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Optimizing Blood Bank Operations: A Centralized System for Enhanced Transfusion Services in Rwanda's Healthcare

(Case Study of Rwanda Biomedical Center (RBC))

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Abstract

This study presents a unified blood bank management system designed to improve the efficiency and reliability of blood distribution services in Rwanda, with a focus on the Rwanda Biomedical Center (RBC). The system addresses key challenges, including inconsistent blood supply, inefficient inventory management, and irregular blood donation campaigns. One of the system's key features is enabling voluntary blood donors, particularly those near district and referral hospitals, to donate regularly without relying on sporadic donation campaigns. The system makes it easier for donors to schedule appointments at their nearest hospital, eliminating the need for donors to wait for irregular blood donation campaigns or travel long distances. For individuals who may live or work far from donation sites, the system reduces barriers such as transportation costs, time constraints, and work-related permissions. With a presence in all 30 districts of Rwanda and four referral hospitals, the system allows each district to function as a user linked to its corresponding district hospital. The system provides real-time updates whenever blood is donated or used for transfusion, ensuring accurate tracking of blood availability. In case of shortages, the system facilitates inter-hospital blood transfer, ensuring that critical blood types are shared between hospitals as needed. Users can also request blood from other hospitals, and once a request is accepted, the system automatically triggers the blood transfer. Data analysis, conducted using SPSS, STATA, and R, demonstrates significant improvements in blood supply, transfusion safety, and operational efficiency. This unified system provides a scalable solution for optimizing blood management, benefiting Rwanda and other similar healthcare settings

I. INTRODUCTION

Blood transfusion services are crucial to healthcare systems worldwide, playing an essential role in saving lives during surgeries, accidents, childbirth, and treatment of chronic conditions. However, in many developing countries, including Rwanda, blood transfusion services face significant challenges. These challenges include an inconsistent blood supply, inefficient inventory management, and irregular donation campaigns, which hinder the ability of hospitals to meet patient needs. In Rwanda, these issues are compounded by logistical barriers such as transportation costs, time constraints for donors, and the challenges faced by individuals living or working far from blood donation sites. For many voluntary donors, especially those who have made donating blood a regular habit, the unpredictability of donation campaigns and the inconvenience of traveling long distances to donation sites have deterred them from contributing.

One of the major obstacles to improving blood donation in Rwanda has been the reliance on periodic donation campaigns. These campaigns are often irregular, with no set schedule, making it difficult for donors to plan their participation and for health institutions to maintain a steady supply of blood. Additionally, many donors face financial and logistical challenges when they need to travel to distant blood collection sites, further discouraging them from donating regularly. As a result, hospitals are often left with limited blood supplies, especially during emergencies, which can lead to delays in providing critical transfusion services.

To overcome these challenges, the Rwanda Biomedical Center (RBC) launched a **centralized blood bank system** that integrates all 30 districts and four referral hospitals across the country. The goal of this system is to ensure a more consistent, efficient, and equitable blood supply to meet the growing demand. By allowing voluntary donors to schedule their blood donations at their nearest district or referral hospital, the system ensures that donors can participate at their convenience, without the need to wait for irregular campaigns. This approach reduces the logistical burden of transportation, making it easier for individuals to donate blood closer to their homes or workplaces, thus lowering transportation costs and addressing time constraints.

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Moreover, the centralized blood bank system facilitates real-time tracking of blood availability across hospitals. Each time a donation is made or blood is used for transfusion, the system is updated, ensuring accurate and up-to-date information about blood inventory levels at participating hospitals. This feature allows for better planning and ensures that blood is always available where it is needed most. The system also addresses regional imbalances in blood supply by enabling inter-hospital blood transfers, ensuring that shortages at one hospital can be quickly addressed by supplying blood from other hospitals that have surplus supplies. This networked approach ensures that critical blood types are available at the right place and time, even during times of shortage or emergency.

While the centralized system has shown considerable promise in improving blood donation services, it also aligns with broader global efforts to enhance blood bank management in countries with similar logistical challenges. Studies conducted in other African countries have demonstrated the benefits of centralized blood management systems, including improvements in donor retention, better inventory control, and the efficient distribution of blood. In Rwanda, the RBC's approach aims to replicate these successes while addressing the unique challenges faced in the country.

The study evaluates the effectiveness of this centralized blood bank system, assessing its impact on blood supply management, transfusion safety, and overall healthcare efficiency in Rwanda. By streamlining the donation process, ensuring the timely availability of blood, and reducing logistical barriers, the system aims to enhance the effectiveness of blood transfusion services. Ultimately, the goal is to improve healthcare outcomes for Rwandans by providing a more reliable, equitable, and efficient blood supply, particularly in rural areas where access to blood and healthcare services is often limited. This study will contribute valuable insights into the functioning of the centralized system, offering potential lessons for other nations seeking to improve blood donation and transfusion services.

II. MATERIALS AND METHODS

This study evaluates the effectiveness of the centralized blood bank system developed and implemented by the Rwanda Biomedical Center (RBC) in improving blood donation and transfusion services across Rwanda. The methodology focuses on data collection, analysis, and evaluation of the performance of the blood donation network, including blood collection sites, total blood units collected, donor engagement strategies, and hospital satisfaction rates. The aim is to assess how well the RBC's centralized system addresses the growing need for blood, optimizes donor participation, and meets the demand of healthcare facilities.

A. Study Design

The study employed a quantitative research design, utilizing both descriptive and inferential analysis to assess the performance and impact of the centralized blood bank system. Data was collected for a full calendar year, 2023, to capture seasonal variations in blood donation trends and supply-demand gaps. The primary data points analyzed included the number of blood collection sites, the volume of blood collected, the number of blood donation sessions, and the satisfaction levels of both donors and healthcare facilities.

B. Participants/Subjects

➢ *The Main Participants in this Study were:*

- Voluntary Blood Donors: These individuals were the source of data on donation frequency, demographics (e.g., age, gender, and blood type), and experiences with the donation process. Data from voluntary donors across the 30 districts of Rwanda and 4 referral hospitals were included.
- Healthcare Facilities: These included 122 transfusing health facilities (district hospitals and referral hospitals) that requested blood throughout 2023. Data from hospitals on their blood demand, satisfaction with the RBC's blood supply, and transfusion safety were also analyzed.
- Blood Donor Representatives (BDRs): These community-level representatives were tasked with encouraging regular donation and providing feedback about donor engagement efforts. Their data, including numbers and activity reports, was included in the study.

C. Data Collection Methods

The data collection process involved gathering quantitative data from multiple sources, ensuring a comprehensive understanding of the performance of the blood transfusion system. The following methods were used:

- Blood Collection Sites Data: The RBC tracks and manages 589 blood collection sites across the country, including fixed sites (in hospitals and community health centers) and occasional sites (such as RDF Barracks, RNP communities, embassies, churches, and public spaces). Data on the number and location of blood collection sites were obtained from the RBC/BTD database, highlighting where blood donations occurred and any changes in the network over time. In 2023, 22 new sites were added, reflecting an expansion to meet growing blood supply demands.
- Blood Collection Sessions: The RBC's Annual Blood Collection Plan (ABCP) for 2023 set out targets for blood donation sessions, which were executed across the blood collection sites. The actual number of sessions performed was tracked and compared to the planned sessions, offering insight into the capacity and reach of the blood collection efforts. In 2023, the RBC exceeded its target, conducting 1,949 sessions, up from 1,686 in 2022. This data was gathered from the RBC's e-Progesa system and quality data indicators.
- Blood Units Collected: The total amount of blood collected was another key data point, as it directly reflects the RBC's capacity to meet demand. The RBC's goal in 2023 was to collect 84,009 blood units, with an actual collection of 86,812 units, surpassing expectations by 103.34%. This data was obtained from the RBC/BTD database, where all blood units collected at each blood collection site were recorded.
- Donor Demographics and Engagement: The study also collected data on the demographic characteristics of the blood donors, such as age, gender, and blood types. The data also examined donor retention, with a particular focus on donor behavior, such as regular participation in blood donation, and challenges faced by donors (e.g., accessibility, transport issues, and long waiting times). This was done through surveys conducted with donors, as well as through feedback from Blood Donor

Representatives (BDRs). BDRs help to recruit new donors and encourage regular donations in their communities, ensuring sustained donor engagement.

- Hospital Satisfaction and Blood Demand: Hospitals and transfusion facilities provided feedback on their satisfaction with the RBC's blood supply. This included data on the number of blood units requested, blood type matching, and hospital satisfaction levels. In 2023, the RBC supplied 99.47% of the blood requested by health facilities, highlighting a high level of satisfaction among hospitals, but also pointing out some areas of improvement for future optimization. This information was collected through direct feedback from healthcare facilities and hospital managers.

D. Instruments

- e-Progesa Database: The e-Progesa system is a comprehensive data management tool used by the RBC to track blood collection activities across the country. It was the primary instrument for collecting data on the number of blood collection sites, blood collection sessions, and the volume of blood units collected. It allows real-time monitoring of blood availability, donor engagement, and system performance.
- Surveys and Feedback Mechanisms: Surveys were distributed to healthcare facilities and blood donors to gather qualitative feedback on the blood donation process. For healthcare facilities, the surveys focused on blood supply reliability, blood type availability, and satisfaction with the RBC's response times. Donors were asked to provide feedback on their experiences with blood donation sessions, wait times, accessibility, and their overall satisfaction with the process.
- Blood Donor Representatives (BDRs): Data from the network of 1,648 BDRs were collected, providing insights into community-level efforts to increase blood donations, challenges faced by donors, and strategies to improve blood collection. BDRs were responsible for outreach, education, and donor engagement at the local level.

E. Data Analysis

The collected data were analyzed using SPSS, STATA, and R statistical software. Descriptive statistics were employed to summarize the data (e.g., frequency counts, percentages, and performance rates). The following analyses were performed:

- Performance Analysis: The actual number of blood collection sessions and units collected in 2023 were compared to the targets set in the Annual Blood Collection Plan (ABCP). Performance rates were calculated for blood collection sessions and the volume of blood units collected.
- Satisfaction Analysis: The satisfaction rate of hospitals with blood supply was analyzed using the feedback from healthcare facilities. This was done by comparing the blood units requested with the units supplied and assessing the degree of satisfaction reported by hospitals.
- Demographic Analysis: Donor demographics were analyzed to identify patterns in donor participation based on age, gender, and blood type. This helped understand the demographic reach of the RBC's blood donation campaigns and identify underrepresented groups.

F. Ethical Considerations

The study was conducted in accordance with ethical guidelines for research involving human participants. Ethical approval was obtained from the relevant research committees. All participants (blood donors and healthcare facilities) were informed about the purpose of the study, and their consent was obtained for data collection. Personal identifiers were kept confidential, and data were anonymized where necessary to protect privacy.

G. Limitations

This study faced some limitations, including potential reporting biases from blood collection sites and healthcare facilities. While the RBC strives to ensure complete and accurate data reporting, gaps may exist, particularly in the recording of donor experiences. Additionally, the availability of blood units may vary depending on the region and time of year, which could influence data consistency.

III. CONCEPTUAL FRAMEWORK

This conceptual framework illustrates the relationship between the Centralized Blood Bank System (Independent Variable) and the Quality of Service Delivered (Dependent Variable). The underlying assumption is that the centralized blood bank system, which is designed to enhance the management of blood donation, collection, and distribution nationwide, directly influences the quality of blood transfusion services provided in healthcare settings. By optimizing blood availability, ensuring timely delivery, and improving operational efficiency, the system is expected to significantly improve healthcare outcomes, hospital satisfaction, and the safety of transfusion practices.

➢ *Independent Variable:*

Centralize blood bank system for efficient for transfusion services in health care setting

➢ *Dependent Variable:*

Variable

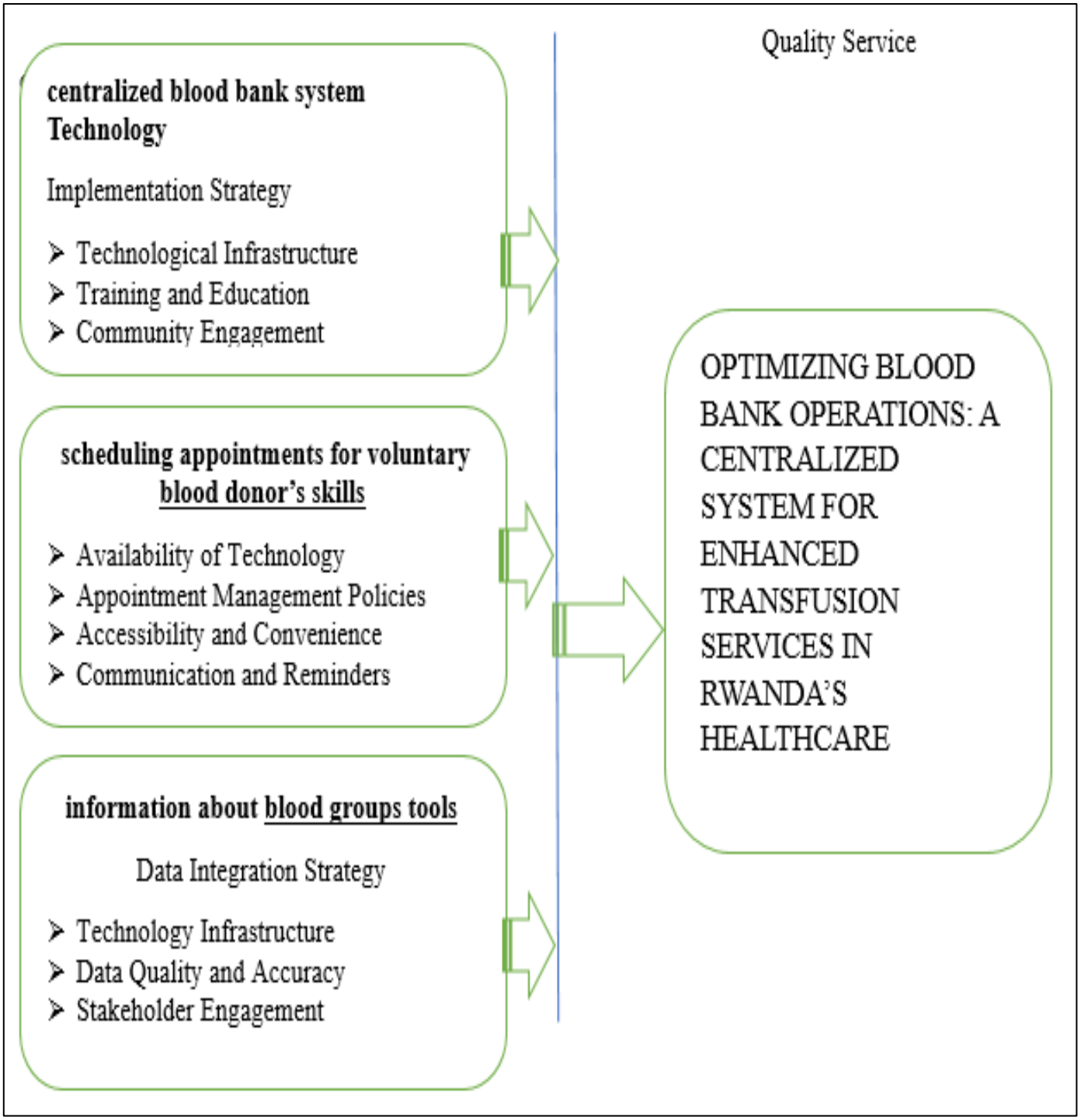

Fig 1: Conceptual Framework

IV. DATA PRESENTATION, ANALYSIS AND INTERPRETATION OF FINDINGS

The data gives useful information about how blood donation is working in Rwanda. It shows the growth of blood collection centers, donation sessions, and the amount of blood collected from 2022 to 2023. This highlights the efforts of the Rwanda Biomedical Centre (RBC) to meet the growing need for blood. The data also shows important details about donors, like their gender, age, and blood types, which helps create better strategies to include everyone. It also shares donor experiences, such as problems with wait times and centralization, which can help improve the donation process. Overall, the data is important for understanding what works well and where improvements are needed in Rwanda's blood transfusion system. Today, blood transfusions are free for all patients, and blood is donated voluntarily by unpaid donors across the country."

In 2023, the Rwanda Biomedical Center (RBC), through its Blood Transfusion Division (BTD), gathered 86,812 units of blood from 589 donation centers. Health facilities in need of transfusions requested 122,628 blood units, and the BTD was able to provide 121,974 units, achieving a hospital satisfaction rate of 99.47%. RBC aims to meet all blood demands at 100% by 2025.

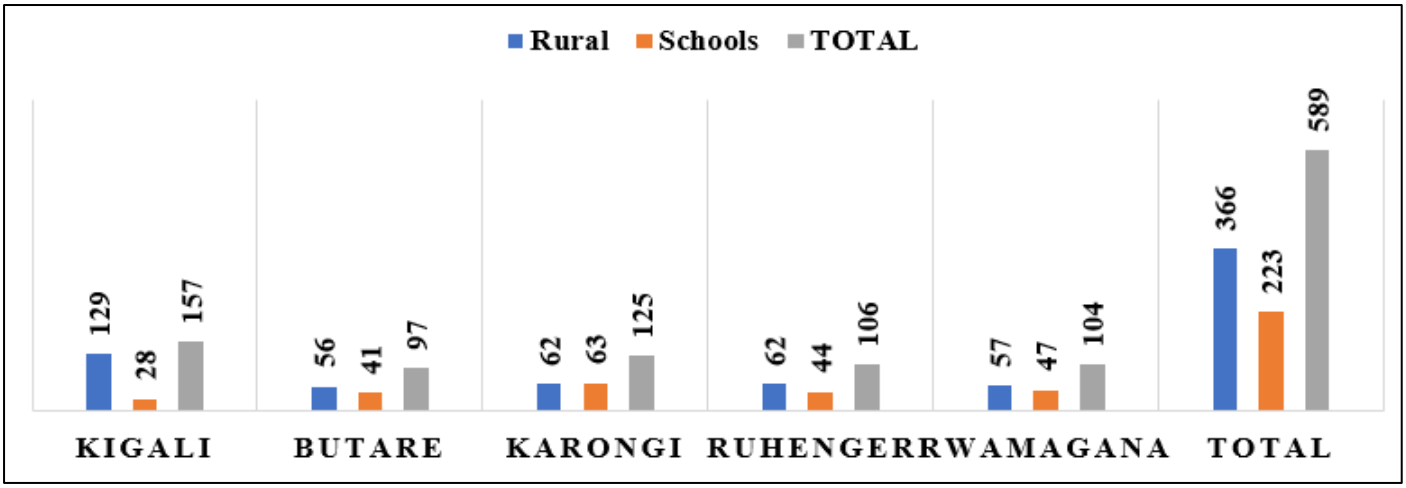

Fig 2: Blood collection sites in 2023
Source: 2023 e-Progesa and Quality Data Indicators for RBC/BTD showing the participation of rural area and schools in general.

In 2023, the Blood Transfusion Division (BTD) collected blood from 589 rural and school-based donation centers nationwide, as well as five (5) fixed sites within each RCBT catchment area. In addition to these, there were several temporary donation sites, including those at RDF barracks, RNP communities, embassies, churches, and public places.

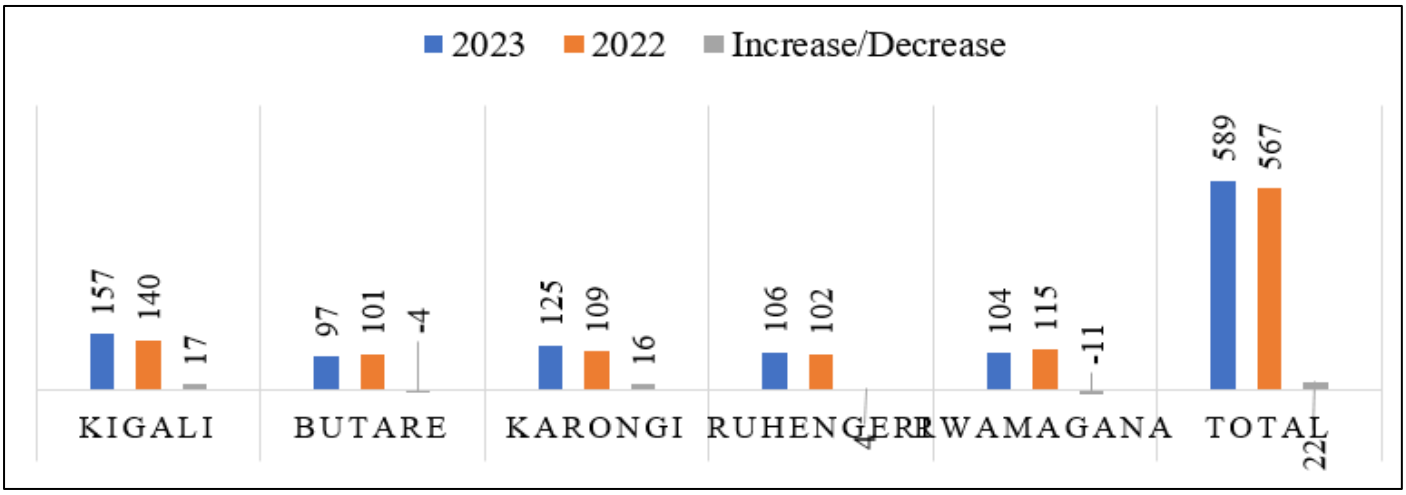

Fig 3: Blood Collection Sites - 2023 vs 2022
Source: 2023 RBC/BTD e-Progesa Database and Quality Data Metrics

Each year, Regional Centers for Blood Transfusion (RCBTs) evaluate and opt to shutter specific blood collection sites based on past performance. Simultaneously, they establish new sites to meet the escalating demand from Transfusing Health Facilities (THFs). In 2023, contrary to the usual practice, no blood collection site was closed; instead, **22 new sites** were added. Consequently, the total number of blood collection sites in 2023 increased **to 589 from the 567 sites** that the Blood Transfusion Department (BTD) had in 2022.

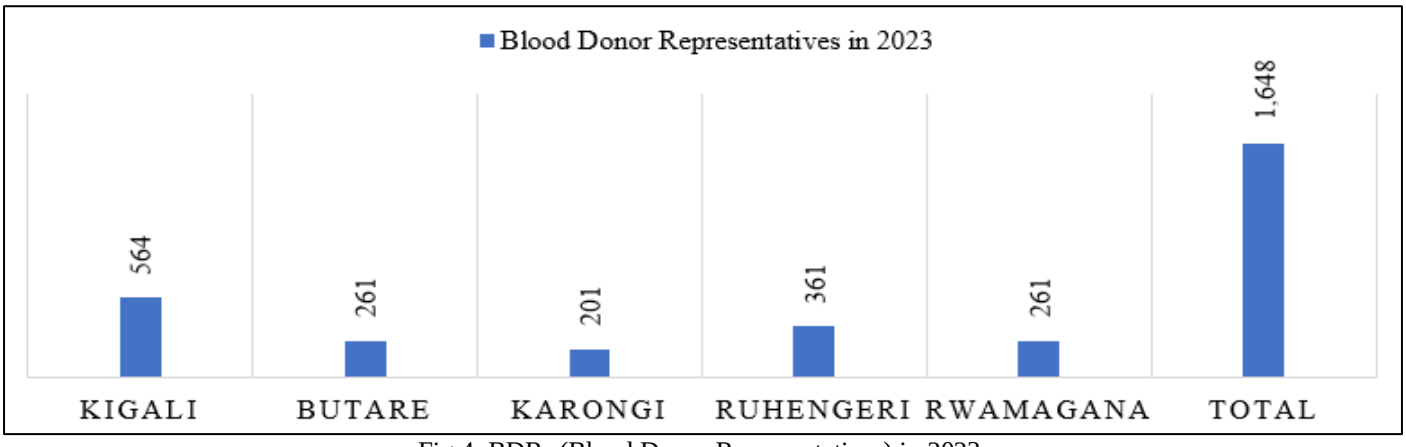

Fig 4: BDRs (Blood Donor Representatives) in 2023
Source: RBC/BTD e-Progesa Database and Quality Performance Metrics, 2023

Blood Donor Representatives (BDRs) are small teams, generally composed of 3 to 5 individuals, who serve as intermediaries for blood donors in their local communities. They play a vital role in identifying potential donors and encouraging continued participation in blood donations. BDRs work in close collaboration with BTD staff to organize and facilitate donation drives on scheduled dates. Following blood donations, BDRs follow up with donors, while BTD staff focus on other responsibilities. In essence, BDRs act as a communication bridge between the BTD and the donor population. By 2023, there were 1,648 BDRs operating nationwide.

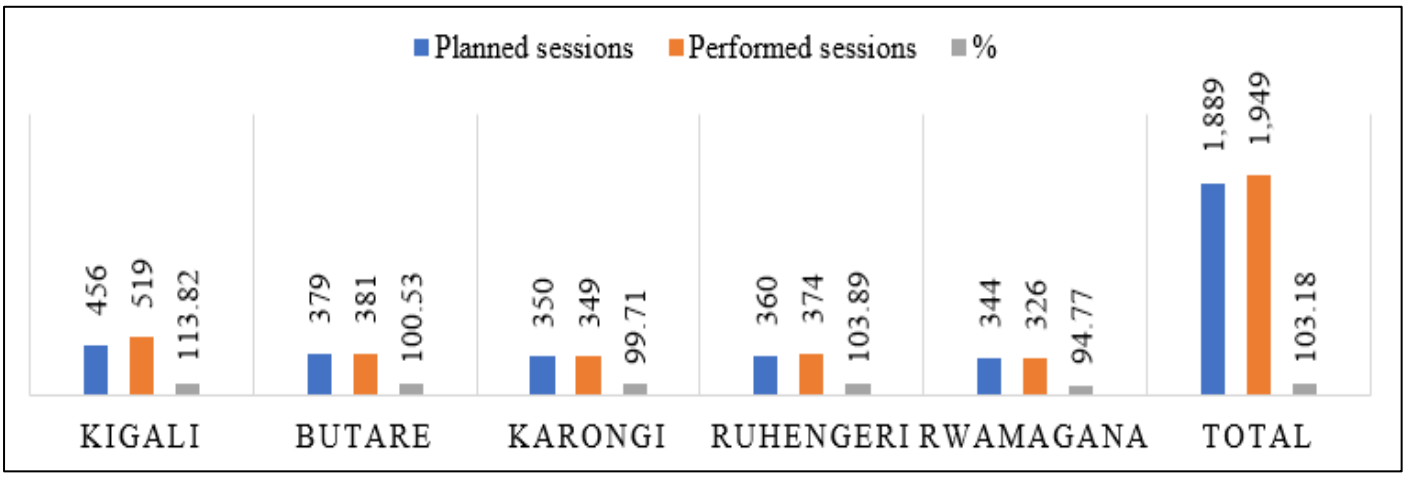

Fig 5: Blood Collection Sessions – 2023
Source: 2023 RBC/BTD e-Progesa Database and Performance Quality Indicators, the Performance is Low But is almost to Planned Sessions

The 2023 Annual Blood Collection Plan (ABCP) set a target of 1,889 blood collection sessions for RCBTs. By year-end, a total of 1,949 sessions were conducted, achieving a performance rate of 103.18%.

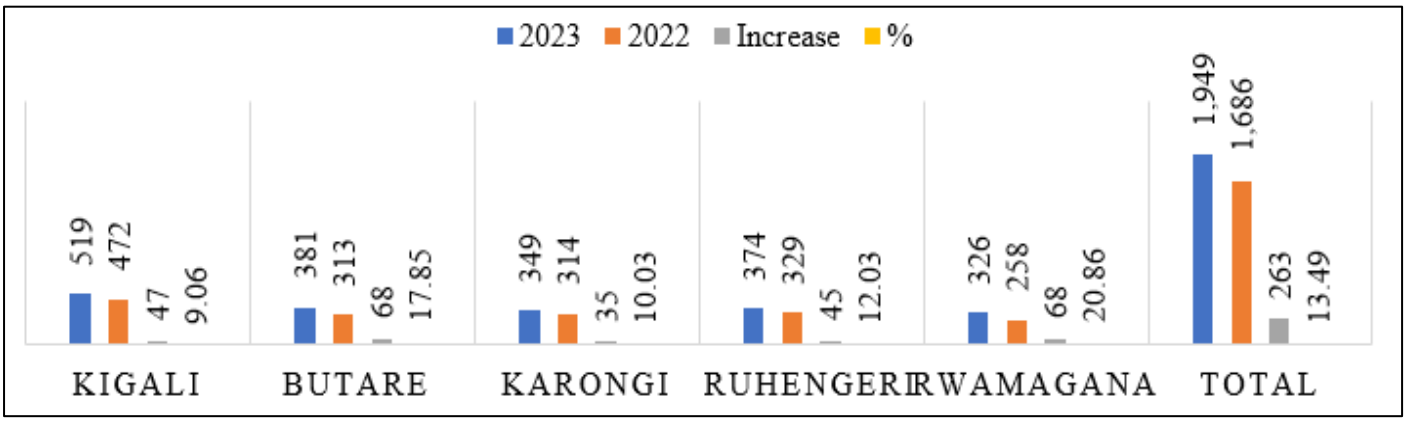

Fig 6: Blood Collection Sessions: 2023 Compared to 2022
Source: 2023 Data from RBC/BTD e-Progesa Database and Quality Indicators, there is no Increase

In 2023, a total of 1,949 blood collection sessions were conducted, compared to 1,686 sessions in 2022. This represents an increase of 263 sessions, reflecting a growth of 13.49%.Blood units in 2023.

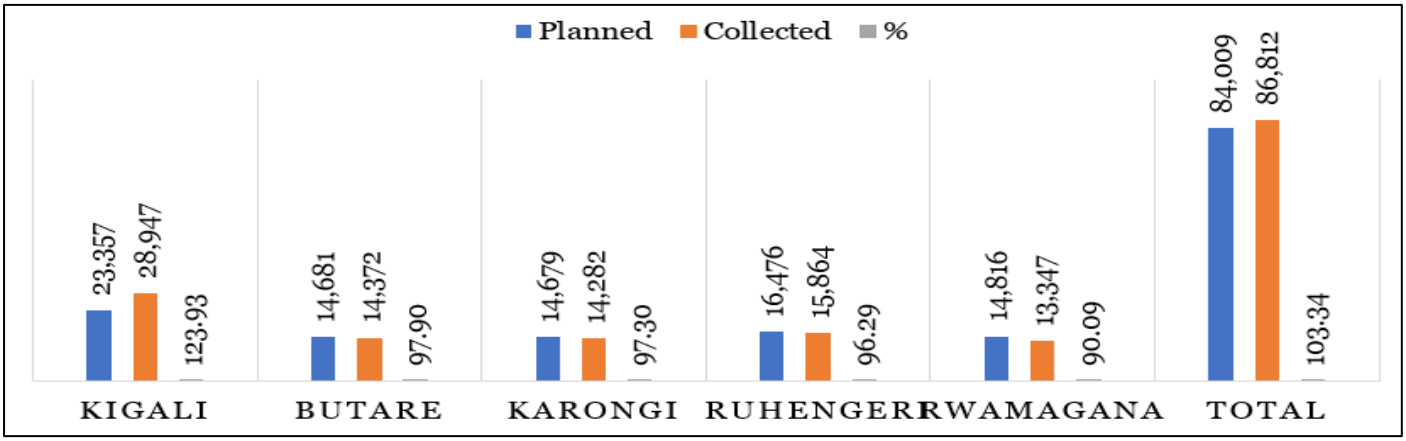

Fig 7: Progesa Database and Performance Quality Indicators
Source: 2023 RBC/BTD e-Progesa Database and Performance Quality Indicators Specifies that Kigali has Big Numbers Compered to another Locations

According to the 2023 Annual Blood Collection Plan (ABCP), RCBTs aimed to collect 84,009 blood units. By the end of the year, they had collected 86,812 units, achieving a performance rate of 103.34%.4.7. Collected blood units - 2023 vs 2022

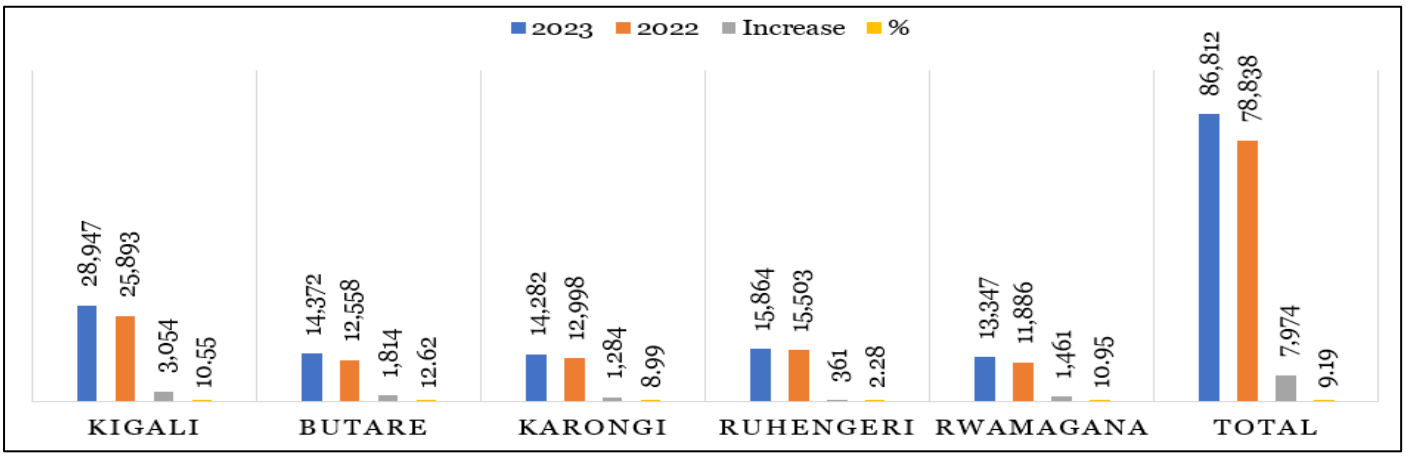

Fig 8: Collected Blood Units - 2023 vs 2022
Source: 2023 Data from RBC/BTD e-Progesa Database and Quality Performance Indicators that is Showing Kigali as High Increase

In 2023, RCBTs collected 86,812 blood units, compared to 78,838 units in 2022. This represents an increase of 7,974 units

V. CONCLUSION

The study concludes that the centralized blood bank system implemented by the Rwanda Biomedical Center (RBC) has successfully addressed challenges in blood transfusion services, such as inconsistent supply and inefficient inventory management. By enabling voluntary donors to schedule appointments and facilitating real-time tracking of blood availability, the system has improved accessibility and hospital satisfaction. In 2023, the RBC met 99.47% of hospital blood demands, with a goal of 100% by 2025. The system's scalability offers a promising model for other countries, and future efforts should focus on expanding the donor base and overcoming logistical barriers.

RECOMMENDATION

- **Research on Blood Donor Retention**: Future research should focus on strategies for improving donor retention, especially addressing factors that discourage repeat donation. This includes studying donor motivations, challenges, and satisfaction levels, and using this data to fine-tune the blood donation process.
- **International Collaboration and Best Practices**: Rwanda can benefit from collaborating with other countries that have similar blood bank systems in place. Sharing best practices and innovations could help refine the existing system and enhance its scalability, especially in other African countries facing similar challenges.
- **Implement Data-Driven Decision Making**: The current system's real-time tracking and data updates are valuable. It is recommended to further develop data analytics tools that can predict blood demand trends and optimize blood distribution, ensuring more accurate matching between supply and hospital needs.
- **Enhance Public Awareness Campaigns**: While the system has improved voluntary blood donation, continuous efforts should be made to raise public awareness about the importance of regular blood donation. National campaigns, especially targeting schools, workplaces, and communities, can help attract more donors and reduce the reliance on occasional donation drives.

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