Rwanda
# Public Health Bulletin

Vol. 3 (2); December 2022

Online ISSN: 2663 - 4651
Print ISSN: 2663 - 4643

## HIGHLIGHTS

1. One Health Approach to Combat Antibiotic Resistance
2. Appropriateness of Antibiotic Prescription Practices
3. Diet and Fluorosis-Related Stigma
4. Improving Awareness to Reduce Stroke Mortality – Policy brief

Ministry of Health

Rwanda Biomedical Centre
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Rwanda
# Public Health Bulletin

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This will allow more and effective communication between policy makers, researchers and health practitioners.

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**Publisher:** Rwanda Health Communication Centre (RHCC).

**Online ISSN:** 2663 - 4651, **Print ISSN:** 2663 - 4643

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**Acknowledgement**

This publication, [Rwanda Public Health Bulletin (RPHB)], was made possible by financial support from the Bloomberg Philanthropies Data for Health Initiative through the CDC Foundation. Its contents are solely the responsibility of the authors and don't necessarily represent the official views of Bloomberg Philanthropies, the CDC Foundation or the U.S. Centers for Disease Control and Prevention.

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# Public Health Bulletin

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## CONTENT

Dear Readers,

I take this opportunity to thank the readers of the Rwanda Public Health Bulletin (RPHB) for the continuous support in the publication of the bulletin.

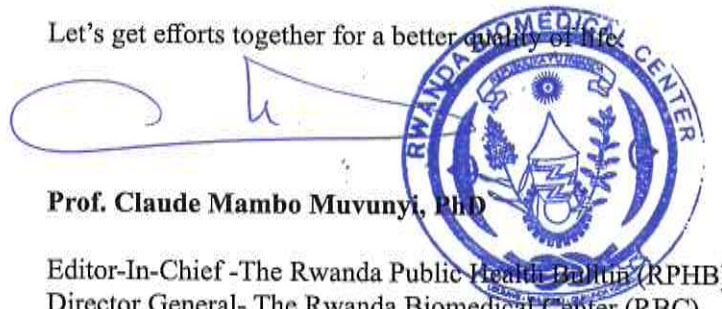
Antimicrobial resistance is an urgent global public health threat, leading to millions of deaths and affecting all people at any stage of life. Resistance to one of the antibiotics can result in serious problems, such as using other potent antibiotics with more adverse effects and more expensive, affecting the patients' economic well-being and added costs from adverse effects. Treating other conditions in the hospital needs infection control, and antibiotic resistance threatens successful outcomes of life-threatening conditions, such as diabetes, cancers, etc.

Rwanda is one of the resource-limited countries with high rates of antimicrobial resistance, increasing the disease burden to already strained healthcare systems. However, there are still some limitations in antimicrobial resistance surveillance, awareness, and prevention, highlighting the urgent need to take action against this serious public health threat.

This RPHB issue focus on antibiotic resistance, including articles on one health approach to combat antibiotic resistance and antibiotic prescription appropriateness. You will also learn about diet and fluorosis-related stigma and stroke awareness policy brief in this issue.

We believe the information transmitted will be resourceful, reinforcing your endeavor to preventive measures for health promotion in Rwanda and worldwide in general.

Let's get efforts together for a better quality of life.




**Prof. Claude Mambo Muvunyi, PhD**

Editor-In-Chief -The Rwanda Public Health Bulletin (RPHB)
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Commentary

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# One Health Approach to Combat Antibiotic Resistance in Developing Countries

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**Received:** January 18, 2022
**Accepted:** October 7, 2022
**Published**: December 31, 2022

**Cite this article as:** Uwurukundo et al. Antimicrobial Resistance: One Health Approach to Combat Antibiotic Resistance in Developing Countries. *Rw. Public Health Bul. 2022. 3 (2): 7-10.*

## INTRODUCTION

The global use of antibiotics is increasing, and the global annual consumption of antibiotics for the treatment of infectious diseases is estimated at 70 billion doses per year [1]. Since the discovery of the first antibiotic, penicillin, in 1926 by Alexander Fleming and other antibiotics discovered later, antimicrobial resistance (AMR) was discovered as an anticipated consequence [2]. Even before antibiotics were discovered, some scientists argued that AMR was an inevitable natural pathway [3]. On the other hand, according to records, since the discovery of the first antibiotic used to treat human infectious diseases, doctors' and veterinarians' abuse and misuse of antibiotics has also affected the rise of AMR [4]. Today, approximately 7 million people die worldwide due to drug resistance, and it is estimated that by 2050 nearly 10 million people with infectious diseases worldwide will die each year from infections caused by antimicrobial-resistant organisms [5,6]. As AMR rises globally, treating human, plant, and animal infections is difficult. AMR poses a threat to the progress of the healthcare system for the treatment of diseases in the entire ecosystem [7]. In the case of Uganda, infectious diseases account for a 50% morbidity and 50% mortality rate [8]. Infectious disease resistance to antimicrobials has also led to longer hospital stays, increased drug costs, and increased morbidity and mortality [9]. To address this burden of disease, the Ugandan National Academy of Sciences made an analysis, in 2015, on antimicrobial resistance and reported increased threats of AMR [8]. The reasons behind AMR have been debatable. Some scientists agree that AMR is due to the misuse and overuse of antimicrobials among physicians, veterinarians, and farmers, while others argue it's an inevitable natural consequence of antimicrobial use for the treatment and prevention of infectious diseases. This paper aims to show how AMR can be minimized through a multisector approach to improve health in developing countries.

### Background

Antimicrobial resistance occurs when bacteria, fungi, and parasites adapt to antimicrobial drugs and stop responding [10]. AMR has been developing since the 20th century and is now a global health issue [4]. If no action is taken to curb AMR, it is estimated that global drug-resistant infections will increase, mostly in developing countries like Uganda, leading to extreme poverty [11].

In the case of Uganda, due to the lack of AMR

**Potential Conflicts of Interest:** No potential conflicts of interest disclosed by all authors. **Academic Integrity:** All authors confirm their substantial academic contributions to development of this manuscript as defined by the International Committee of Medical Journal Editors. **Originality:** All authors confirm this manuscript as an original piece of work, andconfirm that has not been published elsewhere. **Review:** All authors allow this manuscript to be peer-reviewed by independent reviewers in a double-blind review process.  **Publisher:** Rwanda Health Communication Centre, KG 302st., Kigali-Rwanda. Print ISSN: 2663 - 4651; Online ISSN: 2663 - 4653. **Website:** https://rbc.gov.rw/publichealthbulletin/

monitoring data, researchers have observed AMR in the increase of infections. As time goes by, the effectiveness of antibacterial drugs is getting worse, and infections are becoming more difficult to treat [12]. A study conducted by the Uganda National Academy of Sciences reported that the country's antibiotic resistance in humans and animals was increasing [12]. Therefore, if no action is taken and it is not correctly done, preventable deaths will occur from previously treatable infections by antimicrobial drugs, and simple infections won't be treatable. This will increase morbidity, thus hindering the viability of the current health system, which will also affect global health, agricultural well-being, and our common environment [2]. However, it is important to properly identify the root cause of the rapid AMR rise and curb it to take adequate action.

**The root cause of rapid AMR (Human - Animal - Environment)**

Since the first use of antibiotics to treat humans, animals and plants, and the environment, AMR has been occurring. It is commonly attributed to the misuse and abuse of antimicrobial drugs [4]. It is empirical to ask ourselves how antibiotics, "the wonder drug" of all times, reached this point of causing a global threat. As seen in Figure 1, using antibiotics to treat humans, animals, and plants continue to play a role in the persistence of AMR by releasing antibiotics in the environment.

Regarding human health, antibiotics are considered the best treatment for communicable diseases, which gives a leeway to misuse antimicrobial medicine for all infectious diseases [12]. In Uganda, for example, most antibiotics are available over the counter (OTC) and are affordable. So many people in the community can easily purchase them without bearing the cost of formal consultation with a doctor [14]. As the health system allows people to decide how and when to administer antibiotics to themselves, people tend to misuse them either by under-dosing, overdosing, or not finishing the course of the medication (poor adherence). Subsequently, all these excess antibiotics leave residues in the environment, contributing to AMR. Moreover, doctors over-prescribing antibiotics to heal patients promotes AMR. A study done in Ethiopia to evaluate the knowledge and perception among physicians and nurses concluded that there's a vast knowledge gap among healthcare providers about AMR, which explains the complacent behaviors in their use of antibiotics [15].

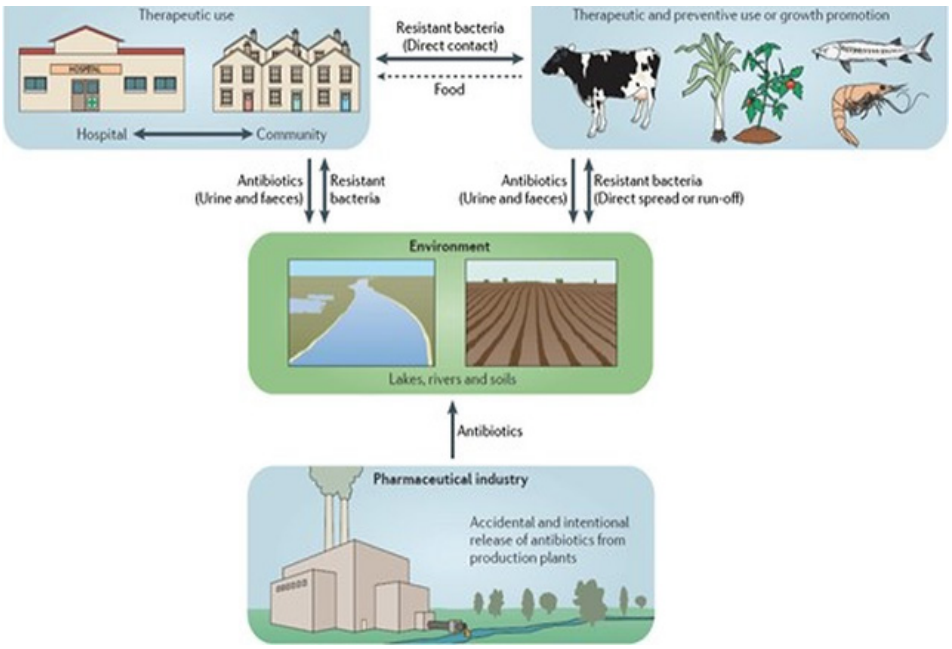


**Figure 1:** *An integrated ecosystem of the dissemination of AMR shows the critical need for a One Health approach to the issue (Adapted from D. I. Andersson and D. Hughes, 'Microbiological effects of sublethal levels of antibiotics', Nature Reviews Microbiology, vol. 12, no. 7, pp. 465–478, 2014, doi: 10.1038/nrmicro3270*

On the other hand, animal husbandry, plant production, and aquaculture are prominent areas that use antibiotics for therapeutic purposes. In these sectors, the misuse of antibiotics has also been identified. A study conducted in Rwanda showed that approximately 97% of farmers inappropriately use antibiotics in their livestock to prevent disease and promote growth while knowing almost nothing about antibiotics or AMR [16]. This practice of farmers in food production also leads to antibiotic residues in human food and the environment.

Lastly, pharmaceutical factories accidentally release antibiotics waste into the environment (Figure 1). As they release them into water bodies and through the vapors, antibiotics residues further accumulate in the environment.

As antibiotics accumulate in the environment, the environment becomes a reservoir for antibiotic-resistant genes [17]. In both soil and water, bacteria adapt to the antibiotic residue, and over time, these antibiotics are rendered ineffective to the now-adapted bacteria. Eventually, these bacteria are reintroduced into the food chain as animals, plants, and humans rely on the affected water and soil. Then, as a response, more and stronger antibiotics are needed to combat these new infections. Still, these new antibiotics also end up being misused and, in return, further contribute to AMR.

The cycle of AMR clearly shows the interrelationship between humans, animals, and the environment when it comes to antimicrobial drugs. Therefore, when dealing with AMR challenges, each of these three sectors must be considered: human health, animal health, and the environment.

## One Health Strategy to Combat AMR

To address AMR globally, the WHO understood that the antimicrobials used in humans are the same as those used in animals and plants; therefore, AMR affects the whole ecosystem globally as migration from one country to the other has become easier with modernization. Thus, a One Health approach was incorporated into the fight against antimicrobial resistance. The One Health approach comes in handy because the multi-sectoral and interdisciplinary approach will allow all sectors involved and other relevant stakeholders to conduct a deeper analysis of the problem under one umbrella and then develop a common solution.

Hence, the World Health Organization (WHO), the World Organization for Animal Health (OIE), and the Food and Agriculture Organization (FAO) have joined forces to combat antimicrobial resistance globally. One of the commitments of WHO/OIE/FAO is to support countries in formulating policies on the appropriate use of antibiotics, establishing institutional and regulatory frameworks and networks, and promoting infection and prevention and control to reduce the use of antibiotics [19].

In addition, WHO/OIE/FAO created the AMR Multi-Partner Trust Fund to curb AMR, expand investment and reduce any financial bottlenecks that hinder the progress of health-oriented AMR national action plans in developing countries [20]. This further proves that the One Health approach was the missing key in the fight against AMR in developing countries.

## Counterargument

Some scholars have challenged the use of a One Health approach to minimize antimicrobial resistance. They also questioned the misuse and overuse of antimicrobials by humans and animals as the only absolute cause of AMR. The argument stems from certain authors' emphasis on antimicrobial resistance as an inevitable natural pathway, and new antibiotic drugs are needed to combat AMR [21]. To support this statement, they explain AMR using two different mechanisms: The intrinsic bacterial mechanism, by which bacteria are naturally resistant to an antimicrobial drug, and acquired resistance, where bacteria adapt themselves and resist antimicrobials [21]. With this understanding, some scientists and leaders advocate for novel technologies and stronger arsenals of antibiotics to curb AMR.

## Conclusion

AMR in developing countries and globally is on the rise as consumption of antimicrobials increases in human health, animal, plants, and the environment. AMR affects all sectors of the ecosystem. Therefore, it is in our best interest globally to put aside the silos of health and gather under the same umbrella of health to tackle the health threat at hand. As pharmaceutical companies are committed to launching new and stronger antibiotics, all relevant stakeholders should work

to alleviate the problem of antibiotic resistance to improve people's health in developing countries. AMR is a multisector problem that needs a multisector solution.

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Original Research

Open Access

# Appropriateness of Antibiotic Prescription Practices in Health Centers in the District of Gisagara, Rwanda

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## ABSTRACT

**Introduction**: Antibiotic over-prescription is a global public health problem. This increases antimicrobial resistance, health costs, and other adverse effects. In Rwanda, most outpatient visits occur in health centers where most antibiotics are prescribed. This study aimed to assess the appropriateness of antibiotic prescription practices in selected health centers in the District of Gisagara, Rwanda.

**Methods:** This was a cross-sectional study that included 645 antibiotic prescriptions between January and December 2017 in the health centers of Kigembe, Kibayi, and Agahabwa of Kibilizi Hospital, Gisagara district in Southern province, Rwanda. Data were collected from outpatient consultation registries. A systematic sampling technique was used to select study participants. A checklist comprising clinical symptoms, signs, diagnosis, and prescribed antibiotics was used for data collection. EPI DATA and STATA software were used for data entry and analysis.

**Results:** The average of antibiotic prescriptions was 54.2%. The mean age of patients treated was 26.6 years. The common symptoms related to antibiotics prescription were fever 29%, cough 26.9%, and running nose 17%. The most prescribed antibiotics were: amoxicillin (37.1%), penicillin V (13.2%), and cloxacillin (12.1%). The main indication was upper respiratory tract infection, 40.6%. The rate of the appropriateness of antibiotics prescription was 38.6%.

**Conclusion:** Antibiotics prescription is inappropriate in the three health centers. There is a need to train health center nurses in diagnostic and rational antibiotic practices to limit the antibiotics' over-prescription and antimicrobial resistance.

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**Received:** January 18, 2022
**Accepted:** December 6, 2022
**Published**: December 31, 2022

**Cite this article as:** Nkurunziza et al. Appropriateness of antibiotic prescription practices in health centers in the District of Gisagara, Rwanda. *Rw. Public Health Bul. 2022. 3 (2): 11-17.*

## INTRODUCTION

Antibiotic over-prescription, which leads to antimicrobial resistance (AMR), is a current global health challenge [1,2]. AMR leads to increased health expenditure due to the high cost of developing new antibiotics or purchasing more expensive but currently effective antibiotics [3,4]. Studies done in Europe and South America in outpatient clinics have shown high prescriptions of antibiotics [5,6]. Studies in Sub-Saharan Africa

showed that antibiotics treat more than 70% of upper respiratory infections (URTI)without clinical evidence of bacteria as a causative agent [7,.8]. It was also found that 40% of infectious diarrhea is treated with antibiotics without confirmation of bacterial cause [9].

A study done in a tertiary hospital in Rwanda documented that amoxicillin was commonly used even though bacteria resistant to amoxicillin were present in 89.3% of bacterial cultures [10]. The 2017 Rwanda Health Management Information System report showed an increased trend toward antibiotic prescriptions in health centers of Kibilizi District Hospital, Gisagara, compared to the previous years. The National Institute of Statistics in Rwanda (NISR) report from 2018 showed that most outpatient visits (77.0%) occur at health centers. We could not find any study conducted at the health center level about prescription antibiotics. Most of the primary health care is provided by nurses at health centers [11,12].

Our study's objectives are to assess the proportion of outpatients receiving antibiotic prescriptions, evaluate the appropriateness of the antibiotic prescriptions based on diagnosis, and set recommendations to prevent AMR.

## METHODS

This is a descriptive retrospective cross-sectional study done in 2019. The study was among those selected by the Rwanda Ministry of Health in a plan to operationalize health research at District levels in 2017 through the district operational research challenge fund. The principal investigator worked at Kibilizi Hospital, Gisagara District, from that time till now. The study was conducted in three nine rural health centers of Kibilizi Hospital, Gisagara District, Rwanda. The hospital serves a population of 207,883. The three health centers, Kigembe, Kibayi, and Agahabwa, were selected for this study because they treated the largest number of patients (125,805) from a total of 345 846 patients consulted from January to December 2017. They prescribed the highest number of antibiotics in March 2017.

We checked the hospital data for the year 2017. We reviewed all patient registries for each of the three selected health centers and counted all the patients who visited the health centers. We divided the number of patients who received antibiotics by the number of those who received any prescription to calculate the antibiotic prescriptions rate. We also reviewed the symptoms and diagnoses for which the antibiotics were prescribed. We matched the diagnosis and the criteria for prescribing antibiotics to determine the appropriateness of the antibiotics prescription. We set recommendations after the findings.

### Study population

This consisted of patients who were prescribed antibiotics in outpatient consultations (68,186) from January to December 2017. In the study, we included patients who received antibiotic prescriptions and had complete required information in the health center registry.

We excluded from the study those whose records had incomplete information.

### Sampling

The World Health Organization (WHO) recommends investigating at least one hundred prescriptions in a facility when researching drug use indicators [13]. We set the proportion of the antibiotic prescription's appropriateness at 50% as there were no data about the previous prevalence in our setting. The register's incompleteness rate was set at 40% to increase the sample size. We divided 384 (minimum sample size for a population where an expected proportion of the element studied was set at 50%, precision at 5%) and 1(100% completeness) minus the above incompleteness rate. The sample size became 645. We considered a number of more than a hundred participants (patients who received antibiotic prescriptions) enough recommended by the WHO. We considered almost an equal number of sample sizes for each health center. The sample sizes were 213, 217, and 215 patients from Kibayi, Kigembe, and Agahabwa health centers, respectively. For each of the health centers, patients were registered by order of arrival from the first to the last day of the month. We set a new order from 1st January to 31st December 2017 from which to allow sampling. We used a systematic sampling technique to select study participants from the list of patients who received antibiotic prescriptions. We obtained the sampling interval by dividing the total number of patients by the sample size. We considered the first patient who took the antibiotic, then we found the second by adding the interval to the first one, and

so on, until the required number was reached

**Data Collection**

We trained three nurses, one for each health center, to collect information from the registry. A predefined questionnaire was used. The questionnaire included the patient's age, sex, symptoms, signs, diagnosis, treatment (antibiotics), and dosage. These elements were used to determine the appropriateness of the prescription, which is the outcome variable. We completed the data collection from July to August 2018.

**Data Analysis**

We set criteria (with reference to a study done in Lesotho) to determine appropriate or inappropriate antibiotic prescriptions [14]. An appropriate antibiotic prescription was defined as one that includes the drug prescribed with dosage and duration appropriately indicated for the patient's clinical condition or prophylaxis [15,16]. The prescription was considered appropriate when it met the following criteria: suggestive signs and symptoms of bacterial infection present, or presence of infection established by laboratory test if any; presenting signs and symptoms absolute for bacterial infection; site of infection or possible areas of infection identified; potential site of infection(i.e., open wound); antibiotic prescribed is only one and indicated against all commonly likely pathogens associated with the area of infection; the prescribed antibiotic, the dosage, and duration of treatment are correct; and antibiotics in multiple therapies are compatible. We considered the antibiotic prescription inappropriate when it did not meet the above criteria.

We entered data in Epidata and exported these in STATA. Descriptive analysis for demographics and other variables (clinical signs and symptoms, prescribed antibiotics) was done using frequency and proportions.

The research protocol has been cleared and approved by the National Health Research Committee (NHRC). Rwanda National Ethics Committee reviewed and approved it (Ref: NHRC/2018/PROT/023).

**RESULTS**

Of 125,805 patient visits at the three selected HCs, 68,186 (54.2%) were prescribed antibiotics. The mean age of study participants was 26.6 years. Children under five years old represented 21.4% of patients. More than half of the study population were female (Table 1).

**Table 1:** *Age and gender distribution of study participants (n=645)*

| Characteristics | n (%) |
|---|---|
| Age group (years) | |
| < 5 | 138 (21.4) |
| 5-14 | 96 (14.9) |
| 15-24 | 101 (15.7) |
| 25-44 | 166 (25.7) |
| 45-64 | 105 (16.3) |
| 65+ | 39 (6.0) |
| Sex | |
| Male | 281 (43.6) |
| Female | 364 (56.4) |

Fever was the most common presenting symptom (29%), followed by dry cough (26.9%), runny nose (17.0%), productive cough (12.5%), and dysphagia (10.9%). Upper respiratory tract infection was the most frequent clinical diagnosis 40.6% followed by non-specific infection (no clear diagnosis) (26.7%), tonsillitis (21.5%), intestinal parasites (13.2%), and wound (10.1%) (Table 2).

The most commonly used antibiotic was amoxicillin (37.1%), followed by penicillin V (13.2%), cloxacillin (12.1%), cotrimoxazole (11.0%) and metronidazole (9.8%) (Table 3).

The study findings revealed that the overall appropriateness of the antibiotic prescription was 38.6%. The lowest test rate of antibiotic prescription suitability was observed in children under five years of age, 24.6%. Among the antibiotics prescribed, amoxicillin was associated with the lowest rate of appropriate prescribing, 20.1%. URTI was the diagnosis most frequently associated with inappropriate antibiotic prescribing 98.1% (Table 4).

**DISCUSSION**

In this study, we assessed antibiotic prescription suitability in three health centers of Kibilizi District Hospital, South Rwanda.

**Table 1:** *Distribution of the symptoms and diagnosis (n=645)*

| Characteristics | n (%) |
|---|---|
| **Symptoms** | |
| Fever | 176 (29.0) |
| Dry cough | 163 (26.9) |
| Running nose | 103 (17.0) |
| Productive cough | 76 (12.5) |
| Dysphagia | 66 (10.9) |
| Wound | 33 (5.4) |
| Liquid diarrhea | 30 (4.9) |
| Abdominal pain | 30 (4.9) |
| Dysuria | 30 (4.9) |
| Skin ulceration | 29 (4.8) |
| Dyspnea | 16 (2.6) |
| Ear discharge | 15 (2.5) |
| Thoracic pain | 13 (2.1) |
| Urethral/vaginal discharge | 12 (2.0) |
| Abscess | 11 (1.8) |
| Vomiting | 10 (1.7) |
| Hemoptic cough | 2 (0.3) |
| Bloody diarrhea | 2 (0.3) |
| Eye discharge | 1 (0.2) |
| Other | 49 (8.1) |
| **Clinical Diagnosis** | |
| URTI | 262 (40.6) |
| Urinary tract infection | 42 (6.5) |
| Pneumonia | 14 (2.2) |
| Gastroenteritis | 10 (1.6) |
| Other | 326 (50.5) |
| **Specified diagnosis** | |
| Non-specific infection | 87 (26.7) |
| Tonsillitis | 70 (21.5) |
| Intestinal parasites | 43 (13.2) |
| Wound | 33 (10.1) |
| Cutaneous infections | 32 (9.8) |
| Otitis media | 15 (4.6) |
| Abscess | 12 (3.7) |
| Dental decay | 8 (2.5) |
| Sexually transmitted infection | 5 (1.5) |

The percentage of patients receiving antibiotic prescriptions was 54.2%. This was more than the WHO's standard, less than 30% [13]. It was almost equal to what has been found in a study done in Ghana, where the percentage of patients receiving antibiotic prescriptions was 55.2% but considerably

higher than that found in Egypt and Saudi Arabia, 39.2% and 32.2%, respectively [17,18]. There was a clear difference in age distribution: children below 5 years old had the lowest appropriateness rate. This may be explained by the fact that children suffer more frequently from URTIs than adults, and we have observed that antibiotics are commonly prescribed inappropriately for this condition [19].

Among the diagnoses made based on the presenting symptoms and signs, we have observed that URTI constitutes 40.6% of the diagnoses. This is not different from the observations made in other studies done in Japan, Cameroon, or Brazil, where the percentages of patients diagnosed with URTI were 46,2%, 21,27%, and 50%, respectively [19,20,21]. The most prescribed antibiotic for this condition was amoxicillin 37.1%, followed by penicillin V 13.1%. The use of amoxicillin for this common condition has been observed in many other studies, including those done in Ethiopia, Botswana, and Bangladesh, where the percentage of patients prescribed amoxicillin was 64,4%,28,4%, and 17%, respectively [22, 23, 24]. Amoxicillin is frequently used in managing URTI, which seems to be linked to low cost and availability as a generic antibiotic. It is also recommended as the first-line medication in managing URTI of bacterial origin.

The three most common clinical conditions where antibiotics were prescribed were fever 29%, dry cough 26.9%, and runny nose 17.0% (Table 4). In studies done in Ethiopia and the United Kingdom, acute cough accounted respectively for 22.7% and 34.4% of the clinical conditions where antibiotics have been prescribed [25,26]. These symptoms are usually related to upper respiratory tract infections and do not require antibiotics in their management [21].

We found that antibiotics were used appropriately at a rate of 38.6%. Appropriateness is defined as prescriptions given with clinical evidence of bacterial infection. In Lesotho, the appropriateness of antibiotic prescription was 76.8% [14]. In a study done in Ecuador, the appropriateness of the antibiotic prescription was found to be 9.7%, very different from our study's results [26]. Similar results were found in a study done in China, where 39.4% of antibiotic prescription was appropriately done [15]. A study done in Zanzibar showed that antibiotics are prescribed inappropriately in primary care centers with no performance-based financing [27].

## CONCLUSION

Though our study is purely descriptive, we found that the appropriateness of antibiotic prescription is low in the three health centers, and the decision-making is mainly based on clinical symptoms. This is likely the primary factor leading to the high rate of inappropriate antibiotic prescriptions. Improper use of antibiotics is felt to be one of the major causes of antibiotic resistance.

### Recommendations

The physicians at District hospital should supervise the application of the available guidelines on managing different clinical conditions, mainly upper respiratory tract infection.

Initiate training for nurses regarding why to prescribe antibiotics and limit their misuse, primarily amoxicillin.

Make countrywide prospective research on appropriateness of antibiotics prescription at the primary health care level to investigate antibiotic over-prescription.

Motivate healthcare workers to appropriately use drugs especially antibiotics through performance based financing (PBF) and other methods

### Acknowledgement

We would to like thank Prof. Cal Wilson, Dr Barry Becon and Kimberly for their contribution in the review of this article.

Ethical considerations

### Funding & Sponsors

The study was funded by the Rwanda Ministry of Health and the Rwanda Biomedical Center through the District Operational Research Challenge Fund initiative.

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Original Research

Open Access

# Diet and Fluorosis-Related Stigma on Gihaya Island, Western Province, Rwanda

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## ABSTRACT

**Introduction**: Dental fluorosis, caused by prolonged and excessive fluoride exposure during childhood enamel formation, often leads to aesthetic changes in tooth shape, pitting and color. It is highly prevalent on Gihaya Island, Rwanda. To better understand potential fluoride sources and community impact, our research aimed to identify food and water sources consumed by island residents and to characterize social experiences of young adults impacted by dental fluorosis.
**Methods**: All families (N=137) with children up to nine years of age were invited to complete surveys on food/water consumption. Mothers with small children and young adults were invited to participate in focus group discussions on food preparation and stigma, respectively.
**Results:** In total, 136 families participated in the survey. High fluoride content items frequently consumed by children were drinking water from Lake Kivu, infant formula, green marog (amaranth), ugali (made of cassava flour), fish, cooked beans, and porridge (made of sorghum, millet, wheat, etc.). Focus group data identified safe water access as a major community concern and confirmed the presence of social stigma for those with dental fluorosis. This was described as negative impacts on marriage prospects, self-esteem, and social identity. The aesthetic consequences of dental fluorosis, likely caused by combined exposure to fluoride-containing foods and water, negatively impact Gihaya Island residents.
**Conclusion**: Interventions to reduce dental fluorosis must be multi-dimensional, addressing reduced access to safe water, poverty, the nutritional trade-offs of locally sourced foods, and the social consequences of this stigmatizing condition.

**Keywords:** Fluorides, Diet, Dental fluorosis, Rwanda

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**Received:** January 18, 2022
**Accepted:** October 7, 2022
**Published**: December 31, 2022

**Cite this article as:** Schurer et al. Diet and Fluorosis-Related Stigma on Gihaya Island, Western Province, Rwanda. *Rw. Public Health Bul. 2022. 3 (2): 18-27.*

## INTRODUCTION

Fluoride is an essential element that contributes to the health of mineralized tissues, such as teeth and bones, when individuals are exposed at appropriate levels [1]. However, adverse health effects, such

**Potential Conflicts of Interest:** No potential conflicts of interest disclosed by all authors. **Academic Integrity:** All authors confirm their substantial academic contributions to development of this manuscript as defined by the International Committee of Medical Journal Editors. **Originality:** All authors confirm this manuscript as an original piece of work, andconfirm that has not been published elsewhere. **Review:** All authors allow this manuscript to be peer-reviewed by independent reviewers in a double-blind review process.  **Publisher:** Rwanda Health Communication Centre, KG 302st., Kigali-Rwanda. Print ISSN: 2663 - 4651; Online ISSN: 2663 - 4653. **Website:** https://rbc.gov.rw/publichealthbulletin/

as dental fluorosis, can result when individuals are exposed above recommended therapeutic concentrations during childhood, pre-eruptive stages of dental development. Dental fluorosis is characterized by hyper-mineralization of enamel causing aesthetic changes in teeth, including staining, severe mottling, pitting, and subsequent weakness of the enamel [2]. Long term exposure continuing into adulthood is associated with skeletal fluorosis, characterized by deformities such as knock-knees and saber tibia [3]. In addition to physical changes to one's appearance, dental fluorosis has also been linked to social stigmatization, and shifts in one's self-esteem [4,5].

People are exposed to fluoride through various sources, including food, water, dust from fluoride-containing soils, and commercial oral health products [6]. Tea leaves, fish, and grain have been shown to contain high levels of fluoride in some contexts [7]. Cooking practices, such as boiling water, or using natural food tenderizers (e.g., magadi, a high fluoride containing trona) can increase fluoride levels in prepared foods [8], [9].

Dental fluorosis affects millions of people globally [10] and is observed among people in the Rift Valley region of East Africa [11]. Children under the age of eight years are at highest risk, due to fluoride exposure during early enamel development (both pre-eruptive and post-eruptive fluoride exposure) and their increased fluoride retention compared to adults [1]. The first two months of an infant's life is a critical period of exposure because fluoride is more readily incorporated into enamel before teeth erupt through the gums [1,12]. In 2018, a study of dental fluorosis on Gihaya Island found 90.7% of children aged 9-15 years to be affected [13]. Dietary habits and social effects of dental fluorosis on the island are not known. The objectives of this study were to (1) identify common foods and water sources used by families with children aged up to nine years of age, and (2) to characterize the social experiences of young adults with dental fluorosis.

## METHODS

**Study design and setting**: This cross-sectional mixed-methods study was conducted in July 2019 on Gihaya Island in Lake Kivu, a volcanic region, located between Rwanda and the Democratic Republic of the Congo (Figure 1) [14]. The island is approximately 7 km2 in length with a population of 1300 people who mostly practice subsistence agriculture, growing food crops, raising livestock, and fishing. Most households have low socio-economic status and have limited access to electricity and telecommunication. Three water boreholes are distributed along the length of the island but only the central pump was operational in 2019. Residents obtain healthcare for minor issues from Community Health Workers at a small health post but must travel to the mainland for all other concerns, including oral health.

**Data Collection:** We developed a quantitative survey to measure frequency of foods ingested by children and adults. Food items and water sources included on the survey were based on the previous visits to the island and conversations with residents. All dietary questions included the option of 'other' to ensure comprehensive inclusion of food and water sources. The survey was developed in English, translated into Kinyarwanda and then back-translated to ensure accurate translation. It was pre-tested with five people in Bugesera District to ensure content validity. Inclusion criteria for survey respondents were male or female heads of households (aged 18 years or older) of all families with children aged nine years old and younger. The selected heads of household were required to know the dietary practices of all members of their household and to have lived on Gihaya Island for at least one year. The only exclusion criteria was any respondent below the age of 18 years old, and who were not current residents of Gihaya Island. Our team employed two Gihaya Island Community Health Workers to identify all households meeting the inclusion criteria, to introduce the team to potential respondents, and to assist with data collection. Data was collected via surveys which were conducted at the respondent's place of residence by data collectors fluent in Kinyarwanda. Survey data was collected on mobile phones using Kobo Toolbox, uploaded to a computer daily, and checked for errors. Quantitative data was uploaded to SPSS software (v25) for descriptive statistical analysis. Frequencies of the various survey responses was the primary analysis performed using SPSS to determine the foods most consumed by the islanders.

Qualitative data regarding household food/water preparation practices and the social experiences of young, single adults with dental fluorosis were obtained through focus group discussions. The

first discussion, focused on food/water preparation, was held at a women's cooperative and included mothers of children up to nine years of age. Two other discussions, divided by gender, were held with unmarried young adults (18-25 years old) on the topic of dental fluorosis. All discussions were held in enclosed spaces to maintain privacy from outsiders. They were facilitated by two Kinyarwanda speakers and were audio-recorded to ensure accuracy of transcripts and notes. Transcripts were translated to English and reviewed by two members of the research team to identify major themes.

## RESULTS

### Demographics

Overall, 137 household met the study inclusion criteria; of these, 136 agreed to participate in the survey (99% participation rate). The remaining person was off the island for the duration of the study period and unavailable to participate. Respondents were most often women (83%) versus men (16%), with a median age of 34 years (range: 18-62). Most (76%) were born on Gihaya Island with the remainder living there between one and 40 years. Of the households surveyed, 124 had at least one child from the age group of 0-1 years old, 117 had one or more children aged 2-5 years, and 99 had one or more children aged 6-9 years.

### Island foods and beverages

Survey data indicated that two-thirds of families consumed small fish from Lake Kivu daily or weekly (65%) and almost all rarely or never consumed meat, eggs (99% each) or cow's milk (92%; Table 1). Most described eating beans daily or weekly (87%). Ugali (porridge) and cassava root were the major sources of carbohydrates, with nearly half consuming cassava root daily or weekly

**Table 1:** *Foods consumed by household heads residing in high prevalence region for dental fluorosis (Gihaya Island, Rwanda; N=136)*

| | Daily | Weekly | Monthly | Rarely/Never |
|---|---|---|---|---|
| | n (%) | n (%) | n (%) | n (%) |
| Cow's Milk | 3 (2.2) | 7 (5.1) | 10 (7.4) | 115 (84.5) |
| Fish | 12 (8.8) | 76 (55.9) | 34 (25) | 14 (10.3) |
| Meat | 0 (0) | 2 (1.5) | 26 (19.1) | 108 (79.4) |
| Eggs | 1 (0.7) | 0 (0) | 10 (7.4) | 125 (91.9) |
| Beans | 36 (26.5) | 82 (60.3) | 15 (11) | 3 (2.2) |
| Cassava root | 4 (2.9) | 38 (27.9) | 27 (19.9) | 67 (49.3) |
| Mango | 1 (0.7) | 0 (0) | 3 (2.2) | 132 (97.0) |
| Avocado | 5 (3.7) | 16 (11.8) | 20 (14.7) | 95 (69.1) |
| Other[1] | | | | |
| Green Marog | 72 (52.9) | 19 (14) | 0 (0) | 2 (1.5) |
| Ugali | 91 (66.9) | 8 (5.9) | 0 (0) | 0 (0) |
| Green Banana | 7 (5.1) | 2 (1.5) | 0 (0) | 0 (0) |
| Sweet Potato | 5 (3.7) | 6 (4.4) | 1 (0.7) | 0 (0) |
| Cassava Leaves | 9 (6.6) | 4 (2.9) | 0 (0) | 0 (0) |
| Sweet Pepper | 1 (0.7) | 2 (1.5) | 0 (0) | 0 (0) |
| Cabbage | 2 (1.5) | 1 (0.7) | 0 (0) | 0 (0) |
| Irish Potato | 1 (0.7) | 0 (0) | 0 (0) | 0 (0) |
| Soybeans | 0 (0) | 1 (0.7) | 0 (0) | 0 (0) |
| Rice | 0 (0) | 1 (0.7) | 0 (0) | 0 (0) |
| Fish Powder | 0 (0) | 1 (0.7) | 0 (0) | 0 (0) |
| Porridge | 0 (0) | 0 (0) | 0 (0) | 1 (0.7) |

[1]*Food or beverage items not listed on the survey*

(42%), and nearly three-quarters consuming ugali daily or weekly (72.8%). Mangoes (99.2%) and avocados (83.8%) were rarely or never consumed, even though both grew on the island. Respondents reported 'other' food items (i.e., those not on the survey but identified by respondents) eaten daily or weekly as green marog (amaranth) (66.9%), cassava leaves (9.5%), sweet potato (8.1%), green banana (6.6%), sweet pepper (2.2%), cabbage (2.2%), Irish potatoes (0.7%), soybeans (0.7%), rice (0.7%), and fish powder (0.7%). Household heads prepared foods by adding salt (99.3%) and oil (73.5%).

Foods most consumed daily or weekly by children aged 2-5 years were fish (70.1%), beans (88.9%), and ugali (64.8%; Table 3). Half of respondents also provided breast milk (47%), infant formula (48.5%), porridge (48.7%) and green marog (50.4%) to children in this age group daily or weekly. Meat (78.6%), eggs (94.9%), and cow's milk (82.1%) were rarely or never provided. Cassava root (31.7%) and ugali (64.8%) were the main sources of carbohydrates. Most rarely or never gave their children mango (97.4%) and avocado (71.8%). Apart from green marog and ugali, 'other' foods ingested daily or weekly included cassava leaves (8.6%), sweet potato (8.4%), green banana (2.4%), sweet pepper (1.6%), rice (1.6%), cabbage (0.8%), and Irish potatoes (0.8%).

**Table 2:** *Foods consumed by children (0-1 years) in a high prevalence region for dental fluorosis (Gihaya Island, Rwanda; N=124)*

| | Daily | Weekly | Monthly | Rarely/Never |
|---|---|---|---|---|
| | | | | n (%) |
| Breast Milk | 120 (96.8) | 0 (0) | 0 (0) | 4 (3.2) |
| Infant Formula | 90 (72.6) | 10 (8.1) | 5 (4) | 19 (15.3) |
| Cow's Milk | 3 (2.4) | 8 (6.4) | 11 (8.9) | 102 (82.3) |
| Porridge | 30 (24.2) | 41 (33) | 10 (8.1) | 43 (34.7) |
| Other[1] | | | | |
| Green Marog | 9 (7.2) | 8 (6.4) | 0 (0) | 1 (.8) |
| Ugali | 21 (16.9) | 1 (0.8) | 0 (0) | 0 (0) |
| Green Banana | 16 (12.9) | 6 (4.8) | 0 (0) | 0 (0) |
| Sweet Potato | 0 (0) | 1 (0.8) | 0 (0) | 0 (0) |
| Sweet Pepper | 1 (0.8) | 2 (1.6) | 0 (0) | 0 (0) |
| Irish Potatoes | 6 (4.4) | 6 (4.4) | 0 (0) | 1 (0.8) |
| Rice | 1 (0.8) | 0 (0) | 0 (0) | 0 (0) |
| Fish | 4 (2.9) | 2 (1.6) | 0 (0) | 0 (0) |
| Avocado | 1 (0.8) | 1 (0.8) | 0 (0) | 0 (0) |
| Beans | 2 (1.6) | 0 (0) | 0 (0) | 0 (0) |

[1]*Food or beverage items not listed on the survey*

Participants did not provide infant formula or breast milk to children aged 6-9 years and rarely offered cow's milk (87.9%; Table 4). Both fish (76.7%) and beans (89.9%) were given to this age group weekly by most survey participants. Meat (82.8%) and eggs (92.9%) were rarely or never provided. Ugali (66.6%) and cassava (36.3%) were most common carbohydrate sources. More than half gave their children green marog (53.5%), but most rarely or never gave mango (99%) and avocado (71.7%). 'Other' food items included cassava leaves (8%), sweet potatoes (6%), green banana (2%), sweet pepper (1%), cabbage (1%), soybeans (1%), and rice (1%).

Water was the beverage most frequently consumed daily or weekly (100%; Table 5). Daily drinking water was mostly sourced from the borehole (66.9%), followed by Lake Kivu (30.9%) whereas daily cooking water was most often sourced from Lake Kivu (93.4%) followed by the borehole (6.6%). Respondents did not generally use rainwater for drinking or cooking and often stored water from different water sources in the same container (79.4%). Nearly all participants described previously using a borehole that was no longer available to them (98.5%). Some respondents treated their water to enhance its

**Table 3:** *Foods consumed by children (2-5 years) in a high prevalence region for dental fluorosis (Gihaya Island, Rwanda; N=117)*

| | Daily | Weekly | Monthly | Rarely/Never |
|---|---|---|---|---|
| | n (%) | | | |
| Breast Milk | 55 (47) | 0 (0) | 0 (0) | 61 (52.1) |
| Infant Formula | 59 (50.4) | 7 (6) | 3 (2.6) | 48 (41) |
| Cow's Milk | 3 (2.6) | 8 (6.8) | 10 (8.5) | 96 (82.1) |
| Fish | 11 (9.4) | 71 (60.7) | 21 (17.9) | 14 (12) |
| Meat | 0 (0) | 2 (1.7) | 19 (16.2) | 95 (78.6) |
| Eggs | 0 (0) | 0 (0) | 6 (5.1) | 111 (94.9) |
| Beans | 31 (26.5) | 73 (62.4) | 7 (6) | 6 (5.1) |
| Cassava Root | 5 (4.3) | 32 (27.4) | 15 (12.8) | 65 (55.5) |
| Mango | 0 (0) | 1 (0.8) | 2 (1.6) | 114 (97.4) |
| Avocado | 6 (5.1) | 14 (12) | 13 (11.1) | 84 (71.8) |
| Porridge | 17 (14.5) | 40 (34.2) | 9 (7.7) | 51 (43.6) |
| Other[1] | | | | |
| Green Marog | 60 (51.3) | 4 (3.4) | 0 (0) | 0 (0) |
| Ugali | 74 (63.2) | 2 (1.6) | 0 (0) | 0 (0) |
| Green Banana | 2 (1.6) | 1 (0.8) | 0 (0) | 0 (0) |
| Sweet Potato | 5 (4.2) | 5 (4.2) | 0 (0) | 0 (0) |
| Cassava Leaves | 7 (6) | 3 (2.6) | 0 (0) | 0 (0) |
| Sweet Pepper | 2 (1.6) | 0 (0) | 0 (0) | 0 (0) |
| Cabbage | 0 (0) | 1 (0.8) | 0 (0) | 0 (0) |
| Irish Potatoes | 1 (0.8) | 0 (0) | 0 (0) | 0 (0) |
| Rice | 1 (0.8) | 1 (0.8) | 0 (0) | 0 (0) |

[1]*Food or beverage items not listed on the survey*

safety, either by filtration (15.4%) or boiling (23.5%). Other beverages consumed daily or weekly included tea (21.3%), juice (8.8%), beer (7.3%), milk (6.6%), and soda (3.6%). Animals drank from Lake Kivu (87.8%) and/or from the functioning borehole water source (93.9%). Some respondents gave away leftover food or liquid from their cooking (66%).

**Food/water preparation**

Mothers of small children participating in the first focus group (n=12) identified poverty, market access, and governance as important factors affecting food and water access. Lack of money prevented women from buying the foods they preferred in favor of lower cost items that could be stretched to feed a family. It also explained why children mostly ate the same food as adults.

*"We do not eat meat, except for at weddings. One kg of meat costs 3000 RWF [Rwandan francs]. How can you afford it when you brought 1000 RWF to the market? How can you buy it? We live a bad life."*

*"When you have 1000 RWF you cannot buy 1 kg of rice and feed the whole family but if you have 1000 RWF you buy cassava flour and it fills up the whole family. That is why it is the most common."*

The women described a sudden recent change that negatively impacted their access to safe water. They agreed that borehole water was safest and had become available in 2004 after a major cholera outbreak prompted Médecins Sans Frontières to install three boreholes. Two pumps broke and the third supplied most families with drinking water until 2019 when it was suddenly repurposed with solar panels and fitted with a lock by a local social enterprise (Water Access Rwanda). Island residents were then obliged to pay for the only source of clean water, which was often unavailable in the rainy season or when the operator was absent. Many could not afford the cost and reverted to water from Lake Kivu, despite

**Table 4:** *Foods consumed by children (6-9 years) in a high prevalence region for dental fluorosis (Gihaya Island, N=99)*

| | Daily | Weekly | Monthly | Rarely/Never |
|---|---|---|---|---|
| | | | | n (%) |
| Cow's Milk | 2 (2) | 7 (7) | 3 (3) | 87 (87.9) |
| Porridge | 5 (5) | 29 (29.3) | 7 (7) | 58 (58.6) |
| Fish | 6 (6) | 70 (70.7) | 15 (15.2) | 8 (8.1) |
| Beans | 24 (24.2) | 65 (65.7) | 7 (7.1) | 3 (3) |
| Cassava Root | 6 (6) | 30 (30.3) | 17 (17.2) | 46 (46.5) |
| Mango | 0 (0) | 0 (0) | 1 (1) | 98 (99) |
| Avocado | 5 (5) | 14 (14.1) | 8 (8.1) | 71 (71.7) |
| Meat | 0 (0) | 4 (4) | 13 (13.1) | 82 (82.8) |
| Eggs | 0 (0) | 0 (0) | 5 (5) | 92 (92.9) |
| Other[1] | | | | |
| Green Marog | 47 (47.5) | 6 (6) | 0 (0) | 0 (0) |
| Ugali | 61 (61.6) | 5 (5) | 0 (0) | 0 (0) |
| Green Banana | 1 (1) | 1(1) | 0 (0) | 0 (0) |
| Sweet Potatoes | 1 (1) | 5 (5) | 0 (0) | 0 (0) |
| Cassava Leaves | 5 (5) | 3 (3) | 0 (0) | 0 (0) |
| Sweet Pepper | 0 (0) | 1 (1) | 0 (0) | 0 (0) |
| Cabbage | 0 (0) | 1 (1) | 0 (0) | 0 (0) |
| Soybeans | 0 (0) | 1 (1) | 0 (0) | 0 (0) |
| Rice | 0 (0) | 1 (1) | 0 (0) | 0 (0) |

[1]*Food or beverage items not listed on the survey*

fear of contracting infectious diseases. They were not able to treat water due to scarcity of cooking fuel and lack of filtration devices at markets.

*"Diarrhea, cholera, and all those diseases came back recently."*

*"Now our children are having intestinal worms. A few days ago, I was about to die. I spent two days unable to get off my bed."*

*"There is no wood for charcoal. How can you find wood to cook water if you don't have wood to cook food?"*

The women were frustrated about the lack of consultation, fearful about increases in disease, and felt abandoned by Water Access Rwanda and the local leader who were both located off the island and therefore unaffected by the water shortage. They agreed that island water sources were inferior to that available on the mainland.

*"We ask our leaders and receive no response. We ask them, we used to have our own water without a problem, without money. Who is the person who changed our water this way? We do not find anyone to respond to us."*

**Self esteem**

Most survey respondents (80.9%) reported having stained and/or pitted teeth; of those, 89% felt dissatisfaction and 62.8% felt shame with the appearance of their teeth. Focus group participants from the two groups (eight men and seven women) experienced reduced self-esteem as well as stigma and described several possible causes of stained teeth: genetics, disease, malnutrition, eating small fish, and drinking unsafe water. Both men and women had been branded with derogatory language ("umushi", meaning outsider) when travelling off the island and hid their teeth to avoid being mocked.

*"Sometimes when we go to a meeting at the other side of the lake, and they tell a joke, you can't laugh. You have to cover your mouth."*

*"When you cross the lake to the other side, and you smile or laugh you can hear people saying this one is "umushi": they ate a lot of small fishes. This doesn't feel so good, just in case you were passing by and wishing to get along with people across the lake."*

**Education and employment**

Although some students had dropped out of school due to discrimination, neither men nor women believed that their employment prospects were affected. Rather, they were upset that people with dental fluorosis were prevented from sharing food or beverages with those unaffected:

*"One of them took a sugar cane and his friend said, 'why did you eat my sugar cane with those bad teeth of yours?' They threw the rest of the sugar cane in the toilet, and those are simply children!"*

*"When people are drinking our traditional beer which we share using the same straw, someone with that dental problem might be your friend and want to share the beer with you. And then you might be like 'I can't drink from the same straw used by him', and you refuse to share the beer with him."*

**Stigma**

Men and women agreed that stained teeth reduced the number of marriage prospects, affecting women disproportionally. As two men stated,

*"Actually, girls are the more vulnerable ones. Because boys are the ones who initiate dates, so there are some factors that a boy follows when asking a girl out."*

*"Here on the island, some people think dental fluorosis problems are genetic. They would say 'if I marry that girl, she will bear children with the same teeth as hers'. That's really heart breaking. Except for someone who doesn't consider teeth's appearance to be a problem.*"

A few participants blamed tooth pain on fluorosis and nearly all wanted to repair the appearance of their teeth. However, treatments available in the region were either ineffective or expensive.

## DISCUSSION

Dental fluorosis negatively impacts the physical and mental wellness of over 200 million people globally [10]. In this study of diet and stigma, we confirmed that residents of Gihaya Island associated dental fluorosis with physical pain, shame, reduced marriage prospects, and social stigma. Moreover, reduced access to safe borehole water resulted in increased consumption of water from Lake Kivu, which is known to contain unsafe levels of fluoride (range: 1.65-1.75mg/L), as well as other harmful pathogens such as E. coli [13]. Rwanda is a low-income country with ambitious goals to improve WASH (water, sanitation, and hygiene) so that 'universal and equitable access to safe and affordable drinking water' be provided for all by 2030 [15]. This national goal is aligned with the United Nations Sustainable Development Goal 6, and as such, improving access to safe water on Gihaya Island is in line with national and global goals for poverty reduction [16].

The upper limit (UL) of exposure describes the highest level of fluoride exposure that is tolerated before adverse effects of fluorosis are caused [17]. Infants tolerate the lowest level of exposure compared to other age groups, with an UL of 0.7 mg/day (0-6 months), and 0.9 mg/day (6-12 months) [17]. Our dietary survey identified three items consumed daily by most infants up to one year (breast milk, infant formula, porridge). Evidence indicates that maternal fluoride transfers poorly through breast milk, suggesting that infant formula and porridge, both prepared with boiled Lake Kivu water, are likely the greatest fluoride source for infants on the island [18]. Elsewhere, infant formula has been linked to an unsafe increase in fluoride consumption due to the mixture of fluoridated water with infant formula concentrate [1]. Porridge prepared on Gihaya Island was determined to have a fluoride concentration of 0.485 mg/g [13]. The UL of fluoride for children 1-3 years is 1.3 mg/day (1-3 years) and 2.2 mg/day for children 4-8 years [17]. In addition to breast milk and infant formula, most Gihaya Island children aged two years and older ate green marog and ugali daily, and fish, beans, and porridge weekly. Green marog, ugali, small fishes, and cooked beans contained mean fluoride concentrations of 0.305 mg/g, 0.161 mg/g, 0.262 mg/g, and 0.211 mg/g respectively, suggesting that moderate daily servings of each would alone exceed the safe UL for this age group [13]. However, the high levels of calcium and antioxidants contained in green marog could serve to moderate fluoride bioavailability [19]. More information on serving sizes is needed to inform public health efforts to reduce fluoride exposure in this hyperendemic region. Moreover, recommendations must consider the high level of poverty, malnutrition, and locally available food items, and the trade-offs between nutritionally dense foods (such as small fishes) and fluoride content.

Gihaya Island study participants drank water more often than any other beverage, followed by tea.

Drinking water was most often collected from the Water Access Rwanda-controlled borehole, while cooking water was primarily collected from Lake Kivu. Eight months previously, Lake Kivu water was found to contain more than 12 times the concentration of fluoride versus the borehole water (1.75 mg/L versus 0.14 mg/L) [13]. The WHO recommends that fluoride levels in water not exceed 1.5 mg/L; however, it has been suggested that in tropical climates where individuals are expected to drink more water than people in temperate climates, fluoride levels in water not exceed 1.0 mg/L [20]. On Gihaya Island, borehole water is currently the safest water source with respect to both fluoride and pathogenic exposure [13]; however, recent changes in access are a major barrier to use. Alternative sources, such as harvested rainwater and Lake Kivu, are feasible but require infrastructure upgrades to ensure safe access and storage. Furthermore, options for removing both pathogens and fluoride from lake water are limited, and costly. These methods include reverse osmosis, ion exchange, lime softening, use of activated alumina, or coagulation followed by direct filtration through sand beds [21].

Young adults affected with dental fluorosis on Gihaya Island described feeling socially excluded, being called derogatory names, hiding their teeth, and reduced marriage prospects. Research demonstrates that dental fluorosis is an esthetic problem to mothers and their children in other East African countries, which may result in embarrassment, distress, and worry. As a result, social stigma can lead to an overall reduced self-esteem and damage to one's social identity [22]–[24]. Amongst the commonly held socio-political narrative of unification in the country declaring 'we are all Rwandans', residents of Gihaya Island are impacted with a sense of 'otherness' from fellow Rwandans when faced with prejudice due to their teeth. Experiences with dental fluorosis on the island also emphasizes gender inequities due to the impacts it has on relationship and marriage prospects, which may only further negatively affect quality of life for those individuals. Young adults sought options to improve the appearance of their teeth and were disappointed with the limited treatment options. Micro-abrasion of the teeth and/or veneers are costly and unrealistic in this context, with prevention remaining as the best option for those on Gihaya Island [25].

One key limitation of this study was our inability to document the quantities of each food item consumed daily by infants and children. This occurred because families often ate one meal per day at a time when it was not possible for the research team to be on the island. As a result, we were unable to calculate fluoride intake among high-risk groups. However, the uniformity of diet between families and the high concentration of fluoride in commonly consumed foods suggest that even moderate intake of foods containing Lake Kivu water is sufficient to exceed the daily UL. Additional laboratory analyses are also needed to quantify fluoride concentrations of other foods commonly ingested on Gihaya Island so that differences in associated with preparation methods can be better understood. Despite our best efforts, certain food items, such as green marog and ugali, were not originally included as official survey options, and their frequency of consumption could be under-estimated because we relied on participants naming them as 'other'.

## CONCLUSION

In Rwanda, efforts to improve access to safe water often focus on reducing transit time to water sources and reducing water-borne pathogens. In this study of Gihaya Island where nearly all children show signs of dental fluorosis [13] we identified several foods (infant formula, porridge, fish, beans, green marog, ugali) and reduced access to safe water as major contributors to fluoride intake among infants and children. Moreover, we documented the negative psychosocial experiences due to stigmatization of dental fluorosis occurring off island. Altogether, this contributes to reduced wellness among an already vulnerable group. An immediate priority for island residents is improving access to water that is low in fluoride and free from waterborne pathogens. While further research is needed to understand the trade-offs of fluoride exposure and nutritional status of commonly ingested foods such as fish, our research suggest that households could reduce exposure by preparing boiled foods with borehole versus Lake Kivu water. Encouraging the sole provision of breast milk over infant formula would reduce fluoride exposure although this might pose a challenge for women with several children among the highest risk age groups. It is vital that the issue of dental fluorosis be investigated further

so as to better serve the health, wellness, and sense of national identity for the population of Gihaya Island. Furthermore, Rwanda's WASH goals for equitable access to safe and accessible water for all by 2030 suggest that improving upon the primary water source on Gihaya Island that is both heavily fluoridated and containing coliforms is of utmost importance.

## DECLARATIONS

### Ethical approval and consent to participate

Ethical approval for this study was obtained from the University of Rwanda Institutional Research Board (reference no: DVC-AAR 529/2019). Further written approval was obtained from the Mayor of the Rusizi district, the Executive Secretary of Gihundwe Sector, and the General Director of Gihundwe Hospital.

### Availability of data and materials

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

### Competing interests

The authors declare that they have no competing interests.

### Funding

Funding was generously provided by the Cumming's Foundation.

### Author's Contribution

All authors contributed to the conception and study design process. AH, JMS, and EMH participated in data collection, analysis, and interpretation. AH and JMS drafted the manuscript. TN developed GIS mapping images of Gihaya Island. All authors reviewed and approved the final version.

### Acknowledgements

We thank Rosine Mukashyaka, for her support during the research process. We thank community health workers Fidele Mbarufite and Nyirandorimana Francine.

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# Time matters: Improving Awareness to Reduce Stroke Mortality – Policy brief

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**Received:** February 28, 2022
**Accepted:** October 7, 2022
**Published**: December 31, 2022

**Cite this article as:**
Dushimiyimana et al. Time Matters: Improving Awareness to Reduce Stroke Mortality. *Rw. Public Health Bul. 2022. 3 (2): 28-31.*

## Key Messages

Stroke kills an estimated 5 million people worldwide each year, with developing countries contributing 3.3 million; the number one cause of stroke is hypertension.
Stroke deaths moved from the 7th (2009) to the 3rd (2019) place as a leading cause of mortality in Rwanda, counting for 5.1% of total deaths.
Provider adherence to screening and treatment protocols can help to control hypertension and its complications in Rwanda.
Improving public awareness of the causes and symptoms of stroke can prevent over 130 stroke deaths per year.

## Problem Statement

A stroke is an acute loss of neurological function due to an interruption of blood supply to the brain. It is the second leading cause of mortality worldwide (5 million annual deaths) [1], the second most common cause of disability (116.4 million Disability Adjusted Life Years (DALYs), and a major public health challenge [2,3] and low and middle-income countries contribute 66% of all stroke deaths worldwide [4]. In the absence of a significant global public health response, projections show that stroke mortality will increase faster in middle and low-income countries than in high-income countries by 2030 (Figure 1) [5]. In 2019, there were 2,915 deaths from stroke in Rwanda, counting for about 5% of total deaths.
Research suggests that the first hour between symptoms onset and clinical care is critical and the gold standard response time [6]. In Rwanda, the median presentation delay is 72 hours for patients with ischemic stroke and 24 hours for patients with hemorrhagic stroke [7]. Although Rwanda has put efforts into the prevention of non-communicable diseases (NCDs), the percentage of deaths due to stroke is still increasing. It remains Rwanda's third leading cause of death (Figure 2) [8]. There is an urgent need to reduce the burden of stroke in Rwanda.

## What are the Policy Options?

To reduce deaths and significant disability from stroke, the Ministry of Health must increase awareness of the causes and symptoms of stroke to ensure that Rwandans act quickly when facing the possibility of stroke. Our policy options include

**Potential Conflicts of Interest:** No potential conflicts of interest disclosed by all authors. **Academic Integrity:** All authors confirm their substantial academic contributions to development of this manuscript as defined by the International Committee of Medical Journal Editors. **Originality:** All authors confirm this manuscript as an original piece of work, andconfirm that has not been published elsewhere. **Review:** All authors allow this manuscript to be peer-reviewed by independent reviewers in a double-blind review process.  **Publisher:** Rwanda Health Communication Centre, KG 302st., Kigali-Rwanda. Print ISSN: 2663 - 4651; Online ISSN: 2663 - 4653. **Website:** https://rbc.gov.rw/publichealthbulletin/

a public education campaign, health professional capacity building for early detection, and training to ensure adherence to high blood pressure (HBP) control protocols.

**Educate the Public on the Causes and Symptoms of Stroke**

**What:** Educate the public using the Act FAST (Facial drooping, Arm weakness, Speech difficulties, and Time to go to hospital) protocol. Highlight the importance of the emergency response to stroke and the availability of time-limited acute stroke treatments [9,10].
**Why:** In Rwanda, stroke mortality is primarily driven by late presentation and assessment. Studies show that Act FAST can decrease late presentation at healthcare facilities [9].
**Feasibility:** High. Research showed the effectiveness of the Act FAST, and in Rwanda, similar educational programs have been conducted successfully.

**Train Healthcare Providers on Stroke Prevention, Symptoms, and Care (Capacity Building)**

**What:** Increase the capacity of health care professionals [1] for early detection and immediate action in case of suspected stroke event [2], to improve the decision-making process in emergency situations, and to transfer suspected cases quickly at the health facility level [3].
**Why:** There is a low number of trained professionals in stroke prevention and management. Improving decision-making and a sense of urgency may result in faster transfers when necessary.
**Feasibility:** High. The Government of Rwanda strongly supports the capacity building of employees through the Ministry of Health and Rwanda Biomedical Centre (RBC) in collaboration with academic institutions and other partners.

**Encourage Adherence to Routine Blood Pressure Testing and Treatment**

**What:** Use refresher training on the importance of HBP control to encourage healthcare providers to screen and treat hypertension. Highlight the significance of HBP as a key risk factor for stroke mortality and adherence to existing HBP screening protocols at all health system levels [1,2].
**Why:** HBP is a silent killer and causes death in 80% of strokes. The prevalence of HBP is 15% in Rwanda, and blood pressure testing is not routine. Research has shown that reducing blood pressure effectively decreases the risk of stroke [11].
**Feasibility:** High. There are existing initiatives through NCD Mass Campaigns, including hypertension screening, and the government encourages the community to participate in HBP testing campaigns.

**Economic Analysis**

We performed the economic evaluation using local data, expert opinion, and evidence from the literature [1]. Guided by the data, we assumed that the FAST campaign would get 50% of the target population (persons aged 35 years and above) [2], healthcare provider capacity would be increased by 50% after the training, and 67% of screened hypertensive patients would be treated (compared to 41% without the intervention) [3]. Due to cost barriers and the impact of hypertension on stroke, the analysis was limited to 10 districts with the highest rates of hypertension and the 3 districts of Kigali, the capital city.

The FAST campaign is the most cost-effective option to reduce stroke deaths, and adherence to screening and treatment protocols will help prevent strokes by controlling high blood pressure.

**Recommendations and Next Steps**

Implementing the screening and treating training and the FAST campaign in 13 districts could lead to over 12,600 cases of controlled hypertension and prevent 133 deaths from stroke respectively. Therefore, we recommend that the Ministry of Health pilot the Act FAST campaign and the screening and treating refresher program through the RBC and its partners. To successfully implement this strategy, high-level policy formulation and endorsement are needed, and activities on the prevention of stroke deaths should be prioritized in next year's (2023) action plan. Also, key stakeholders and donors such as RBC, private healthcare providers, local leaders, civil society organizations, and academic institutions should be mapped and mobilized for participation. The stakeholders should be involved in the development and modification of the documents

**Table 1:** *Evaluation of the selected policy options*

| Description | Status quo (No intervention) | Population campaign | Provider capacity building | Screening & treating BP training |
|---|---|---|---|---|
| Estimated annual deaths | 1,594 | 1,461 | 1,489 | NA |
| Estimated cases of controlled BP | 43,088 | NA | NA | 55,774 |
| The difference in deaths/ BP control | N/A | 133 | 106 | 12,685 |
| Estimated annual cost (USD) | N/A | 20,004.2 | 63,570.9 | 708,410.6[ɳ] |
| Cost per life saved (or per BP controlled) in USD | N/A | 150.57 | 601.45 | 55.84 |
| Cost per life saved (or per BP controlled) in Rwandan Francs (RWF) | N/A | 147,554.4 | 589,424.4 | 54,727.9 |

[ɳ] *The estimated cost is the training cost plus the difference in treatment costs due to a higher rate of treatment.*
*USD is United State Dollar*
*BP is blood pressure; the Difference figures are between intervention and status quo.*

needed for the policy options. This will help ensure campaign approval, ownership by beneficiaries and local leaders, and the sustainability of the projects. Stroke Day should be added to the calendar, and the week before the stroke day, several activities, such as blood pressure monitoring, should be conducted to raise awareness further. Finally, we recommend multisectoral collaboration to increase public exposure to information on stroke prevention and care.

**Acknowledgments**

We acknowledge support from Center for Diseases Control and Prevention (CDC) mentors, Bloomberg Data to Policy Initiative, and RBC leadership, including Non-Communicable Diseases and Research innovation and data sciences. A special thanks go to Michael Washington and Ruxana Jina. This work was supported by a grant from the CDC Cooperative Agreement (Grant Number 1 NU2GGH002203-01-00).

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Rwanda
Public Health Bulletin

**About the Rwanda Public Health Bulletin (RPHB)**

The Rwanda Public Health Bulletin (RPHB) is a printed and open access, peer-reviewed journal, published as the flagship scientific and technical periodical publication. RPHB is a public health bulletin launched in March 2019 by the Rwandan Ministry of Health, through the Rwanda Biomedical Centre (RBC) in collaboration with the CDC Foundation and with support from Bloomberg Philanthropies Data for Health Initiative.

**Mission**

To serve as a scientific information dissemination platform of national and international significance, mainly in areas related to the Rwanda Ministry of Health's essential mission to strengthen national and local health systems and improve the health of the people of Rwanda. The Rwanda Public Health Bulletin publishes disease surveillance summaries, public health response guidelines, public health notices, case reports, outbreak reports, original research papers, and policy briefs among others. It generally features issues of importance to its targeted audience, which is health professionals, academic researchers, policymakers and anybody interested in health issues. Articles for publication are received from doctors, nurses, allied health professionals, students, policymakers, government bodies, non-governmental bodies and others.

**Aim**

To bridge the gap in public health information sharing between policy-makers, researchers, health professionals and practitioners.

**Publisher**

RPHB is a publication of the Rwanda Health Communication Centre (RHCC) which is the communication arm of the Rwanda Ministry of Health and operating under the Rwanda Biomedical Centre (RBC).

**Registration**

Online ISSN: 2663 - 4651, Print ISSN: 2663 - 4643

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## INSTRUCTIONS TO AUTHORS

All works submitted to this bulletin will have to belong to the types of articles stated below:

## 1. ORIGINAL RESEARCH

Referred to as "Primary Research" pioneer in a determined domain. It can be from various aspects: Clinical features, pathophysiology, biochemistry, molecular biology, etc...

## THE TITLE

The title of the article should be concise and informative. It should contain enough thoughts on the subject.

## ABSTRACT

Abstract of 250 words maximum must accompany each manuscript and be divided into 4 paragraphs with the following headings and MeSH keywords:

**Introduction:** stating the purposes/aims of the work; the research undertaken, the hypothesis tested or the procedure evaluated.
**Materials and methods:** briefly stating what was done and what materials were used, including the number of subjects, the methods to assess the data and to control bias.
**Results:** Providing key findings of the study, including indicators of statistical significance, actual numbers, as well as percentages.
**Conclusion:** Summarizing in 1 or 2 sentences the work on the basis of the findings. It emphasizes new and important aspects of the study or observations.

## THE MAIN TEXT

The text of observational and experimental articles is divided into sections with the following headings: Introduction: should always begin the text, and requires brevity and focuses. It conveys the nature and purpose of the work, and quotes the relevant literature. Only strictly pertinent background information is necessary for understanding why the topic is important. We suggest the final paragraph clearly states the hypothesis or purpose of the study.

## METHODS

Details of clinical and technical procedures should follow the introduction. A clear description of the selection of the observational or experimental subjects should be given. The identification of all aspects of the study, its reasoning, and the related relevance should be explicitly justified. In case, the study was done in a particular way, the guiding principles should all be clarified. Exclusion and inclusion criteria or partial inclusion, the reliability index, the confidentiality index, the analysis step, and the data collection processes should be also carefully specified. This section should provide sufficient details on the methods, instrumentation, procedures, all drugs and chemicals used (including generic names, doses, routes of administration). It should allow other workers to reproduce the study if necessary.
This section should also state the self-evaluation of the study by: independent/consensus readings blinded or unblinded to other information and estimate the fluctuation of recall biases by random ordering of studies.

Be clear about the retrospective or prospective nature of the study. Finally, provide references to established methods, including statistical methods that have been published, forthcoming, or that may not be well known. New description or substantially modified methods may be used however, give reasons for the use of these techniques, and evaluate their limitations. Statistical methods should be described with enough details to enable a knowledgeable reader with access to the original data to verify the reported results. A general description of methods would be defined in the methods section, whereas a specific statistical method used into analysis would be summarized in the results section. Any general use of the computer program should be

specified, and more details have to be clarified about any randomization issues.

**RESULTS**

Logical sequence of presentation of results is required in the text; along with tables, and illustrations. Repetition of data from illustrations into the text should be avoided; however, emphasize or summary of only important observations would be helpful. Avoid the ‘’non-technical use’’ of technical terms in statistics which should be defined and reserved for the right purpose. Moreover, define all those statistical terms aside with or including abbreviations and/or most used symbols. Any complication and/or unexpected finding should be reported and the more possibly explained and the author should report lost to follow up and dropouts from a clinical trial.

**DISCUSSION**

Use ample subheadings. Emphasize the new and important aspects of the study and the conclusions that follow from them. Avoid repetition of details included in other parts. This section requires the mention of the implication of the findings, and their limitations for future research, involving relating the observations to other relevant studies.

Finally, the conclusions should be linked to the goals of the study; though mostly avoiding:

Unqualified statement not completely supported by the data

Statement on economic benefits and costs unless the report includes economic data and analyses

Claim of priority and alluding to work that has not been completed.

Whereas new hypotheses could be suggested when warranted, but they should be clearly labeled as such and recommendations, when appropriate and needed, may be given.

**Acknowledgments**

List all contributors who do not meet the criteria of authorship, such as those who provided purely technical help, writing assistance, or a department chair who provided only general support; and their respective contribution will be headed as provided. Everybody must have given written permission to be acknowledged. References: References should be numbered consecutively in the order in which they were first mentioned in the text. They will be identified in the text, tables, and legends by arabic numbers. This bulletin uses the IEEE style (Institute of Electrical and Electronics Engineers) for referencing the citations. It is advised to avoid citations or personal communication unless they provide essential and pertinent information. In all case, the name of the person and date of communication should be cited in parentheses in the text.

**2. CHECKLIST FOR SURVEILLANCE REPORTS**

Disease surveillance summaries are reported following the checklist below:
**Title**: Compose a title that includes the name of the health condition, population, time and place.
**Abstract:** Provide a structured abstract including the following sub- headings: Background; Objectives; Methods; Results; and Conclusion.

**INTRODUCTION**

**Context**: Summarize the current situation regarding the health condition under surveillance and identify why it is important. Objectives: State the objective of the surveillance report.

**METHODS**

**Setting**: Describe the setting, locations and dates of the surveillance period.
**Population**: Describe the population under surveillance. Definitions: Provide definitions for each health event under surveillance, including

case definitions and any public health interventions. **Information sources**: Describe all data sources, including the objective of any surveillance systems, what data were collected and how data were gathered, transferred and stored. Supplementary data: If appropriate, note where to access supplemental material (e.g., www.opendata.gc.ca). **Data quality, missing data and reporting delays:** Describe how the data quality was assessed. Explain how missing data were addressed. If data is reported by date of diagnosis or symptom onset, include a statement about whether the data for the most recent periods may be revised.

**DATA ANALYSIS**

Describe any analytical methods used providing sufficient detail to enable a knowledgeable reader with access to the original data to judge its appropriateness and to assess the reported results.

**RESULTS**

**Descriptive**: Provide a summary of the descriptive data, including demographics.
**Data Quality**: Report on data quality (e.g., completeness, missing data, under reporting)
**Analytic data**: Provide a summary of the analysis including (when indicated) estimates of trends. When applicable, point estimates should include appropriate indicators of measurement error such as 95% confidence intervals (e.g., average annual percentage change used to describe trends or odds ratios used to describe subgroup differences).
**Figures**: Create the minimum number of figures to highlight key results. Create a title that includes person, time and place.

**DISCUSSION**

**Key results**: Summarize key results with reference to study objectives
**Comparison**: Consider these findings in relation to the current literature. Strengths and weaknesses: Discuss the strengths and weaknesses of the study (data quality, completeness, sources of potential bias). Interpretation and generalizability: Provide a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies and other relevant evidence.
**Conclusion:** Ensure conclusions address objectives and follow from the results.

**3. PUBLIC HEALTH NOTICES / OUTBREAK REPORTS**

Following the Center for Disease Control recommendations, for public heath notices and outbreak reports to be published they need to cover all four components as stated below:

**INTRODUCTION**

Generally, the introductory paragraph should begin with 1 to 3 sentences establishing the existence of the outbreak or underlying public health problem (e.g., "On January 2, 2008, the Nevada State Health Division contacted CDC concerning surveillance reports received regarding two persons recently diagnosed with acute hepatitis C."). The introductory paragraph also usually contains: a) a statement that an investigation was conducted, when and by whom; b) the most important finding(s); c) the actions taken to stem the outbreak; and d) a statement of the public health implications and actions that should be taken in response to the investigation. Investigation and results: First, present the initial investigation and its findings. This might include: 1) a description of the setting and a statement of how the outbreak came to the attention of health authorities; 2) a clinical description of the index case or initial cases; 3) initial key test results; and 4) hypothesis generation activities and results. Next, summarize the full investigation, including: case definition, case-finding activities, method of investigation, and results. Cases should be counted and described by clinical characteristics, treatment, and outcome, as well as time, place, and person descriptive results. Next, present the methods and results of any analytic epidemiologic studies (e.g.,

cohort or case-control studies). Finally, provide the results of any relevant microbiologic, genetic, or toxicologic results, followed by the results of any testing of environmental samples. Public health response: When appropriate, a brief description summarizing any public health interventions taken and the results of the interventions follows.

**DISCUSSION**

Same as for a Full Report, except that a Limitations paragraph might not be required for an Outbreak Report.

**4. POLICY BRIEFS**

This bulletin will use guidelines on reporting/ publishing policy notes as they are suggested by the Center for Disease Control (CDC). As the CDC defines them; Policy Notes are intended to announce new official policies or recommendations (e.g., from ACIP or CDC). These reports can be thought of as briefs. Maximum word count at submission is 1,400 words. Up to three tables, figures, or boxes may be included. Policy Notes contain no Discussion or Limitations, and a summary box is not required. Although policy notes or brief might vary, following is a rough guide of what basic notes should have: Introduction: The introductory paragraph should be limited to 150–200 words. It might contain all or some of the following components: a brief introductory statement orienting the reader to the topic and placing it in context, a brief description of the public health problem, a brief statement of the rationale for the policy or recommendation, mention of the most important parts of the policy or recommendations, and one or two sentences stating the conclusions and the public health implications of the new policy or recommendations.

**BACKGROUND**

The Policy Note should include a paragraph after the introduction that summarizes background information relevant to the policy or recommendation that can help the reader understand the context and need for the policy or recommendation.

**Methods**: Should include a summary of the methods used to establish the policy or recommendation, including answers to some or all of these questions: Who was involved in the production of the guidelines or recommendations, and how? What evidence base was considered? What was the rationale for considering this evidence base? Was other evidence excluded from consideration and, if so, why? Rationale and evidence: The Policy Note should provide a concise review of the rationale for the policy or recommendation and a descriptive review of the scientific evidence used to establish it. It should include an explanation of how the policy or recommendation adds to, or differs from, relevant policies or recommendations established previously. Presentation of the policy or recommendation: The policy or recommendation should state clearly when it takes effect and to whom and under what circumstances it applies.

**DISCUSSION OR COMMENT**

The Policy Note should comment on the likely impact of the new policy or recommendation and plans for assessment of the policy or recommendation

**5. CASE REPORTS**

These are reports of an individual patient on their symptoms, treatment reactions on a disease or condition of interest. These reports normally focus on unusual reactions or occurrences. Similar cases to other research reports, case reports might include a literature review of previous similar. Case reports might also address positive patient outcome on particular treatment guidelines or individual impact of a particular intervention. These are mainly used for educational and decision-making purposes. Case reports are normally reported following a checklist found at the CARE Guidelines.

**6. CASE STUDIES**

We recommend authors to follow the "EQUATOR Network" for ample explanations and guidelines in the writing of such articles. They have to be well-described case studies on health care interventions of public health concern. These could be:

Rigorous assessments of processes and program interventions.

Recommendations on possible health interventions.

Never on individual patient (= case report)

**7. COMMENTARIES / OPINION / METHODOLOGY ARTICLES**

We recommend authors to follow the "EQUATOR Network" for ample explanations and guidelines in the writing of such articles. Though these articles are moderated, they should be:

Short, focused, opinionated to previous articles or any subject related to the journal entirely.
Contemporary and focusing on specific issues.
Normally up to 800 words.

Frank critics to the journal are bravely motivated and would be as much as possible published.

**8. FORMATTING THE MANUSCRIPT**

Please note that articles which are not correctly formatted will be returned to the authors

**Format text**: Style: No Spacing, Single column, Single Spacing
Font: Single Spacing, Times New Roman - size 12
Titles: Capitals and bold, size 14
**Format tables:** Times New Roman, Font size 9
No vertical lines. Horizontal lines in the table can be removed. No table should be larger than a single A4 page. Footnote should be size 9 and italic

Rwanda
# Public Health Bulletin

## Publisher

Rwanda Health Communication Centre.

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## Acknowledgement

This publication of Rwanda Public Health Bulletin (RPHB) was made possible by financial support from the Bloomberg Philanthropies Data for Health Initiative through the CDC Foundation. Its contents are solely the responsibility of the authors and don't necessarily represent the official views of Bloomberg Philanthropies, the CDC Foundation or the U.S. Centers for Disease Control and Prevention.