 2.7)
BMI (kg/m^2)	16.2 (10.9 - 21.3)	20.3 (12.9 - 27.3)	16.9 (12.1 - 20.7)	21.2 (11.6 - 33.2)
BMI z-score	−0.3 (−5.4 - 2.2)	0.5 (−2.8 - 2.5)	0.2 (−3.2 - 1.9)	0.3 (−4.2 - 2.8)
Waist circumference (cm)	60.9 (54.0 - 67.0)	68.4 (54.0 - 85.0)	61.8 (54.0 - 70.0)	70.9 (53.0 - 90.0)
Waist circumference z-score	1.0 (−0.7 - 1.9)	0.5 (−1.7 - 2.2)	1.2 (−0.4 - 2.5)	1.3 (−1.5 - 3.2)
Total cholesterol (mg/dl)	157.2 (96.2 - 228.2)	150.6 (89.3 - 281.1)	171.7 (63.0 - 229.0)	159.5 (78.5 - 237.0)
Triglycerides (mg/dl)	96.9 (40.4 - 224.0)	83.1 (31.7 - 275.9)	111.1 (24.0 - 389.3)	90.6 (54.6 - 117.5)
LDL-C (mg/dl)	83.3 (33.8 - 167.4)	79.4 (37.3 - 228.8)	103.2 (19.2 - 241.8)	86.9 (24.6 - 209.8)
HDL-C (mg/dl)	57.3 (−46.9 - 106.0)	51.9 (−76.7 - 201.0)	50.4 (−42.9 - 98.6)	50.3 (−33.7 - 89.3)
Blood glucose (mg/dl)	117.0 (87.0 - 152.0)	107.1 (79.0 - 189.0)	106.4 (84.0 - 137.0)	107.0 (71.0 - 154.0)

Values = mean (min - max).

those of the younger children (5 to 9 years). Mean blood glucose concentration was significantly higher ($p = 0.002$) among the younger children (5 to 9 years) than those who are 10 to 16 years.

4.2. Prevalence of Lipid Disorders with Respect to Gender and Age

The prevalence of lipid disorders in relation to gender and age is presented in Table 2. There was an 18.5% increase in the prevalence of hypercholesterolemia (TC ≥ 200 mg/dl) in girls when compared with boys ($X^2 = 20.187$, $p < 0.001$). Also, the prevalence of hyper-LDL-cholesterolemia significantly increased by 19.2% in girls ($X^2 = 28.053$, $p < 0.001$) than boys. Hypertriglyceridemia was also higher for girls than boys. However, this difference was not statistically significant ($X^2 = 0.207$, $p = 0.649$). The prevalence of hypo-HDL-C was higher in boys (36.0%) than girls (33.0%). However, the difference was not significant ($X^2 = 0.519$, $p = 0.471$). The prevalence of dyslipidemia was highest among the younger children than their older peers. For instance, the prevalence of hypercholesterolemia and hypertriglyceridemia was highest among 5- to 9-year-old girls and boys respectively. On the contrary, the prevalence of hypo-HDL-cholesterolemia was highest among the 10- to 16-year-old boys. It is also important to note that the prevalence of combined dyslipidemia in the whole sample was 19.3%. On a gender basis, combined dyslipidemia was higher among girls (21.0%) than boys (17.4%).

4.3. Height Increase and Serum Lipid Concentrations

Table 3 shows the relationship between height increase and serum lipid concentrations in the study participants. The mean body height for the first, second, third and fourth quartiles of height z-score were 138.2, 141.8, 145.9 and 148.1 cm respectively for the whole sample. When the study participants were classified according to increasing quartiles of height z-score, inverse relationships were observed with serum lipids. In boys, there was a significant decrease in the adjusted mean TC, TG and LDL-C concentrations with increasing height quartiles. Body height in boys was also inversely related with HDL-C. However, this relationship

Table 2. Prevalence of lipid disorders in relation to gender and age.

Variables	Boys		Girls	
	5 - 9 years	10 - 16 years	5 - 9 years	10 - 16 years
n	240	232	194	340
TC ≥ 200 mg/dl	24.2 (17.4 - 32.6)	19.0 (12.9 - 27.1)	57.7 (44.8 - 67.1)	30.0 (23.6 - 37.3)
TG ≥ 100 mg/dl and ≥130 mg/dl	56.7 (47.7 - 65.2)	37.1 (28.5 - 46.1)	45.4 (35.8 - 55.3)	51.2 (43.7 - 58.6)
LDL-C ≥ 130 mg/dl	12.9 (8.0 - 20.2)	10.8 (6.4 - 17.7)	40.2 (31.0 - 50.2)	25.9 (19.9 - 33.0)
HDL-C < 35 mg/dl	25.0 (18.0 - 33.6)	46.7 (37.9 - 55.6)	32.9 (24.4 - 42.8)	32.9 (26.3 - 40.3)

Values = % (95% CI).

was not significant. In girls, there was a significant decrease in the adjusted mean TC and HDL-C concentrations with increase in height.

4.4. Prevalence of Lipid Disorders in Relation to Height-for-Age

Figure 1 shows the prevalence of lipid disorders in relation to increasing height-for-age in boys and girls. The prevalence of hypercholesterolemia decreased significantly with increasing quartiles of height z-score in both boys (*p*

Table 3. Changes of serum lipid concentration in relation to height.

Height quartiles	N	TC (mg/dl)		TG (mg/dl)		LDL-C (mg/dl)		HDL-C (mg/dl)	
		Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
Boys									
First	108	169.1 (5.4)	168.8 (4.0)	103.0 (5.7)	99.0 (5.1)	94.5 (7.5)	91.1 (4.2)	58.4 (2.2)	63.0 (5.0)
Second	134	154.0 (3.5)	156.6 (4.2)	86.7 (6.7)	88.3 (5.7)	79.6 (2.5)	81.1 (4.7)	57.1 (2.6)	53.7 (5.4)
Third	101	151.6 (4.3)	152.4 (4.5)	85.2 (5.2)	87.8 (6.3)	78.3 (2.9)	78.8 (4.3)	52.1 (9.2)	55.6 (4.8)
Fourth	129	133.2 (4.3)	127.4 (4.9)	86.1 (5.3)	84.1 (5.3)	66.6 (3.1)	69.4 (5.2)	49.6 (2.9)	41.0 (5.9)
p-value for trend		0.007	< 0.001	0.019	0.039	0.002	0.018	0.704	0.053
Girls									
First	140	171.3 (2.7)	171.2 (4.4)	102.3 (5.7)	98.4 (7.9)	99.3 (6.8)	96.6 (5.8)	60.8 (2.2)	62.8 (4.5)
Second	130	166.4 (3.4)	167.6 (4.1)	104.2 (5.9)	97.3 (7.6)	94.3 (5.2)	91.6 (5.3)	54.5 (4.8)	57.0 (4.7)
Third	158	169.3 (4.9)	168.3 (4.0)	94.0 (2.4)	91.9 (6.9)	87.4 (3.1)	92.3 (6.1)	50.3 (4.5)	48.3 (4.4)
Fourth	106	142.9 (6.1)	144.7 (4.6)	92.6 (6.4)	95.0 (7.1)	87.9 (7.4)	91.2 (5.4)	31.4 (5.5)	28.7 (4.9)
p-value for trend		<0.001	0.004	0.034	0.211	0.123	0.732	<0.001	<0.001

Values = mean (standard error). The mean serum lipid concentrations were adjusted for age, gender, body weight, waist circumference and fasting blood glucose.

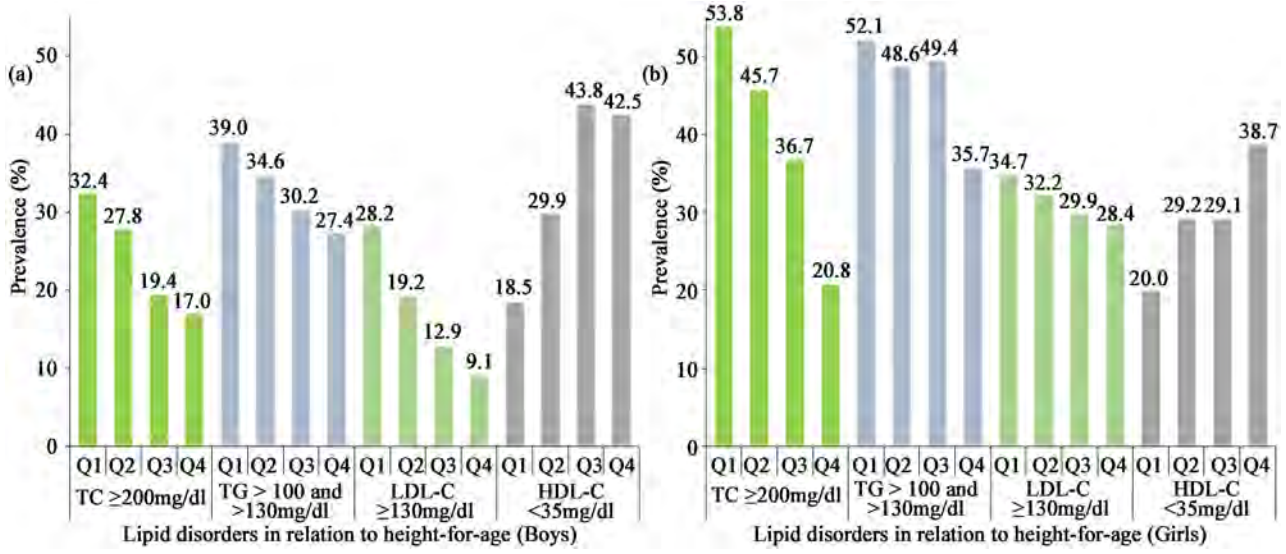

Figure 1. Prevalence of lipid disorders in relation to height-for-age in boys (a) and girls (b).

for trend < 0.001) and girls (p for trend = 0.002). Also, the prevalence of hypertriglyceridemia decreased with increase in height in boys (p for trend = 0.009) and girls (p for trend = 0.041). In addition, the prevalence of hyper-LDL-cholesterolemia significantly decreased with increasing quartiles of height-z-score in boys (p for trend = 0.001) and girls. However, in girls, the decrease observed was not statistically significant (p for trend = 0.699). In the case of hypo-HDL-cholesterolemia, the prevalence increased with increase in height for both boys (p for trend = 0.002) and girls (p for trend < 0.001).

5. Discussion

This study set out to determine the prevalence of lipid disorders with respect to gender and age and also to determine the changes in serum lipid concentrations with respect to increased height-for-age. On a gender basis, the prevalence of hypercholesterolemia, hyper-LDL-cholesterolemia and hypertriglyceridemia were generally higher for girls than boys. However, the prevalence of hypo-HDL-cholesterolemia was higher in boys than girls. This finding is in line with that of a recent study in which the prevalence of elevated TG and LDL-C increased by 1.7% and 3.3% respectively in girls compared to boys and the prevalence of low HDL-C increased by 6.7% in boys compared to girls [25]. This can be explained by the fact that the levels of serum lipids are influenced by sex hormones during puberty and adolescence [26]. For example, a previous report had indicated that lower LDL-C and HDL-C were associated with an increase in plasma concentrations of estrogen and progesterone in girls and testosterone in boys [11] [27]. Also, changes that occur in the expression of some genes like apoA-1 and ABCA1 that occur during development, have been linked to alterations in esterified cholesterol concentrations and a reduction in HDL-C production [28].

With respect to age, the prevalence of elevated TC, TG and LDL-C decreased and low HDL-C increased among boys between the ages of 10 and 16 years when compared with their younger peers. In girls, the prevalence of elevated TC and LDL-C decreased among those between the ages of 10 and 16 years. These also correspond with the observed decrease in mean concentrations of TC, TG and LDL-C among the older children in this study, though not statistically significant. There is evidence indicating that serum lipids usually peak in children between the ages of 9 and 10 years, and then decrease after [11]. A recent German Health Survey for children and adolescents revealed that serum lipid concentrations increased in children up to the age of 9 years and lower lipid measures were observed in children between the ages of 10 and 17 years [29]. Also, a previous report had shown that during adolescence, serum LDL-C and HDL-C decrease in children, with boys experiencing a more remarkable decrease in HDL-C [13] [30]. This is in line with the current study in which a higher prevalence of hypo-HDL-cholesterolemia was observed among the older boys (10 to 16 years). The decrease in serum lipids observed in older children observed in

this study could be explained by the fact that during puberty, hormonal alterations occur, which are linked to growth spurt and sexual maturation. These physiological processes lead to an increased in cholesterol requirement for the synthesis of cellular membranes in growing cells and tissues, which eventually lead to lower levels of lipids [8] [31].

An important finding of this study is that after controlling for confounding variables like age, gender, body weight, waist circumference and fasting blood glucose, inverse relationships were observed between height and mean serum lipid concentrations. The mean serum TC, TG, LDL-C and HDL-C concentrations significantly decreased with increasing quartiles of height z-score in boys. In girls, height had an inverse relationship with TC and HDL-C. Also, in both boys and girls, the prevalence of hypercholesterolemia, hypertriglyceridemia and hyper LDL-cholesterolemia were lower in taller children and the prevalence of hypo-HDL-cholesterolemia was higher in taller children. The above findings are in line with previous observations. For instance, a previous study in Japan indicated that height was inversely associated with TC and HDL-C in boys and girls [26]. Also, the Bogalusa Heart Study revealed that the observed changes in height over a five-year period had negative associations with TC, LDL-C and HDL-C in boys [8]. In addition, a three-year follow-up study in Japan showed that height was inversely associated with TC in pubertal children [9]. Moreover, a recent study has indicated that shorter height was associated with adverse lipid profiles in adolescents [5].

The above findings suggest that children with a higher height-for-age might also have lower concentrations of atherogenic lipids and children with a lower height-for age might have higher concentrations of atherogenic lipids. In fact, some authors had indicated that height and age should be considered in the evaluation of serum lipids in children [26]. Evidence indicates that growth spurt during puberty is negatively associated with changes in serum lipid levels [8]. Bone growth is influenced by increased growth hormone secretion during puberty and growth hormone has a lipolytic effect, which eventually improves lipid profiles [14]. Therefore, it can be suggested that pubertal children with sufficient growth hormone will experience an optimal growth and have acceptable lipid profiles [5]. The skeletal system is also involved in lipid metabolism. Osteocalcin is a hormone found in bone, which contributes to the expression of adiponectin gene in bone cells [32]. Adiponectin raises the level of serum HDL-C and reduces the concentration of serum TG [33]. Therefore, children with a high concentration of osteocalcin and experiencing a rapid growth velocity [34] are likely to have acceptable lipid profiles [35]. A recent study had investigated the relationship between height and CAD using a genetic approach [2]. The study revealed that height-related single nucleotide polymorphisms (SNPs) were significantly associated with CAD, and this represented a 13.5% increase in the risk of CAD for each one-standard deviation decrease in height. Also, this association was partly

attributed to the relationship between shorter height and elevated levels of TG and LDL-C [2].

6. Limitations of the Study

A limitation of this study is that the sample is not representative of Cameroon children. It is also not possible for causal relationships between height and adverse lipid profiles to be established because of the cross-sectional design of the study. Also, the effects of tanner stage, dietary intake and other lifestyle factors were not controlled for in the analysis. However, this study has assessed the relationship between height and dyslipidemia in Cameroon children for the first time and has controlled for confounding variables like age, gender, body weight, waist circumference and fasting blood glucose.

7. Conclusion

To conclude, this study has shown that the prevalence of dyslipidemia is generally higher for girls than boys. Also, the prevalence of dyslipidemia was higher among the younger children than their older peers. In addition, this study provides evidence that children with shorter heights have elevated levels of serum lipids, which may track to adulthood. Longitudinal studies with larger samples are needed in the future to track serum lipid changes with chronological age in children and adolescents.

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Availability of Data

Data and material are available from the corresponding author upon reasonable request.

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Authors Contributions

LKN was responsible for the conception and design of the study, direct collection of data and processing, statistical analysis and drafting of the manuscript. LLN contributed to the conception and design of the study and participated in data collection as well as interpretation of data and drafting of manuscript. TBC and EAR contributed to the conception and design of the study as well as interpretation and analysis of data. All authors revised the manuscript and gave a final approval of the submitted version.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Incidence, Mortality, and Epidemiology of Leukemia in South Asia: An Ecological Study

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Abstract

Background: Nowadays cancer is a buzzword in every corner of the world. Back a few decades, cancer was not that much known to the people of South Asia let alone known of Leukemia. Many countries in the South Asian region are designated as developing countries. Hence, the deficiency of diagnosis system, treatment, management, and lack of knowledge about leukemia in this region are major problems. Therefore, the incidence rate, mortality rate, and several deaths are increasing day by day. **Methods:** This cross-sectional study is aimed to investigate the incidence and mortality of leukemia in South Asian Countries for the year 2020 by acquiring data from the global cancer project (GLOBOCAN2020) accessible at https://gco.iarc.fr. **Results:** In South Asia, 1,733,573 cancer cases were documented in 2020 where 62,163 cases were leukemia related. The highest incidence rate was reported in Pakistan (4.3 in 1,000,000) and Sri Lanka (4.1 in 1,000,000) and the lowest in Bangladesh (1.8 in 1,000,000) and Nepal (2.0 in 1,000,000). On the other hand, 1,124,875 death had been reported in 2020, where 45,707 (4.1%) death was associated with leukemia. Pakistan (3.4 in 1,000,000) and Maldives (3.1 in 1,000,000) had the highest death and lowest in Bangladesh (1.4 in 1,000,000) and Nepal (1.5 in 1,000,000). Adults aged from 60 - 85 years old have the highest rate of incidence and mortality rate in all countries except Nepal. **Conclusions:** Leukemia is one of the major concerning cancer of all ages people in South Asia, the situation and related risk factors information can be helpful to reduce death through proper treatment.

Keywords

Leukemia, Blood Cancer, South Asia, Incidence, Mortality, Epidemiology

1. Introduction

Cancer is considered a massive range of diseases that can initiate or proliferate in any part of the organ or tissue of the human body, it occurs when the growth of cells undergoes unusual such uncontrollably, will go beyond the usual barrier to invade adjoining segments of the human body and expand to other parts of the body's organ. (*World Health Organization*) Cancer is positioned as a dominant cause of death all around the world after cardiovascular disease, which plays a key role as the hurdle in the extension or elevation of average life expectancy in every continent and developed and developing countries and others. Leukemia is described as blood cancer that refers to a group of malignant disorders. In leukemia, the number of white blood cells raises unusually in the blood and bone marrow, where the stem cell initiates the production of different types of blood cells [1]. It is thought to be that leukemia originated from anomalies in bone marrow blood cells or stem cells, which ultimately lead to a high rate of immature and unappropriated blood cells and hinder the formation and proffering of normal and mature blood cells [2]. There are mainly four types of leukemia. Types of leukemia are based on the pathogenesis, origin, incidence, and prognosis. In chronic lymphocytic leukemia, the mature cells are predominantly present in the blood. The precursor of various lineage is greater in acute leukemia. However, in chronic myeloid leukemia, not only the precursor lineage is present at a greater rate but also the mature cells in chronic lymphocytic leukemia. The incidence rate of leukemia may differ among people due to different ages, sexes, races, and the environment they belong to. All these factors play a major role in mortality rate as well as in prevalence rate [3]. These discrepancies are mainly characterized by/involved with the intensity of exposure to environmental risk factors such as radiation, fume, smoking, etc. and genetic risk factor. For instance, about 10% of individuals might develop Chronic Lymphocytic Leukemia, who have a genetic history of their family to have this disease [4]. The fundamental reason for the incidence of leukemia is unrevealed and still mysterious, but the researcher, scientists, and many scholars have done numerous studies to find out the reason, which was conducted in different countries. They reach out to declare that there are some factors to be incorporated with the development of cancer and leukemia as well. The risk factors that are considered as the stimulant or precursors of leukemia are the weight of infant after birth, exposure to X-ray radiation, age of the mother at the time of childbirth, tonsillectomy, habits of smoking among the parents, use of insecticides, rate of birth, longer lactation period prolonged more than 6 months [5] [6]. Between acute lymphoblastic leukemia and acute myeloid leukemia, the most consistently diagnosed leukemia in children and young adults is Acute Lymphoblastic Leukemia, with incidence peaks between 2 and 5 years of age [7]. On the other hand, Acute Myeloid Leukemia is mostly found among adult individuals [8]. Leukemia was found to be the unceasingly happening cancer among all different races and ethnicities with relative coherence differing between 25% and 40% [9]. As per the data of the

global cancer project (GLOBOCAN2020), leukemia exhibited the 15th rank for most diagnosed cancer and 11th prime reason for cancer death in the year 2020 resulting in 474,519 new cases and 311,594 deaths of cancer. Across the World, the disease burden is higher among males than females by leukemia.

The incidence rates and mortality rates of leukemia in men are 2.7% and 3.2% respectively. And in women, the incidence rates and mortality rates are 2.6% and 3.0% respectively in the world [10].

2. Objective

This study was pointed out to estimate of leukemia incidence and mortality rates of infants to old adults (0 - 85+ years) in South Asian countries in an age-specific group.

3. Materials and Methods

This study attempts to observe the incidence and mortality rate of leukemia in 8 South Asian countries named Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka. The data were accumulated from the Global Cancer Project in the year 2020 accessible on https://gco.iarc.fr Global Cancer Project is a web platform that shows the statistics of global cancer by "International Agency for Research on Cancer" a part of the WHO. Here we classify in 6 age-specific groups (0 - 14, 15 - 29, 30 - 44, 45 - 59, 60 - 74, 70 - 85 and over).

Age-Specific Incidence Rate

The procedures estimate the gender, the age-country specific approximation is based on available data for each country. A complete appropriate data is impossible to find for the incidence and mortality valuation due to several varieties and complications in measuring methods as countries. So, an alphamerical counting scheme autonomously defines the obtainability of the data found at the country level. The collective evaluation is shown for each country to offer an extensive hint of the estimation.

These procedures evaluate the gender, age, and country-specific incidence rates of cancer incidence rates fall into several categories, based on priority:

1) Observed the rates up to the year 2020 (45 countries). 2) Observed the most recent incidence rates in the population of 2020 (54 countries). 3) National mortality data estimates were mated from cancer registries via mortality-to-incidence ratios (14 countries). 4) National mortality data was estimated from cancer registries via mortality-to-incidence ratios in adjacent countries (37 countries). 5) Age and sex-specific rates were obtained by overall rates of adjacent countries. 6) The partitioned rate for specific spots by existing relative frequency data of specific cancer (5 countries). 7) Estimated an average rate for selected adjacent countries (30 countries).

Age-Specific Mortality Rate

Adequate data on the national mortality rate fall into several categories, based on priority:

1) Observed the rates up to the year 2020 (80 countries). 2) Observed the most recent mortality rates in the population of 2020 (21 countries). 3) National mortality data was estimated from cancer registries via mortality-to-incidence ratios in adjacent countries (81 countries). 4) Estimated an average rate for selected adjacent countries (3 countries) [11].

4. Result

Incidence Rate

In South Asia total of 1,733,573 cancer Cases had reported in 2020, where 62,163 (3.59%) cases were associated with leukemia. In those leukemia cases, the number of men were 36,315 and females were 25,848. The highest incidence is shown in India (48,419), Pakistan (8305), and Bangladesh (2812). Pakistan (4.3 in 1,000,000) and Sri Lanka (4.1 in 1,000,000) had the highest incidence rates and where the highest number of incidences in men shown in Maldives and women in Pakistan (Table 1).

According to the age-specific range, the highest incidence rate was observed in 0 - 14 years in Maldives (4.8 in 100,000); between 15 - 29 years in Sri Lanka (2.6 in 100,000); in the age range 30 - 44 years in Pakistan, Sri Lanka (3.2 in 100,000); then age range of 45 - 59 years in Maldives (12.4 in 100,000); later 60 - 74 years in Maldives (12.7 in 100,000); in the end 70 - 85+ years In Bhutan (20.6 in 100,000) (Figure 1).

Mortality Rate

In South Asia total of 1,124,875 death had been reported in 2020, where 45,707 (4.1%) death was associated with leukemia. In leukemia death, men were 26,105 and females were 18,602. The highest mortality is shown in India (35,392), Pakistan (6261), and Bangladesh (2132). Pakistan (3.4 in 1,000,000) and Maldives (3.1

Table 1. Leukemia incidence and mortality rate of ASR and case number in male, female and both sex in 2020.

Country	Incidence Rate						Mortality Rate					
	Male (ASR)	Male (Case No.)	Female (ASR)	Female (Case No.)	Both Sex	Both Sex (Case No.)	Male (ASR)	Male (Case No.)	Female (ASR)	Female (Case No.)	Both Sex (ASR)	Both Sex (Case No.)
Afghanistan	3.5	606	2.9	472	3.2	1078	2.7	434	2.1	327	2.4	761
Bangladesh	2.1	1616	1.6	1196	1.8	2812	1.6	1250	1.1	882	1.4	2132
Bhutan	3	13	1.8	7	2.4	20	2.7	12	1.6	6	2.2	18
India	4.2	28,274	3.1	20,145	3.6	48,419	3	21,054	2.1	14,338	2.6	35,392
Maldives	5.8	15	3	5	-	20	4.1	12	1.7	3	3.1	15
Nepal	2.3	305	1.8	293	2	598	1.8	219	1.3	218	1.5	437
Pakistan	5	4941	3.6	3364	4.3	8305	3.9	2699	2.8	2562	3.4	6261
Sri Lanka	5.2	545	3.2	366	4.1	911	3.7	425	2.1	266	2.8	691
Total:		**36,315**		**25,848**		**62,163**		**26,105**		**18,602**		**45,707**

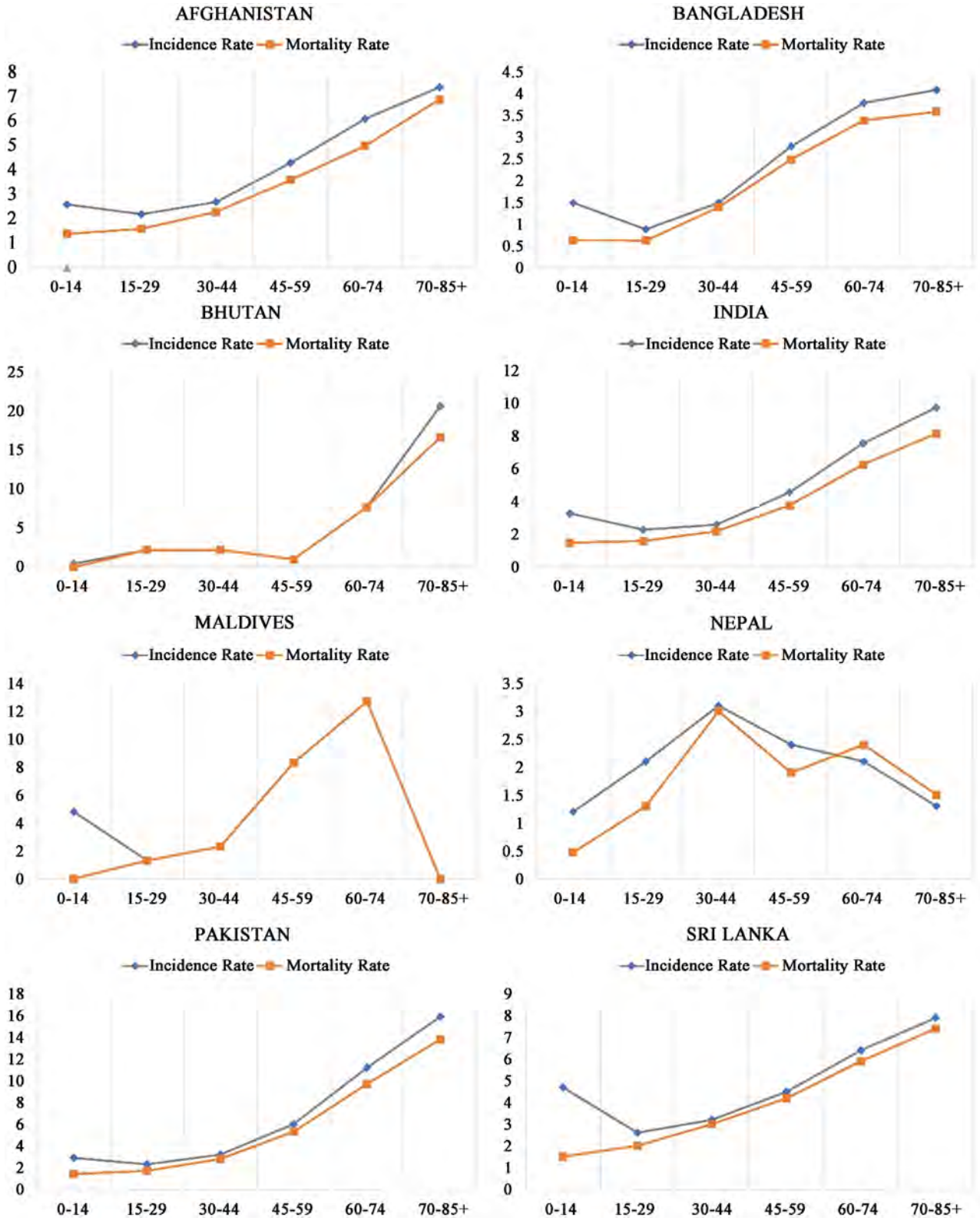

Figure 1. Age-specific incidence and mortality rate of leukemia in 8 countries.

in 1,000,000) had the highest death and where the highest number of deaths in women shown in Maldives and men in Pakistan (Table 1).

The highest mortality rate was observed in India and Sri Lanka in the age range 0 - 14 years (1.5 in 100,000); between 15 - 29 years in Bhutan (2.2 in 100,000); in the age range of 30 - 44 years in Nepal, Sri Lanka (3.0 in 100,000); then age range of 45 - 59 years in Maldives (8.3 in 100,000); later 60 - 74 years in Maldives (12.7 in 100,000); in the end 70 - 85+ years in Bhutan (16.6 in 100,000) (**Figure 1**).

5. Discussion

About 44% of leukemia is diagnosed compared to all kinds of cancer in the age range 0 - 15 years population [12]. About 10% of cases have been epidemiologically and clinically distinguished in childhood cancers and the rest of 90% of cases of cancer could not identify with specific diagnostics. In childhood leukemia, it is observed that not only leukemia but also other cancer is associated with the environment and multiple genes [13].

Fatigue, Muscular cramps, musculoskeletal pain, abdominal disturbances, edema, and skin problems are the most common symptoms of leukemia [14]. Bone marrow biopsy is one of the diagnosis methods of leukemia. Chemotherapy, intensification therapy, stem-cell transplantation, and continuation treatment are widely used to treat this cancer [15]. This kind of cancer is a common reason for child death. The routine screening agendas might be useful for early identification and proper medical support for this kind of patient [16].

In the last four decades, the treatment and diagnosis system of leukemia has noticeable progress for all aged people. 30% - 40% of younger people with leukemia can be lifelong cured by different treatment systems [17]. Several diagnoses criteria and the treatment duration of leukemia needed a heavy resource which is an economic burden. Treatment cost of acute myeloid leukemia between 2007-2016, almost $386,077 is paid for each patient in the USA. At the time of treatment, around 60% of costs are spent in inpatient situations [18].

The highest incidence rate was reported in South Asia in Pakistan and Sri Lanka as 4.3 and 4.1 cases compared with other lower mortality rates in Bangladesh, Nepal, and Bhutan as 1.8, 2.0, and 2.4 cases per 100,000 people (**Figure 2**).

In 2020 around 56,876 (13% of the world) incidence cases of leukemia and 26,941 (8.7% of the world) mortality cases were shown in northern America. Compared with less-developed South Asian countries, the mortality rate is a significantly decent scenario in developed countries like northern America. The developed countries have significantly comparable mortality of leukemia due to proper treatment, medication, healthcare system, implantation of stem cells for a specific class of leukemia [19].

In European countries, the incidence of leukemia rate was 3.8 in 100,000 people of both genders [20]. According to the Surveillance, Epidemiology, and End Results (SEER) report (1973) incidence rate is 3.43, but in 2010 it rose to 4.2 in the United State of America [21]. According to Healey *et al.* [22] stated that this rate in Canada is 4.01 in 100,000 people.

In Nordic countries including Denmark, Finland, Iceland, Norway, and Sweden showed that the age and sex-specific incidence rate of Acute Lymphoblastic Leukemia (ALL) in the four-year interval of 3.84 - 4.03 cases per 100,000 population where the yearly mean of 0.22% [23].

In 2012, 8301 cases occur in Australia-New Zealand. This incidence is 11.3 in males and 7.2 in females per 100,000 people and the male-female ratio is 1.6. In Africa, 5.6 males and 2.6 females are affected by leukemia [11].

Here, the highest mortality rate was reported in Pakistan and Maldives as 3.4 and 3.1 cases compared with lower mortality rates in Bangladesh, Nepal, and Bhutan as 1.4, 1.5, and 2.2 cases per 100,000 people (**Figure 3**).

In Asia, the mortality rate in males is 3.8 cases and 2.6 in females per 100,000 people. The peak mortality rate reported in Eastern Asia, especially in China, and Japan were an average of 4.2 cases in males and 2.9 in females. In Western Asia, the mortality rate is 6.8 cases in males and 4.8 in females per 100,000

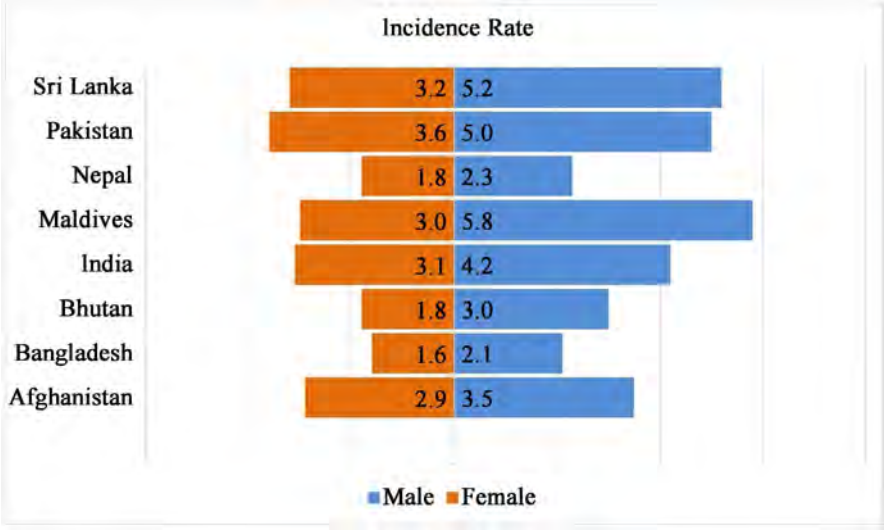

Figure 2. Leukemia incidence rate in 8 South Asian countries (male and female).

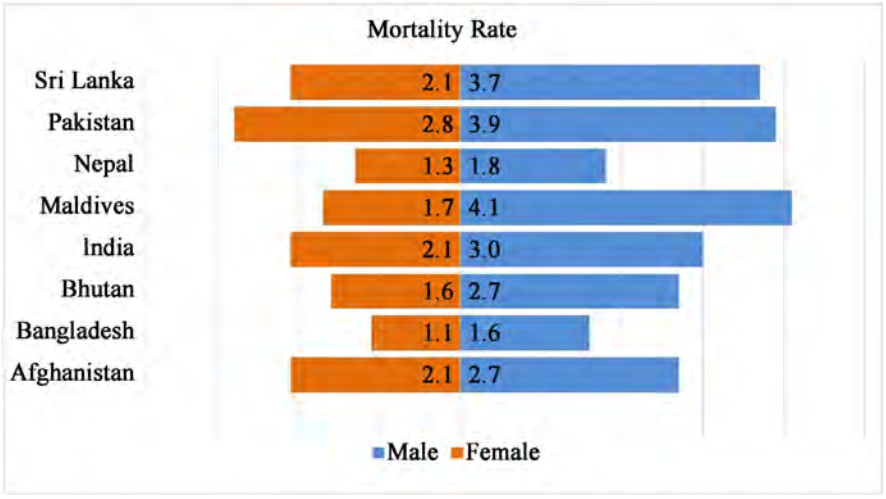

Figure 3. Leukemia mortality rate in 8 south Asian countries (male and female).

people [19]. Observe this continent, the western part of Asia has the highest mortality rate than Asia.

In Age-specific analysis incidence and mortality is quite high in Geriatrics people (especially those above 60 years older) compare with younger. In children (0 - 14 years), the rate is a little bit high. In the comparison between 8 countries, not only the incidence rate but also the mortality rate is enormously high in Bhutan, Maldives, Pakistan.

Poverty is one of the obstacles of detect the early diagnosis of leukemia. Lack of Sufficient nutrition and proper health facility makes complications of this kind of cancer treatment. As a result, the mortality e also is increased. Prevalence studies of leukemia should be keeping an effective role to identify the specific regions to identify the factors that can be reduced not only the incidence but also the mortality of leukemia.

6. Conclusion

Screening programs can be one of the effective supervision systems for identifying the incidence of leukemia. The prevalence and evaluation of all kinds of cancer occurrences might provide a vital role in evidence and prediction so that it is effective to decrease the incidence of cancer. Proper diagnosis-counseling and treatment could reduce the mortality of those patients.

Author Contribution

RHR & MRR designed and supervised the study. SI was responsible for the abstract and introduction. MMA contributed to the writing methodology. ATS contributed to the acquisition of data, and analysis of data and figures. MSP wrote the result, discussion and prepared the manuscript. MRR edited the final manuscript. All authors have read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Disability to Admit as a Change of Life after a Road Crash: Estimates and Related Factors in Benin for Prevention

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Abstract

Background: Disability is an underestimated issue in public health, with road crashes as leading cause. In Africa, motorcyclists disproportionately bear the burden of road crash injuries, including disability. To contribute to decision-making for disability prevention, this study aims to determine the prevalence and factors associated with disability at 12 months among motorcyclists involved in road crashes in Benin. **Methods:** This is a prospective, cross-sectional, analytical study based on 12-month follow-up data from a cohort of road crash victims set up in five hospitals in Benin. Data were collected from November 2020 to January 2021. Sample used for this analysis size was 297 motorcyclists. Disability was assessed using the Washington Group on Disabilities Statistics question set. Logistic regression analysis was used to identify risk factors for disability in victims 12 months after the crash. **Results:** The prevalence of disability was 12.5% 95% CI (9.2 - 16.7). Disability occurrence was associated with being over 45 years old (OR = 3.1; 95% CI = 1.5 - 6.6), severity of initial injury (OR = 3.3; 95% CI = 1.5 - 7.3) and hospitalisation of the victim (OR = 6.9; 95% CI = 2.0 - 24). **Conclusion:** Age over 45 years, severity of initial injuries and hospitalisation of the victim were risk factors for the occurrence of disability among motorcyclists who were victims of road crashes in Benin. User awareness, law enforcement, holistic and early management of road crash victims could contribute to reducing the prevalence of disability among victims in Benin.

Keywords

Disability, Motorcyclists, Road Traffic Accident

1. Introduction

Disability has become an important issue in health care, but still insufficiently considered in public policies. According to the World Health Organization (WHO), disability is not linked to the individual but results from the interaction between a health problem and personal and environmental factors. It can be experienced very differently by each individual and therefore reflects an individual perception of capabilities [1] [2]. People with disabilities are exposed to social inequality and disability has a direct impact on development as it can increase the risk of poverty [2]. This requires targeted interventions to meet their specific needs, which may include disabled seating on public transport, access to public buildings, disabled-friendly pavements and traffic lights. Road crashes are one of the leading causes of injury and years of life lost due to disability worldwide and in sub-Saharan Africa [3]. Disability prevalence is estimated to be around 16% of the world's population [1] and related factors commonly identified for post-crash disabilities are factors such as age, sex, injury severity, injury location, and referral conditions [4] [5] [6] [7] [8]. In Africa, motorbikes are more exposed to crashes (28% of road crash deaths worldwide), due to their vulnerability and their importance in the transport and in the general population [9] [10] [11]. They represent about more 75% of road crashes victims in hospital in Benin [12]. Research on the disability consequences of road crashes is relevant for complementing mortality and morbidity data or for developing road safety policies. It is also useful for planning rehabilitation needs and monitoring the Sustainable Development Goals (SDGs) at the country level [13]. An estimation of the prevalence of disability and the identification of its related factors could help to have a better understanding of the specific needs of motorcyclists and contribute to the development of a better road safety policy. Therefore, this study aims to provide data on disabilities resulting from road traffic crashes by estimating its prevalence and associated factors 12 months after the crash among road traffic victims in Benin.

2. Materials and Methods

2.1. Setting and Type of Study

This is a cross-sectional study with an analytical focus, involving road crashes motorcyclists victims from a cohort set up in five hospitals in Benin in 2019 and followed up until 2021.

2.2. Data Source and Participants Selection

The TraumAR cohort was set up as part of the Multidisciplinary Research

Project for the Prevention of Road Traffic crashes (ReMPARt) in Benin [12]. Initial collection took place from July 2019 to January 2020 in five referral hospitals for the management of road traffic injuries in Benin. They were selected based on their annual number of admissions for road crashes and their status as referral centres for several other health facilities in the health system.

After the baseline collection, two other data collections were conducted to complete the follow-up data of the TraumAR cohort. The baseline collection was led from July 2019 to January 2020 and consisted in a questionnaire directly addressed to inpatients. This was followed by exploitation of their medical records. The collection of the 6-month follow-up was carried out by questionnaire administered via a phone call interview and took place from May to June 2020. It collected data on the short-term consequences of the crash. The second follow-up point took place approximately 12 months after the crash, from November 2020 to January 2021. All eligible subjects (alive at the time of collection, giving consent for follow-up, residing in the southern zone of Benin) received a clinical examination and face-to-face administration of various specific tools related to the evaluation of health status: 1) physical or functional (disability, pain, health status), 2) psychological (anxiety, depression, post-traumatic stress disorder). Quality of life, return to work and the negative impact of the crash on income and family were also assessed. The present study considers baseline and 12-month follow-up data including disability assessment data.

The population was represented by the motorcyclists involved in crashes in the TraumAR cohort followed at 12 months. Inclusion criteria for this study were: consent for 12-month follow-up in the cohort, availability of all information on the variables studied, and being at least 18 years of age. The sampling was exhaustive with a sample size of 297 motorcyclists.

2.3. Disability Assessment Tools and Study Variables

Variables were collected at baseline and 12-month follow-up by trained interviewers through structured interviews using pre-tested questionnaires.

The dependent variable was disability by road crash dichotomized into two modalities "yes and no". It was assessed using the short tool of the Washington Group on Disabilities Statistics [14]. This tool is based on the WHO's International Classification of Functioning, Disability and Health Status (ICF) and is the result of a process validated by scientists, clinicians and people with disabilities. It considers the interactions between the person with a disability and the effect of their interactions with their environment. Hence, emphasis is placed on the patient's own subjective perception of his or her ability to do or to not do.

It explores the following six impairment areas through the following questions [14]:

1) Vision: "Do you have difficulty seeing, even if you wear glasses?"

2) Hearing: "Do you have difficulty hearing, even if you use a hearing aid?"

3) Mobility: "Do you have difficulty walking or climbing stairs?"

4) Memory: "Do you have difficulty remembering or concentrating?"

5) Personal care: "Do you have any difficulties taking care of yourself (for example) washing, dressing?"

6) Communication: "Using your usual (native) language, do you have any difficulties in communicating, e.g. in understanding or making yourself understood?"

The possible answers are presented on a scale of 1 to 4, according to the level of difficulty for each item:

1 = No difficulty,

2 = Yes—some difficulty,

3 = Yes—a lot of difficulty,

4 = Impossible to do at all.

A victim is diagnosed with a disability if he or she answers "Yes—a lot of difficulty" or "Cannot do it at all" to any of the 6 questions in the tool.

The independent variables were: 1) socio-demographic factors and history: age, gender, marital status, Chronic disease history, road crash history; 2) behavioural factors: helmet use, fatigue/drowsiness during the crash, use of psychoactive substances (doping drugs, use of sleeping pills, alcohol use, tobacco use), speeding during the crash and distraction during the crash; 3) clinical factors: injury severity, injury location (head/neck, upper limb, thorax/abdomen, lower limb) and hospitalization; 4) road features and crash circumstances: type of road (national interstate road, rural track, national road, alley), pavement condition (good, poor, under construction), visibility (acceptable, good, poor), time of day (00 - 06 h, 07 - 19 h, 20 - 24 h), reason for travel (private, work related), 5) referral and care conditions: means (ambulance, motorbike, private vehicle), referral time (less than one hour, more than one hour), health worker status (surgeon, general practitioner, medical student, nurse). Hospitalization is defined as the victim's stay in hospital for at least 24 hours. Injury severity was assessed with AIS scale with M-AIS equal or above 3 defining severe injury [15]. The psychoactive substance use was self-reported with questions related to recent consumption prior the crash. Questions were adapted from Alcohol, Smoking and Substance Involvement Screening (ASSIST) Test tool of WHO [16].

2.4. Data Processing and Analysis

The data were processed and analyzed using Stata 15 software. Categorical variables were presented using absolute and relative frequencies. Comparison of proportions was performed using chi-square and Fisher tests. Logistic regression analysis was used. A difference was considered statistically significant at a p-value ≤ 0.05. Risk factors for disability in motorcyclists, 12 months after the crash were assessed by deriving Odds Ratios (OR) followed by their 95% confidence intervals (95% CI). In the simple logistic regression analysis, each covariate was examined for inclusion in the multiple regression model based on a threshold $p < 0.2$. The multiple regression used a top-down stepwise strategy. Variables with a p-value greater than 0.05 were gradually removed from the

model. The final results were presented as the adjusted Odd Ratio (ORa) followed by the 95% confidence interval. The collinearity test was performed. Similarly, the Hosmer-Lemeshow goodness-of-fit and final model specification tests were performed.

2.5. Ethical Statement

The study protocol was validated by the ethical committee of the University of Parakou under number 0182/CLERB-UP/P/SP/R/SA. Only patients who gave a written consent were included in the study. Victims were free to withdraw their participation at any time and were therefore removed from the study without prejudice. A briefing note providing additional information about the study was given to each participant. Authorizations for data collection were signed by the heads of the centers participating in the study.

3. Results

3.1. Prevalence of Disability

Among this sample of 297 motorcyclists followed-up at 12 months, the prevalence of disability was 12.5% 95% CI (9.2 - 16.7). The most common types of disability were walking difficulties (76%), memory difficulties (43%) and self-care difficulties (30%).

3.2. Descriptive Statistics

As far as socio demographic features are concerned, the motorcyclists followed up at 12 months were aged between 30 and 44 years (44.8%), mostly male (91.2%), married or engaged (83.2%). On behavioral aspects, most of motorcyclists declared wearing a helmet (90.9%), 11.8% were under the influence of fatigue/drowsiness during the crash. Speeding was self-reported by 13.1% of the victims and 14.8% declared that they were distracted at the time of the crash.

The injuries were severe in 16.2% of cases. More than half of the motorcyclists got injuries to their lower limbs (56.6%). For road features and crash circumstances, crashes occurred mostly on alleys (67.3%) followed by crashes on national roads (17.2%). The daytime between 07:00 and 19:00 recorded more crashes than the rest of the day (61.3%). These road crashes often occurred in good visibility conditions (72.7%) and on roads in good pavement condition (83.5%). The ambulance was the most common means of referral for victims (40.1%), with hospital admissions often taking more than one hour (72.7%).

3.3. Factors Associated to Disability

In univariate analysis, using simple logistic regression, Table 1 shows that the risk of disability at 12 months was higher in subjects over 45 years of age compared to subjects aged 18 - 44 years (OR: 4.1; 95% CI: 1.4 - 11.4; $p = 0.003$). The risk of disability occurrence was also higher in severely injured (OR: 4.7; 95% CI: 2.2 - 9.9; $p < 0.001$) or hospitalized (OR: 8.6; 95% CI: 2.6 - 28.6; $p < 0.001$) patients

compared to non-severely injured and non-hospitalized patients respectively. Similarly, Table 2 shows that compared to crashes on alleys, motorcyclists had a

Table 1. Univariate analysis for disability at 12 months among motorcyclists involved in road crashes in the TraumAR cohort, n = 297.

Variables	n (%)	Disability (N = 37) n (%)	Crude OR	95% CI	p-value
Socio-demographic factors					
Age (years)					0.003
18 - 29	75 (25.2)	05 (6.7)	1		
30 - 44	133 (44.8)	16 (9.0)	1.4	0.5 - 4.1	
45 years and more	89 (30.0)	20 (22.5)	4.1	1.4 - 11.4	
Gender					0.441
Male	271 (91.2)	35 (12.9)	1.8	0.4 - 7.9	
Female	26 (8.8)	02 (7.7)	1		
Marital status					0.295
Single	50 (16.8)	04 (8.00)	1		
Married or engaged	247 (83.2)	33 (13.36)	1.8	0.6 - 5.3	
History of chronic disease					0.280
Yes	69 (23.2)	06 (8.7)	0.6	0.2 - 1.5	
No	228 (71.8)	31 (13.6)	1		
History of road crash					0.394
Yes	107 (36.0)	11 (10.3)	0.7	0.3 - 1.5	
No	190 (64.0)	26 (13.7)	1		
Behavioural factors					
Helmet use					0.697
Yes	270 (90.9)	33 (12.2)	0.8	0.3 - 2.5	
No	27 (9.1)	04 (14.8)	1		
Fatigue/drowsiness					0.150
Yes	35 (11.8)	07 (20.0)	1.9	0.8 - 4.8	
No	262 (88.2)	30 (11.5)	1		
Use of doping drugs					0.196
Yes	18 (6.1)	04 (22.2)	2.1	0.7 - 6.9	
No	279 (93.9)	33 (11.8)	1		
Use of sleeping pills					
Yes	12 (4.0)	01 (8.3)	0.6	0.1 - 5.0	0.659
No	285 (96.0)	36 (12.6)	1		
Alcohol use					0.367

Continued

Yes	223 (75.1)	30 (13.5)	1.5	0.6 - 3.6	
No	74 (24.9)	07 (9.5)	1		
Tobacco use					0.575
Yes	25 (8.4)	04 (16.0)	1.4	0.4 - 4.3	
No	272 (91.6)	33 (12.1)	1		
Speeding during the crash					0.334
Yes	39 (13.1)	03 (7.7)	0.5	0.2 - 1.9	
No	258 (86.9)	34 (13.2)	1		
Distraction during the crash					0.812
Yes	44 (14.8)	05 (11.4)	0.9	0.3 - 2.4	
No	253 (85.2)	32 (12.7)	1		

Table 2. Univariate analysis for disability at 12 months among motorcyclists involved in road crashes in the TraumAR cohort, n = 297.

Variables	n (%)	Disability (N = 37) n (%)	Crude OR	95% CI	p-value
Clinical factors					
Injury severity					<0.001
Yes	48 (16.2)	15 (31.3)	4.7	2.2 - 9.9	
No	249 (83.8)	22 (8.8)	1		
Injury location					0.226
Head/neck	68 (22.9)	06 (8.8)	1		
Upper limb	57 (19.2)	04 (7.0)	0.8	0.2 - 2.9	
Thorax/abdomen	4 (1.3)	01 (25.0)	3.4	0.3 - 38.5	
Lower limb	168 (56.6)	26 (15.5)	1.9	0.7 - 4.8	
Hospitalization					<0.001
Yes	182 (61.3)	34 (18.7)	8.6	2.6 - 28.6	
No	115 (38.7)	03 (2.6)	1		
Road features and crash circumstances					
Type of road					0.009
National interstate road	34 (11.5)	08 (23.5)	3.5	1.4 - 9.1	
Rural track	12 (4.0)	02 (16.7)	2.3	0.5 - 11.4	
National road	51 (17.2)	11 (21.6)	3.2	1.4 - 7.2	
Alley	200 (67.3)	16 (8.0)	1		
Pavement condition					0.529
Good	248 (83.5)	33 (13.1)	2.0	0.6 - 6.8	
Poor	42 (14.1)	03 (7.1)	1		

Continued

Under construction	7 (2.4)	01 (14.3)	2.2	0.2 - 24.4	
Visibility					0.300
Acceptable	39 (13.1)	07 (18.0)	1.1	0.3 - 3.5	
Good	216 (72.7)	23 (10.7)	0.6	0.2 - 1.5	
Poor		42 (14.2)	07 (18.0)	1	
Time of day					
00 - 06 h	26 (8.7)	04 (15.4)	1		0.806
07 - 19 h	182 (61.3)	21 (11.5)	0.7	0.2 - 2.3	
20 - 24 h	89 (30.0)	12 (13.5)	0.9	0.3 - 2.9	
Reason for travel					0.458
Private	176 (59.3)	24 (13.6)	1		
Work related	121 (40.7)	13 (10.7)	0.8	0.4 - 1.6	
Referral and care conditions					
Referral means					0.001
Ambulance	119 (40.1)	25 (21.0)	5.5	2.0 - 14.9	
Motorbike	108 (36.3)	05 (4.6)	1		
Private vehicle	70 (23.6)	07 (10.0)	2.3	0.7 - 7.5	
Referral time					0.251
Less than one hour	81 (27.3)	13 (16.1)	1		
More than one hour	216 (72.7)	24 (11.1)	0.7	0.3 - 1.4	
Health worker status					0.599
Surgeon	66 (22.2)	05 (7.6)	1		
General practitioner	92 (31.0)	13 (14.1)	2.0	0.7 - 5.9	
Medical student	21 (7.1)	03 (14.3)	2.0	0.4 - 9.3	
Nurse	118 (39.7)	16 (13.6)	1.9	0.7 - 5.5	

higher risk of disability at 12 months in crashes on national interstate road (OR: 3.5; 95% CI: 1.4 - 9.1; p = 0.009) or national roads (OR: 3.2; 95% CI: 1.4 - 7.2; p = 0.009). In addition, victims referred by ambulance were more likely to develop a disability than those referred by motorbike (OR: 5.5; 95% CI: 2.0 - 14.9; p = 0.001).

In the final model, by multiple logistic regression, adjusted for other variables, age over 45 years (OR: 3.3; 95% CI: 1.1 - 9.9; p = 0.029), severity of initial injury (OR: 3.2; 95% CI: 1.5 - 7.2; p = 0.004) and victim hospitalization (OR: 6.9; 95% CI: 2.0 - 24.0; p = 0.002) were the risk factors for the occurrence of disability 12 months after the crash among motorcyclists of the cohort (Table 3).

The Hosmer-Lemeshow goodness-of-fit test and the specification test performed show that the final model is adequate and specific. Moreover, there is no

Table 3. Risk factors for disability at 12 months among motorcyclists involved in road crashes in the TraumAR cohort: final model.

Variables	Adjusted OR	95% CI	p-value
Age (years)			0.029
18 - 29	1		
30 - 44	1.0	0.3 - 3.2	
45 years and more	3.3	1.1 - 9.9	
Injury severity			0.004
No	1		
Yes	3.2	1.5 - 7.2	
Hospitalization			0.002
No	1		
Yes	6.9	2.0 - 24.0	

collinearity between the variables studied.

4. Discussion

Our study suggests that active male adults are more exposed to disabilities resulting from road traffic crashes. This profile is consistent with the common profile of most literature review studies, regardless of the context [7] [17] [18] [19] [20] [21]. This predominance of young males among road crash victims can be explained in Beninese settings by the fact that these young men (more than women or older people) engage in activities that require a lot of travel with most of the time risky behaviors such as speeding, non-compliance with traffic regulations, use of psychoactive substances and other driving habits that are more risky in traffic (passing between several vehicles, risky overtaking, aggressive driving in search of thrills). The assumption, entirely plausible in the Beninese context, is confirmed by recent work in China, in which male drivers were found to be more likely to take extreme risks while driving, explaining their preponderance among the victims [22]. Setting up policies to prevent accidents and consequently post-accident disability must therefore integrate this profile as being particularly high-risk and more vulnerable to the phenomenon.

The prevalence of disability in the present study was 12.5%. The main types of disability observed were walking difficulties (75%), memory difficulties (43%) and body care difficulties (30%). Regarding disability prevalence, there are very large variations depending on the context (close to 15% in Africa, around 30 - 50% Iran and Brazil) and the comparison remains difficult and not necessarily relevant [4] [19] [23] [24] [25] [26]. Indeed, integrating differences between contexts, used assessment tools, patient's specific clinical profiles, follow-up times, defining outcomes, and data sources as well as evaluation times makes it difficult to have proper objective comparisons [25] [26]. For example, regarding

assessment tools, the United Nations Washington Group on Disability Statistics questionnaire used in this study is internationally recommended for the assessment of disability in general. It explores the main types of disability according to the recommendations of the International Classification of Disability, Functioning and Health (ICF), taking into account the interaction of disabled people with their environments by proposing an exploration on the six (06) functions with a self-report of the patient. This self-reporting which remains for its part subjective can be discussed, as well as the definition of the six functions or the levels of scale used and these reservations justify the exploration through other tools like the WHODAS, developed by WHO [27], or Barthel Index, which is a 10-item tool that assesses disability on a scale of 0 to 20 [28]. Furthermore, the results of the studies could differ according to the data sources as in population studies offers precise data [24] and that hospital surveys suffer from selection bias and may be an issue for representativeness. Thus, according to what is recommended, it is necessary to standardize methodological approaches and tools [26].

As far as type of disability is concerned, the disability is more related to mobility with a focus on walking difficulties (76%) in this study and likewise in reviews [8] [29]. Lower body injuries are the most common, and some authors have established a greater risk of disability in patients with lower extremity injuries [27]. Also, when motor function is affected, the person is more reliant on others than on other functions. The self-reporting of the tool might influence the diagnosis.

Age was the first associated factor with disability plausible due to the great fragility of older peoples. They got a longer recovery process than younger people who have more resistant bodies. Our findings fit those of the literature review [4] [8] [24].

No other socio-demographic variables were associated with the risk of disability in this study whereas sex was linked in other studies [4], as well as the level of education and incomes [6] [8]. Variations in populations, sampling and the availability of some variables that have not been studied account for the differences. On the one hand, wider-scale explorations are necessary to better investigate the problem, but the need for standardization of approaches recommended by some authors is confirmed here [26].

In this study, the severity of the initial injury and the hospitalization of the patient were also factors that influenced the occurrence of disability as logical consequences. Similar findings have been made in studies where the length of hospital stay and injury severity were risk factors for post-crash disability [5] [27] [28] [29] at 6 and 12 months after a road crash. This result also explains the other paradoxal findings related to the fact that ambulance transport to the hospital was significantly associated with disability. Although this variable is not significant in the final model, it can be explained regarding the fact that most serious injuries are transported by ambulance, which usually takes a long time to reach the site of the accident. The quality of pre-hospital care on site can help reduce

the initial severity of the injuries (whose evaluation, recall, is done in the context of the first reception and management structure) and probably the length of hospitalization. In fact, improving the quality of pre-hospital care is a relevant and potentially effective area of intervention to be considered in implementing strategies to prevent disabilities after road crashes [19].

Besides, due to the link with technological evolution and the impacts on individual and family life with significant socio-economic consequences, disability is thus a problem of public health for which, a better knowledge of the extent and the identification of the associated factors will allow to better target the most relevant interventions.

This study has some limitations due to the restriction of the 12-month follow-up to patients living in the south of the country. The health barrier put in place during the pandemic period at COVID-19 did not allow for the inclusion of all initial collection sites, some of which were located in the northern part of the country. However, this did not significantly influence the quality of the data as few patients were recruited in hospitals in this area. In order to limit the number of missing data, eligible victims were sufficiently reassured about the measures taken to prevent contamination by COVID-19 in the collection hospitals. This may have improved the adherence of victims. In addition, they were informed that the data collected is not part of any legal proceedings relating to their crash. Nevertheless, some behavioral or clinical variables could not be collected from certain victims, which explain the missing data. In addition, some bias could have been introduced into the study due to the likely false answers given by the victims for certain non-verifiable behavioral variables.

5. Conclusion

Age over 45 years, severity of initial injury and hospitalization of the victim were risk factors for the occurrence of disability in the motorcyclist victims. Campaigns against road crashes (awareness raising and enforcement of the road safety law), holistic and early management of seriously injured people over 45 years of age, could contribute to reducing the prevalence of disability among victims in Benin.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Prevalence and Clinical Relevance of *Schistosoma mansoni* Co-Infection with *Mycobacterium tuberculosis*: A Systematic Literature Review

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Abstract

Tuberculosis disease stands for the second leading cause of death worldwide after COVID-19, most active tuberculosis cases result from the reactivation of latent TB infection through impairment of immune response. Several factors are known to sustain that process. *Schistosoma mansoni*, a parasite of the helminth genus that possesses switching power from an immune profile type Th1 to Th2 that favors reactivation of latent TB bacteria. The aim of the study was to assess the prevalence of the co-infection between the two endemic infections. Systematic literature was contacted at the University Clinical Research Center at the University of Sciences, Techniques, and Technologies of Bamako in Mali. Original articles were included, and full texts were reviewed to assess the prevalence and better understand the immunological changes that occur during the co-infection. In total, 3530 original articles were retrieved through database search, 53 were included in the qualitative analysis, and data from 10 were included in the meta-analysis. Prevalence of the co-infection ranged from 4% to 34% in the literature. Most of the articles reported that immunity against infection with helminth parasite and more specifically *Schistosoma mansoni* infection enhances latent TB reactivation through Th1/Th2. In sum, the impact of *Schistosoma mansoni* co-infection with *Mycobacterium tuberculosis* is under-investigated. Understanding the

role of this endemic tropical parasite as a contributing factor to TB epidemiology and burden could help integrate its elimination as one of the strategies to achieve the END-TB objectives by the year 2035.

Keywords

Schistosoma mansoni, Tuberculosis, Co-Infections, LTBI, Reactivation

1. Introduction

Before the COVID-19 pandemic, *Mycobacterium tuberculosis* (*M. tb*) represented the deadliest infectious agent, killing more than 4000 people per day, exceeding the human immunodeficiency virus (HIV) and malaria two times each [1] [2] [3]. Despite, that tuberculosis (TB) incidence is slowly decreasing but still not sufficient enough to meet the World Health Organization's (WHO) Ending TB objectives by the year 2035 [1] [4]. Latent TB infection (LTBI) is defined as an immunologically controlled *M. tb* infection with no apparent clinical and radiological sign of active TB. LTBI control involves the establishment of T helper 1 (type-1) inflammatory granuloma to block *M. tb* bacteria replication and spread. Several immune cells and cytokines are involved in this mechanism, such as T-cells lymphocytes, macrophages, monocytes, interleukin (IL)-1, 2, 6, 10, 12, IFN-γ, and TNF-α [5] [6] [7]. In immunocompetent individuals, LTBI can remain harmless throughout their entire lifetime. Reactivation or progression to active TB is defined as a transition from the latency stage to a symptomatic disease due to the escape and replication of the bacteria throughout a breach in the immune system induced by a new infection or failure to control an existing condition [5] [7] [8] [9]. Several health conditions can impair immune response leading to a possible reactivation of LTBI, they are classified from high-risk such as HIV, organ transplants, chronic hemodialysis, and alcohol abuse to low-risk factors including smoking, diabetes, and use of corticosteroids [10] [11].

Schistosoma mansoni (*Sch. m*) is one of the sub-species of *Schistosoma spp*, a parasite of the helminth family and trematode genus encountered in sleeping water and causing schistosomiasis, one of the neglected tropical infectious diseases (NTDs) still endemic in more than 78 resource-limited countries in Africa, South America, and Asia. Its prevalence in Sub-Saharan Africa represents 93% of all cases worldwide [12] [13].

Recent studies have shown that chronic infection with *Schistosoma mansoni* (*Sch. m*) impairs the host immune response and affects the formation and maintenance of type-1 granuloma by inducing T helper 2 (type-2) inflammatory granuloma. The process enhances a switch from the host's existing type-1 immune response profile to a type-2 that weakens the strength of type-1 granuloma [14]. Cytokines produced during *Sch. m* chronic infection such as IL-5, 9, 10, and 13 were found to be significantly associated with liver fibrosis [15]. A decrease in CD4+ T cell response was observed in LTBI patients co-infected with

helminth parasites which increased after treatment [16]. Similarly, a lower protective effect of the *Bacilli Calumet-Guerin* (BCG) vaccine in people with *Sch. m* infection which may lead to *M. tb* reactivation in case of LTBI co-infection [17]. Hematological and biochemical parameters were found to be altered in patients with *Sch. m* infection compared to healthy individuals who were improved after praziquantel treatment [18]. Several clinical studies reported statistically significant associations between the two infections and have also strengthened the hypothesis that *Sch. m* infection enhances LTBI reactivation to active TB through the reduction of the host's protective immune response. A study in Uganda (2006) assessed the incidence of active TB in HIV patients co-infected with *Sch. m* versus HIV mono-infected and found an increased risk of developing active TB in HIV and *Sch. m* co-infected patients compared to those without *Sch. m* co-infection [19]. A case-control study in Tanzania (2017) also observed similar findings, patients with active TB had significantly higher odds of being *Sch. m* co-infected compared to their household healthy controls [20]. Based on pulled observation data from the WHO Global TB reports, there is a trend between Schistosomiasis endemic areas and TB burden. Active TB incidence is found to be higher in geographic regions where the prevalence of Schistosomiasis infection is important in sustaining the possible relationship between the two endemic infectious agents (**Figure 1**). The treatment of *Schistosoma mansoni*

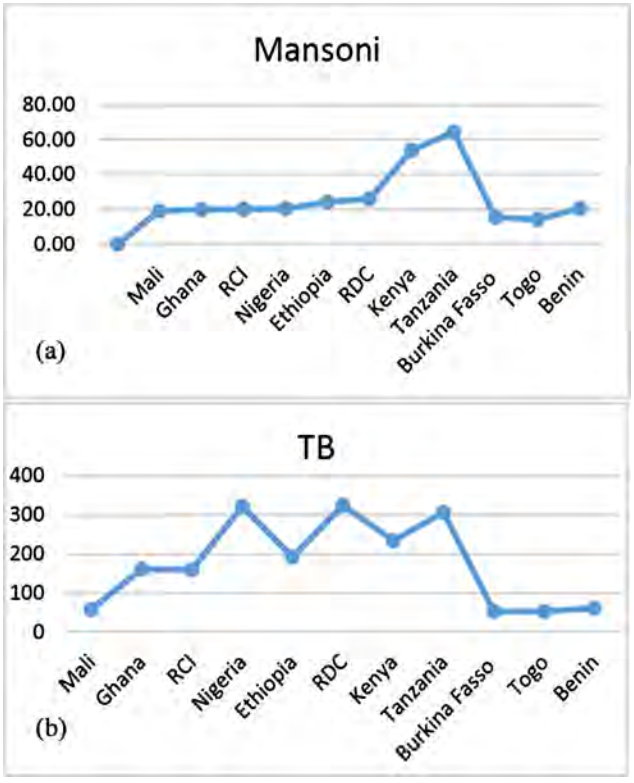


Figure 1. (a) Prevalence in percentage of Schistosomiasis in 11 Sub-Saharan African countries; (b) Incidence of Tuberculosis per 100,000 population in the same countries. Comparing the two figures, there is a trend between Schistosomiasis prevalence and Tuberculosis incidence.

consists of a single oral dose of Praziquantel (PZQ) 40 mg/Kg repeated after 2 - 4 weeks. The first dose will kill adult worms present in the intestines and the second will target new parasites from egg hatch [21]. The treatment regimen recommended by WHO for people with drug-susceptible TB is a 6-month duration [22] including 2-month of isoniazid (H), rifampicin (R), ethambutol (E), and pyrazinamide (Z) followed by 4-month of isoniazid, rifampicin (2RHZE/4RH). Several regimens are proposed for LTBI treatment, from monotherapy with Rifampicin daily dose for 4-month or Isoniazid 6 or 9-month to bi-therapy with Isoniazid and Rifapentine weekly for 3-month or Isoniazid and Rifampin daily for 3-month [23]. Some works have been conducted on the immunological harm of the co-infection between tuberculosis and *Schistosoma mansoni* but still, there is more to be investigated for clinical evidence. The treatment of LTBI is confronted with several issues; insufficient investigations to differentiate active from latent TB and poor treatment adherence. The aim of this systematic literature review was to assess the effects of *Sch. m* infection on LTBI reactivation to active disease and existing data on the frequency of co-infections between *M. tb* and *Sch. m*.

2. Materials and Methods

2.1. Study Design and Setting

This study was designed to evaluate the clinical relevance of TB/*Sch. m* co-infection in the disease progression and active tuberculosis epidemiology dynamic. Therefore, published original research articles that reported the immunological interaction, and clinical frequencies of *Mycobacterium tuberculosis* and *Schistosoma mansoni* co-infections were searched and reviewed.

2.2. Article Search

Relevant research articles were searched using two search terms from two different databases, (Google Scholar, Embase, Scopus, PubMed, and Web All of Science) detailed as follow:

> "*Mycobacterium tuberculosis*" [MeSH Terms] OR ("mycobacterium" [All Fields] AND "tuberculosis" [All Fields]) OR "mycobacterium tuberculosis" [All Fields] OR ("tuberculosis" [All Fields] AND "mycobacterium" [All Fields]) OR "tuberculosis mycobacterium" [All Fields]) AND ("tuberculosis" [All Fields] OR "tuberculosis" [MeSH Terms] OR "tuberculosis" [All Fields] OR "tuberculoses" [All Fields] OR "tuberculosis" [All Fields]) AND ("*Schistosoma mansoni*" [MeSH Terms] OR ("schistosoma" [All Fields] AND "mansoni" [All Fields]) OR "*Schistosoma mansoni*" [All Fields]) AND ("co-infect" [All Fields] OR "co-infected" [All Fields] OR "co-infecting" [All Fields] OR "co-infection" [MeS Terms] OR "co-infection" [All Fields] OR "co-infections" [All Fields] OR "co-infects" [All Fields]).
>
> All full-text articles found throughout this database search were assessed and

all those eligible with an abstract in English were included in this study regardless of the language of the full article.

2.3. Inclusion and Exclusion Criteria

All full-text research articles from the search result of the study using the two search terms built from the words "Tuberculosis and *Schistosoma mansoni*" were included in the study. All studies that full text or abstract have not been found in the search and studies that do not include results of one of the two infections were excluded from the study.

2.4. Data Collection and Interpretation

Each included article was reviewed to retrieve information about TB and *Schistosoma mansoni* co-infections. Article on immune response interactions between the two-infection found in the literature was also described and analyzed in this literature review. Case reports, case series, case control, and cohort studies were summarized in different tables (Table 1 & Table 2).

Table 1. Case reports of co-infection between TB and *Schistosoma mansoni*.

Country	Year of report	TB localization	*Sch. m* & Parasitic disease	Sex	Age (yrs)	HIV test	Patient origin	No. of reference
Australia	2001	Pulmonary tuberculosis	*Schistosoma Japonicum*	M	30	Unknown	Philippines	*Torresi et al.* [61]
Brazil	2006	Hepatic tuberculosis	*Schistosoma mansoni*	Male	17	Unknown	Brazil	*Ferrari et al.* [51]
France	2007	Lymphadenitis tuberculosis	*Schistosoma mansoni*	Male	32	Unknown	Mauritania	*Basile et al.* [52]
Italy	2014	Pulmonary tuberculosis	*Schistosoma mansoni*	Male	27	Negative	Mali	*Gobbi et al.* [53]

Table 2. Frequency of *Mycobacterium tuberculosis* and *Schistosoma mansoni* co-infections.

Country	Year of report	Sample Size (n)	TB patients screened (n)	TB/*Sch. m* co-infection (n (%)	Control patients (n)	*Sch. mansoni* co-infection (%)	Odds Ratio 95% CI (aOR), p-value	Reference
Uganda	2006	462	462	10.0	20/168		2.31 (1.0 - 5.3)	*Brown et al.* [19]
Tanzania	2007	655	532	34				*Range et al.* [54]
Ethiopia	2012	112	32	19.0	38	16.5		*Abate et al.* [55]
Tanzania	972	2017	597	5.7	375	4.0	2.15 (1.0 - 4.5) p = 0.040	*Mhimbira et al.* [20]
Tanzania*	2018	668	668	7.9				*Sikalengo et al.* [60]
Ethiopia	2019	384	384	4.3				*Gashaw et al.* [59]
Kenya□	2021	941	194	14.0	747	4.0		*McLaughlin et al.* [57]

Tanzania*: *Schistosoma mansoni* was 16.4% in the rural area vs. 4.13% in the Urban. Kenya □: HIV/TB co-infected patients.

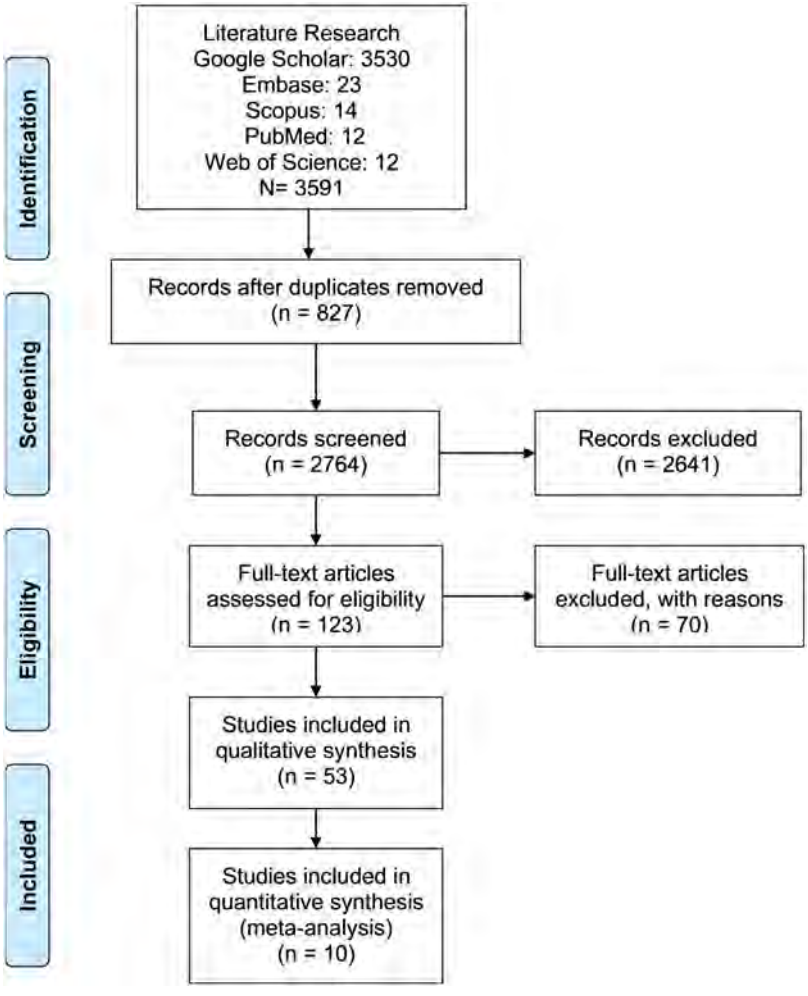
2.5. Ethical Approval

The conduct of this systematic review was approved through a current project on the prevalence of *Schistosoma mansoni* among pulmonary TB patients in Mali by the Ethics committee of the Faculties of Medicine and Odonto-Stomatology, and Pharmacy of the University of Sciences, Techniques, and Technologies of Bamako (USTTB) in Point-G, Bamako, Postal Box: 1805; Mali.

3. Results and Discussion

3.1. Search Results

In total five (5) search engines were explored using the same term, three thousand five hundred ninety-one (3591) articles were found in the databases, including *Google Scholar* (3530), *Embase* (23), *Scopus* (14), *PubMed* (12) and *Web of Science* (12) (Figure 2). After removing duplicates and those not fulfilling



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Figure 2. Data search flow chart.

TB and *Schistosoma mansoni* co-infection criteria, one hundred twenty-three (123) articles were eligible among those, fifty-three (53) were used for qualitative discussion and ten (10) for the quantitative analysis and data discussion.

3.2. *Mycobacterium tuberculosis* and Helminth Co-Infections: Expression of Th2 Immune Response Profile

The immunological disturbances occurring during *M. tb* and helminth co-infections have been reported in animal but also human studies. Since the beginning of the 20th century, *Kullberg et al.* (1992) observed that *Sch. m* infection down-regulates the host's Th-1 immune response, and induces an exaggerated Th-2 response that alters existing protective immune response against other infectious agents; the findings were later supported by observations of *Rafi et al.* (2012), that helminth infection diminishes immune protection against LTBI [24] [25] [26]. In vaccinology, helminth chronic infection has also been found to affect immunization conferred by vaccines; *Kondělková et al.* (2010) & *Méndez-Samperio et al.* (2014), found in their investigation that Treg cells modulate immune reaction by suppressing cell's multiplication and production of cytokines, implying that the presence of helminth infection confers a buffer medium that neutralizes the effect of ongoing immune responses [27] [28]. *McArdle et al.* (2018) reported that reactivation of latent TB infection (LTBI) in the presence of helminth infection comes from a switch from Th1 to Th2 cytokine production [29]. *Abate et al.* (2015) observed that the simple presence of helminth infection without any clinical manifestation in patients with active TB could downregulate host immune response similar to that seen in patients with immunodepression. The co-infection creates a coexistence of T-Regulatory Cells (Treg cells), and type-1 cytokines (IL-10) but also the secretion of type-2 expressing cytokines (IL-5) conferring an immunodeficiency status to the patient. Thereby, the low bacteria load in sputum observed in TB and *Sch. m* co-infected patients was already reported as a common finding in TB and HIV co-infection [30] [31]. *Babu et al.* (2016) also brought evidence from the animal model and human studies that helminth infections affect the host immune control of TB infection, thereby increasing the risk of TB bacteria reactivation in an organism with both infections [32]. *Rajamanickam et al.* (2019 & 2020) found that helminth and LTBI co-infection exposes LTBI control failure by inducing low-production chemokines and alteration of their function. They also observed an alteration of monocyte cells' function through inadequate activation and polarization during the co-infection [33] [34]. C*admus et al.* (2020) reported in a literature review that helminth infection negatively impacts the strength of vaccination response, thereby immunization programs should consider helminth endemic areas regarding the protection level of vaccines [13] *Kiflie et al.* (2021) found that helminth co-infection in active TB patients had a positive correlation between TB disease severity and an increase of helminth-specific TGF-β+ Tregs that was restored after anti-helminth treatment [35]. *Resende et al.* observed that TB and helminth

co-infection leads to a decrease in T-cells and natural killers number, cytokine production, and severe lung damage compared to TB mono-infected patients and healthy controls [36] [37]. A similar observation was reported by *Bogdan et al.* (1991); *Gong et al.* (1996); *Abate et al.* (2015) and *Aira et al.* showed that IL-10 production down-regulates Th1-driven immune response against TB infection [38] [39] [40] [41]. These observations demonstrate that in the presence of helminth infection, the expression of the Th2 immune profile involves Treg cell proliferation and certain types of cytokines that down-regulate existing Th1 immune inflammatory response against other types of infections and particularly in the case of LTBI.

3.3. *Schistosoma mansoni* Impairs Immune Response to *Mycobacterium tuberculosis* Leading to Latent Tuberculosis Infection Reactivation

In more than four past decades, *Olds et al.* (1981) reported that *Sch. m* co-infection impairs immune response in active TB patients, and a decrease in killer monocyte cell rate was observed in *Sch. m* co-infected and TB patients [42]. Several other studies supported the hypothesis that in the presence of *Sch. m* infection, the host immune response undergoes a modulation process leading to a poor immune response quality against a new or an existing infection. *Elias et al.* (2006) reported a low protective effect of the BCG vaccine in children infected with *Sch. m* [17]. The observation was further supported by *Musaigwa et al.* (2022) that *Sch. m* infection affects vaccine response again TB infection by inducing deaths of plasmablast and plasma cells in the bone marrow [43]. Among the diverse helminth, *Sch. m* one of the Schistosoma subspecies, has been identified to possess specific proteins that lead to failure of maintaining type1 granuloma formation by promoting a strong type 2 inflammatory immune response. *Monin et al.* (2015) were pioneers of that observation by describing that during *M. tb* and *Sch. m* co-infection, *Sch. m* increases susceptibility to TB reactivation but also the disease severity by increasing the level of inflammatory response with the accumulation of arginine-1 expressing macrophages [44]. *Pearce et al.* also demonstrated that the presence of soluble *Sch. m* egg antigen inhibits IL-12 cytokine production by dendritic cells and induces a Th2 inflammatory immune response profile promoting T-cell regulatory (Treg) responses that inhibits the establishment of type Th1 response [45]. *Giera et al.* have also identified lipids such as prostaglandins (rich in *Sch. m* eggs) to be specifically driving expression of type Th2 immune response profile during *Sch. m* infection [46]. *Meurs et al.* in Senegal investigated cytokine production during schistosomiasis infection and observed that *Sch. m* induces the production of Th2 profile cytokines but *is* not as stronger compared to *Schistosoma haematobium* (*Sch. h*). This implies that *Sch. m* can induce a switch of immune response profile from Th1 to Th2 but does not induce such a stronger response to limit damages from other infections [47]. *Schramm et al.* (2018) investigated the immune modulatory effect of *Sch. m* and observed that using *Sch. m* egg-specific antigens can sig-

nificantly decrease the immune response against Salmonella infection [48]. *Dinardo et al.* (2016) observed that *M. tb*-specific CD4+ T-cell functions are altered in presence of soluble schistosome antigen and block the maturation of macrophage phagolysosome [49]. However, *McLaughlin et al.* (2020) reported a contradictory finding that Th1 immune functions are still maintained by TCD4 cells during TB and *Sch. m* co-infection [50].

Lessons learned from this step are that *Sch. m* infection induces a buffered media in the immune response pattern and plays an important role in TB infection control. In the presence of *Sch. m* antigens, the host immune system fails to establish an appropriate defense against other infections. This immunological disaster happens when the host immune system is facing an acute infection and knocking it down to a latency phase or when *Sch. m* infection occurs in an individual with an immunologically well-controlled latent TB infection (**Figure 3**).

3.4. Prevalence of *Schistosoma mansoni* and Tuberculosis Coinfections across Clinical Studies

Schistosoma mansoni and *Mycobacterium tuberculosis* co-infections have gained increasing interest over the last two decades. Observations started with single case reports; *Cristina et al.* (2006), in Brazil reported a case of hepatic TB co-infected with *Sch. m* [51]. *Basile et al.* (2007) published one of the first cases of *Sch. m* and *M. tb tuberculosis* co-infection in a 32-year-old, male, living in France but of Sub-Saharan African origin [52]. *Gobbi et al.* (2014), further support a case of *Schistosoma mansoni* and *Mycobacterium tuberculosis* co-infection mimicking a single infection of *Schistosoma mansoni* in the lung [53]. *Range et al.* (2007) in Tanzania found more than one-third (35.5%) of *Schistosoma mansoni* co-infection among confirmed pulmonary TB patients and also HIV co-infection was 43.6% [54] Ten years later, structured case series started to report remarkable frequencies, and clinical characteristics of patients with the co-infection. Earlier in 2012, *Abate et al.* (2012) conducted another study in Ethiopia, the frequency of *Sch. m* co-infection among TB patients was 19% [55]. *Li* & *Zhou* (2013) conducted a systematic review on TB and parasite co-infections, they observed a prevalence of 5.4% of *Sch. m* among TB patients [56]. *McLaughlin et al.*, in a recent study in Kenya, it has been observed a 4% increase in TB incidence in HIV-Negative people infected with *Sch. m* (19.7%) compared to *Sch. m*-uninfected cases (15.8%) whereas a 14% increase was observed in TB incidence in HIV-Positive patients co-infected with *Sch. m* (27.3%) compared to HIV-Positive *Sch. m*-uninfected patients (41.2%) [57]. *Tegegne et al.* (2018) conducted a study in Gondar (Ethiopia) that reported a prevalence of 0.4% of *Sch. m* in patients suspected of pulmonary tuberculosis [58]. *Gashaw et al.* (2019) reported a prevalence of 4.3% of *Sch. m* in active TB patients with under-nutritional status in Northeastern Ethiopia [59]. *Mhimbira et al.* (2017) found 5.7% of *Sch. m* co-infection in TB patients compared to their household control individuals. There was a 2.15-fold higher risk of *Sch. m* co-infection in TB patients compared to their household controls. *Sch. m* and *M. tb* co-infected patients had a

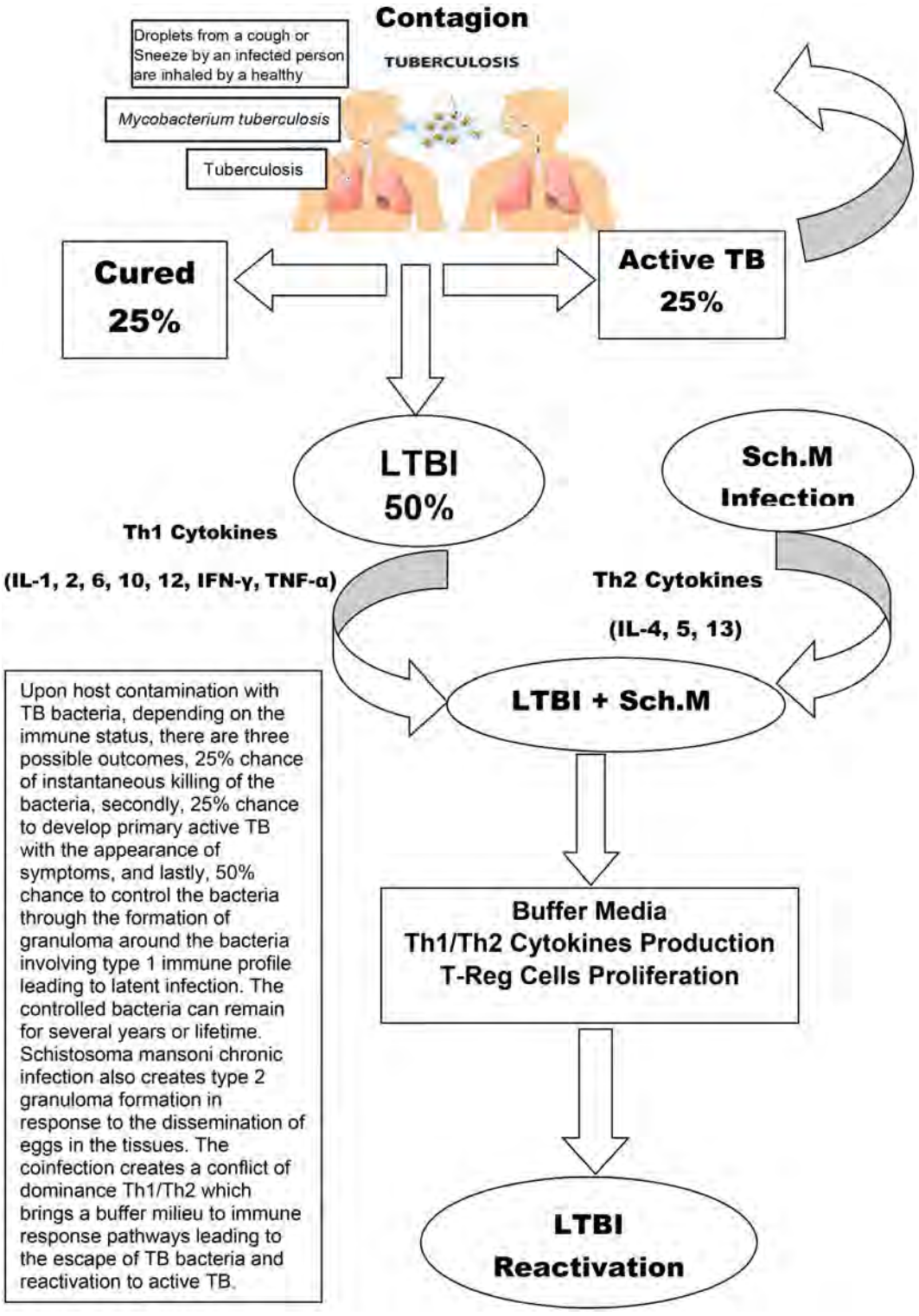


Figure 3. TB Infection Transmission and reactivation through *Schistosoma mansoni* infection.Th1/Th2 immune impairment during *Schistosoma mansoni* Latent TB co-infection.

2.63-fold risk of being in the group of TB patients with lower sputum bacterial load, and also 0.41-fold less chance of having pulmonary cavitations [20]. *Sikalengo et al.* (2018) in Tanzania found 16.4% of *Sch. m* co-infection among active

TB patients living in the rural area of Dar Salam [60]. From the findings of this review, there is evidence of an association between the two infections that *Sch. m* infection increases active TB incidence in individuals with LTBI regardless of their immunological status and there is a clear pathway explaining the mechanism of switching Th1 immune response to a predominant Th2 cytokines production creating a buffer media that drive out the immune control of TB latent bacteria.

4. Conclusions

This Systematic Literature Review has narrowed down findings from different investigational studies on the harms of *Sch. m* infection on the acquired immune response that controls *M. tb* infection during the latency stage.

Th2-driven immune response expressed in *Sch. m* infection down-regulates Th1-induced immune reaction which disrupts immunological cascades against other infectious agents, particularly in patients with LTBI where cell-based immune reaction is predominantly needed to lockdown the TB bacteria in a latent stage when failing its elimination.

Based on this review, we speculate that strategies for TB elimination must consider *Schistosoma mansoni* eradication actions where both infections are endemic. Large sample sizes and multicentric cohort studies are needed to deeply investigate the epidemiological and clinical implications of *Sch. m* infection on the global active TB burden, especially in endemic settings.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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