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# Cardiac Rehabilitation in Young Patients: Experience of the Mohamed V Military Teaching Hospital (Based on 58 Patients)

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**ABSTRACT:**

Cardiovascular diseases (CVDs) are the leading cause of mortality worldwide and in Morocco, despite significant advancements in emergency therapeutic strategies. Cardiac rehabilitation (CR) has emerged as a key intervention to optimize secondary prevention, reduce morbidity and mortality, and improve patients' quality of life.

**Objective:**
This study aims to evaluate the impact of the cardiac rehabilitation program at the cardiology center of the Mohammed V Military Teaching Hospital in Rabat, Morocco, on the quality of life and functional capacities of young patients with various cardiac conditions.

**Methods:**
A prospective cohort study was conducted at the cardiac rehabilitation unit of the Mohammed V Military Teaching Hospital from October 2017 to 2023. A total of 58 young adult patients with diverse cardiac conditions, whether post-surgical or non-surgical, were enrolled. Patients underwent a comprehensive clinical evaluation, including electrocardiography (ECG), transthoracic echocardiography (TTE), biochemical analysis, a six-minute walk test (6MWT), and cardiopulmonary exercise testing (CPET) with VO2 max measurements. The CR program consisted of three progressive phases: hospital-based, outpatient, and maintenance.

**Results:**
The program demonstrated significant improvements in patients' functional and cardiorespiratory capacities, as well as enhanced quality of life. The multidisciplinary approach, including physical reconditioning, therapeutic education, and optimization of medical management, contributed to these outcomes.

**Conclusion:**
Cardiac rehabilitation effectively enhances functional capacity and quality of life in young patients with cardiovascular diseases. It underscores the importance of multidisciplinary care in managing chronic cardiovascular conditions.

**Keywords:** cardiac rehabilitation**,** cardiopulmonary exercise testing, VO2 max, six-minute walk test, Therapeutic education

**Consent: The authors confirm that written consent for the submission and publication of this case,**

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**Conflict of interest: None declared.**

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**Consent:** The authors confirm that written consent for the submission and publication of this case, including images, has been obtained from the patients in line with the Committee on Publication Ethics (COPE) guidance.

**Availability of Data and Materials:** Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

**Conflict of interest:** None declared.

**Funding:** None declared.

**Figure Legend:**

- **A.** The cardiac rehabilitation (CR) program at the Mohammed V Military Teaching Hospital (HMIMV)
- **B.** Representation of the Distribution of Cardiovascular Risk Factors (CVRFs)
- **C.** Representation of Load, $VO_2$ Max, and Exercise Heart Rate (EHR) before and after CR.
- **D.** Representation of Distance Covered During the 6MWT before and after CR.

## Introduction

Cardiovascular diseases (CVDs) remain the leading cause of mortality globally and nationally, despite advancements in emergency therapeutic strategies. Significant strides have been made in secondary prevention through enhanced control of cardiovascular risk factors, the development of novel pharmacological treatments, and improved patient education programs.

Cardiac rehabilitation (CR) has emerged as a cornerstone intervention in this context. The World Health Organization (WHO) defined CR in 1993 as "a comprehensive set of coordinated activities required to influence favorably the underlying cause of the disease, as well as to ensure the patient achieves optimal physical, mental, and social functioning, enabling them to resume and maintain their place in society through their own efforts" [1].

The primary objective of CR is to facilitate optimal adaptation of patients to their cardiovascular condition, empowering them as active participants in the management and optimization of their health [2].

CR is founded on three essential components:

- **Physical reconditioning**: Including supervised exercise programs and training in long-term physical maintenance activities.
- **Therapeutic education**: Aimed at enhancing patient understanding and self-management of their condition.
- **Therapeutic optimization**: Tailoring and maximizing medical therapy for improved outcomes.

CR is implemented in three progressive phases: an inpatient (hospital-based) phase, an outpatient (ambulatory) phase, and a maintenance phase focused on long-term adherence and lifestyle integration.

CR is indicated in various cardiovascular pathologies, with the most frequent being ischemic heart disease, heart failure, and post-cardiac surgery recovery. It aims to promote healthy behaviors, foster active lifestyles, and educate patients about their disease to reduce cardiovascular risk factors, lower morbidity and mortality rates, and improve overall quality of life.

The evaluation of CR outcomes is based on the patient's self-assessment of their disease and treatment's impact on their well-being, often measured through validated questionnaires. This has become a standard approach in the management of chronic diseases.

This study aims to assess the impact of the cardiac rehabilitation program at the cardiology center of the Mohammed V Military Teaching Hospital on the quality of life of young patients and to evaluate the progression of their functional capacities at the end of the program.

## Materials and Methods

The study was conducted within the cardiac rehabilitation unit of the cardiology center at the Mohammed V Military Teaching Hospital (HMIMV), located in Rabat, the capital city of Morocco.

This is a prospective cohort study involving 58 young adult patients admitted to the cardiac rehabilitation unit at HMIMV.

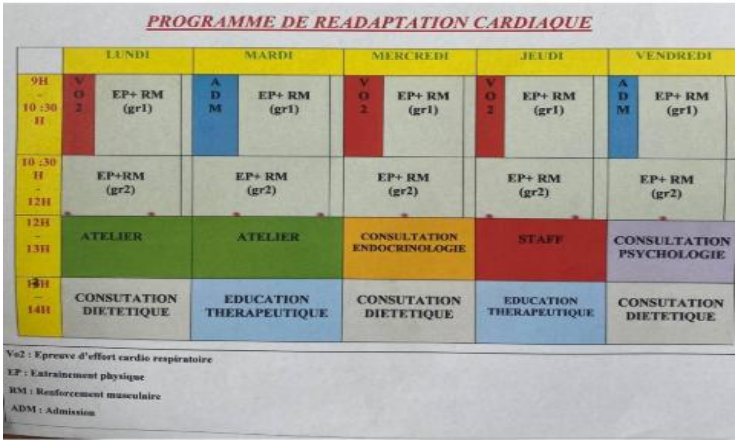
The study population consists of 58 young patients admitted to the CR unit between October 2017 and 2023, covering a duration of approximately six years.

The objective of this research is to evaluate the efficacy of cardiac rehabilitation in enhancing the functional and cardiorespiratory capacities of young patients with diverse cardiac conditions, whether post-surgical or non-surgical.

Patients underwent comprehensive clinical evaluations, including electrocardiography (ECG), transthoracic echocardiography (TTE), biochemical analysis, a six-minute walk test (6MWT), and cardiopulmonary exercise testing (CPET) with VO2 max measurement.

The cardiac rehabilitation unit is integrated within the cardiology center at HMIMV. The facility includes a dedicated stress testing room, a gymnasium for exercise sessions, and a room equipped with ergometers and treadmills, all under continuous professional supervision.

The multidisciplinary team comprises a cardiologist, a psychologist, three physiotherapists, a dietitian, nursing staff, a pulmonologist, and an endocrinologist.
The pulmonologist conducts awareness sessions on smoking-related risks, while the endocrinologist focuses on diabetes management. The program structure is detailed in the attached figure.




**A. <u>Figure A: The cardiac rehabilitation (CR) program at the Mohammed V Military Teaching Hospital (HMIMV)</u>**

The initial assessment encompasses the following components:

1. **Clinical Evaluation**:
   - **Patient History**: Detailed collection of the patient's clinical history, including past medical and familial conditions.
   - **Comprehensive Physical Examination**: Systematic evaluation of the patient's general health status.
2. **Paraclinical Investigations**:
   - **Electrocardiogram (ECG)**: Identification of abnormalities such as atrial fibrillation (AF), ventricular hypertrophy, and conduction disturbances.
   - **Laboratory Testing**: Blood tests to assess metabolic profiles, identify risk factors, and detect any underlying conditions.
   - **Transthoracic Echocardiography (TTE)**: Evaluation of left ventricular function, presence of ventricular dilation, and pericardial effusion.
   - **6-Minute Walk Test**: Assessment of functional capacity pre- and post-cardiac rehabilitation (CR) to determine the distance covered.
   - **Cardiopulmonary Exercise Test (CPET) with VO2 Max**: Quantification of maximal aerobic capacity (VO2 max), workload (in Watts), and heart rate during exertion, both before and after CR.

## Results

1. **Patient Demographics**:
   - **Age**: The mean age of the patient cohort was 36.5 years, with a standard deviation of 13.5 years.
   - **Gender Distribution**: There was a significant male predominance, with 51 males (87.9%) and 7 females (12.1%).

2. **Etiological Factors**:
   - **Ischemic Heart Disease**: The predominant etiology in 65.5% of patients, including both ST-segment elevation myocardial infarction (STEMI), non-ST-segment elevation myocardial infarction (NSTEMI), and chronic coronary syndrome (CCS).
   - **Valve Pathology**: 22.4% of patients had undergone at least one valve replacement.
   - **Dilated Cardiomyopathy (DCM)**: Three patients were diagnosed with DCM, presenting with severe left ventricular dysfunction.
   - **Aortic Dissection**: One patient had undergone surgical intervention for aortic dissection.

These findings provide a comprehensive overview of the patient demographics and the diverse etiologies of cardiovascular diseases observed in the study population.

| **<u>Chronic coronary syndrome</u>** | **14** |
|---|---|
| - Medical treatment | 8 |

| | |
|---|---|
| - Angioplasty | 4 |
| - Bypass surgery | 2 |
| **NSTEMI** | **7** |
| - Medical treatment | 4 |
| - Angioplasty | 3 |
| - Bypass surgery | - |
| **SCA ST+** | **17** |
| - Medical treatment | 2 |
| - Angioplasty | 15 |
| - Bypass surgery | - |
| **DCM** | **3** |
| **Post-COVID Myocarditis** | **2** |
| **Cardiac surgery** | **17** |
| - Valve Replacement | 10 |
| - Double Valve Replacement | 2 |
| - CABG | 2 |
| - Aortic Dissection | 1 |
| - Chronic Constrictive Pericarditis | 1 |
| - EI | 1 |

**C. Cardiovascular Risk Factors**:

- **Smoking**: Smoking was the predominant cardiovascular risk factor in the studied population, with 65% of patients being smokers.
- **Hypertension (HTA)**: The second most common risk factor, present in 38% of patients.
- **Dyslipidemia**: A significant risk factor in 27% of the cohort.
- **Diabetes**: 25% of patients were diabetic.
- **Obesity**: Obesity was noted in 12% of the patients.

The **mean body mass index (BMI)** was 26.2 ± 9.9 kg/m², indicating a tendency towards overweight or obesity within the population.

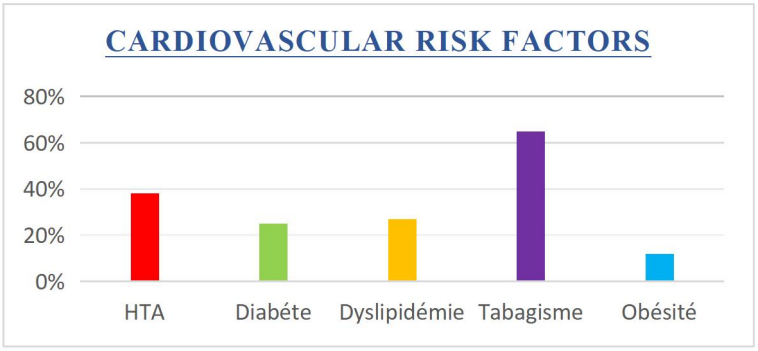



**Figure B: Representation of the Distribution of Cardiovascular Risk Factors (CVRFs)**

**D. Clinical Data**

The general examination revealed an average body weight of 74.5 kg ± 29.5, an average height of 1.66 m ± 0.2, and a mean body mass index (BMI) of 26.2 kg/m² ± 9.9 kg/m².

The remaining clinical parameters, including **blood pressure (BP)**, **heart rate (HR)**, **respiratory rate (RR)**, as well as the **cardiovascular examination** (auscultation of heart sounds, assessment for signs of right heart failure, palpation and auscultation of large vascular axes), were within normal limits for the studied cohort. Additionally, the **sternotomy scar** in post-operative patients was generally observed to be clean and well-healed.

**E. Complementary Examinations**

ECG findings showed that 16.6% of patients exhibited **atrial fibrillation (AF)**, 15% had **conduction abnormalities**, and 10% displayed **ventricular hypertrophy**.

The chest radiographs showed an average **cardiothoracic ratio** of approximately 0.57, with the **pulmonary parenchyma** demonstrating adequate transparency, indicating no significant pulmonary congestion or pathology.

TTE revealed that 5% of patients had **left ventricular dilation**. The **left ventricular ejection fraction (LVEF)** had a mean value of 42.5% ± 27.5%.

- Three patients had a **severely reduced LVEF** ranging from 15% to 30%, associated with significant **left ventricular dilation**.
- Ten patients showed a **moderately reduced LVEF**.
- A majority, 75.86%, had a **preserved LVEF**.

The pericardium was typically dry, with a **pericardial effusion** present in only 10% of cases.

The **workload (in Watts)** demonstrated a progressive increase over successive sessions.

- The average workload before cardiac rehabilitation (CR) was 95 ± 55 W, which increased to 110 ± 50 W post-rehabilitation.

The **maximal oxygen consumption (VO2 max, in ml/kg/min)** improved from 17.85 ± 11.25 to 19.6 ± 12.3 between the baseline and the end of the CR program.

**Resting heart rate (HR)** decreased significantly, from an average of 76.5 ± 25.5 bpm before CR to 68 ± 22 bpm following the program.

Finally, **exercise heart rate (bpm)** also showed a reduction, with the average heart rate during exercise decreasing from 119 ± 37 bpm prior to CR to 115 ± 45 bpm after completing the CR program.

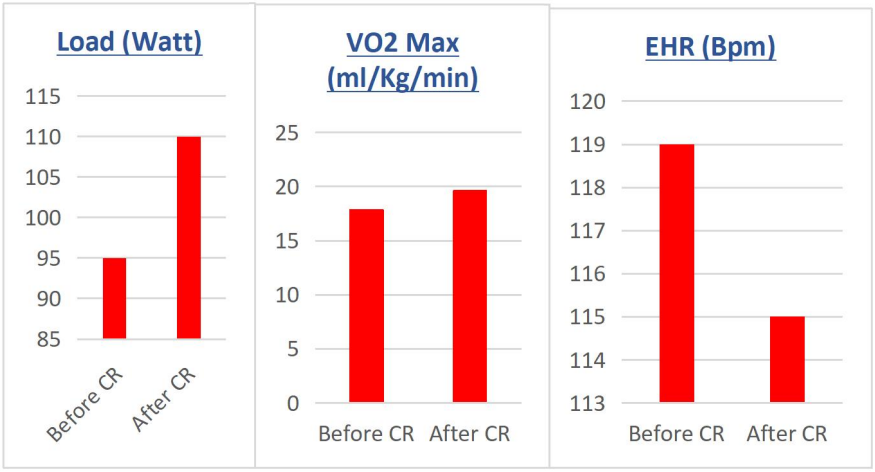



**Figure C: Representation of Load, $VO_2$ Max, and HER before and after CR.**

The distance covered during the six-minute walk test was measured both before and after the cardiac rehabilitation (CR) program. The results were as follows:

- The **average distance** covered before the start of the CR program was **458.5 meters** (m), with a range between **273 m** and **644 m**.
- After completing the CR program, the **average distance** increased to **568 meters** (m), with a range between **351 m** and **785 m**.

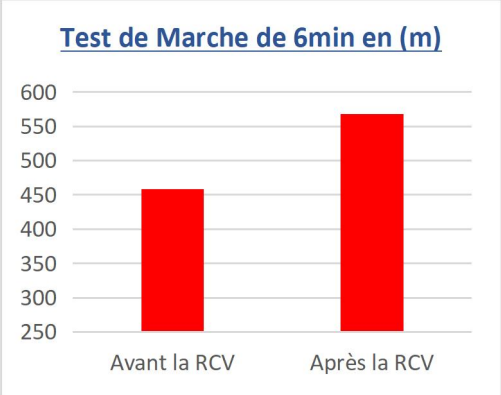



**Figure D: Representation of Distance Covered During the 6MWT before and after CR.**

## DISCUSSION

### A. Patient Characteristics

Data on cardiac rehabilitation in young individuals, in particular, remains limited, resulting in their rehabilitation protocols often being aligned with those of heart failure patients across all age groups. In our study, the mean age of patients was 36.5 years ± 13.5, with a clear male predominance, which is consistent with studies such as the German study by Lesniak et al. [3], involving 1586 patients, all under 65 years of age, predominantly male (77%). The Portuguese study by Rosa et al. [4] examined 129 patients, with a mean age of 56 years, and 89% men, following an acute coronary syndrome. Similarly, Popovic et al. [5] reported on the improvements in cardiorespiratory exercise parameters following a rehabilitation program for 142 coronary patients (77% male) with a mean age of 63 years. Our study shows a younger mean age than the Algerian study, which reported a mean of 61 years, with extremes ranging from 45 to 76 years [6], and also lower than the study by Gotzmann et al., with an average age of 78.6 ± 6.6 years [7-8]. These findings further suggest that male sex is a cardiovascular risk factor, which may be attributed to the protective effects of estrogen before menopause [9]. Moreover, women are less likely to complete cardiac rehabilitation programs due to multiple social constraints [10].

### B. Etiology

In our study, 65.5% of the etiologies were dominated by ischemic heart disease, a figure consistent with the proportion of patients admitted for coronary syndrome in the German study by Lesniak et al. (66%) [3]. Additionally, 29.3% of our patients had undergone cardiac surgery prior to rehabilitation, 37.9% had undergone angioplasty, and 24.3% had received medical treatment alone. Notably, 22.4% of the patients in our study had undergone single or double valve replacement, with 8.33% of those having undergone poly-valvular surgery (including replacement of the mitral, aortic, and tricuspid valves), which is lower than the 20% observed in Europe [11].

### C. Cardiovascular Risk Factors

The most frequent cardiovascular risk factors vary across studies. In our study, smoking was the leading risk factor, found in 65% of patients, followed by hypertension (HTA), diabetes, dyslipidemia, and obesity. In contrast, the German study by Lesniak et al. [3] ranked hypertension first, followed by dyslipidemia, smoking, and then diabetes. A European study showed that 53% of patients had at least two cardiovascular risk factors [12].

- **Smoking**: Smoking is the primary risk factor in our population, justifying the focus on smoking cessation as part of the therapeutic education. This high prevalence is also influenced by the youthful and predominantly military nature of the cohort. Furthermore, smoking history is associated with an increased likelihood of referral to cardiac rehabilitation, and it is also a significant predictor of non-adherence to the rehabilitation program [13].
- **Hypertension**: Present in 38% of our patients, hypertension is the leading cardiovascular risk factor in several recent African and European studies [14-15]. It is well-established that training 3 to 7 times per week is associated with a reduction in blood pressure [95]. Current guidelines recommend moderate-intensity exercise lasting at least 30 minutes, although meta-analyses do not always demonstrate a clear relationship between exercise intensity and blood pressure reduction [16]. As with antihypertensive medications, exercise standards may not be universally applicable, highlighting the need for individualization in rehabilitation programs.
- **Dyslipidemia**: Present in 28% of our patients, dyslipidemia is a major risk factor for ischemic heart disease. A study conducted in Senegal found a prevalence of 41.5%, compared to 35.2% in the CORONAFRIC 1 study. The difference may be attributed to variations in diet across countries. However, the beneficial effect of physical exercise on improving lipid profiles, particularly increasing HDL cholesterol and reducing triglycerides, is well-established [16]. This improvement is observed with moderate-intensity aerobic exercise, and higher-intensity exercise does not show superior efficacy.
- **Diabetes**: Present in 25% of our patients, compared to 18% in a European study [12], diabetes increases surgical and post-operative risks. Diabetic patients experience more complications than non-diabetic patients, including infections, heart failure, and delayed wound healing [17].

Studies show that regular physical activity is associated with improved insulin sensitivity and better glucose control, particularly with resistance or aerobic training, and even better results when combining both forms of exercise [16].

**D. Complementary Examinations**

- **ECG**: In general, our study found that patients entering cardiac rehabilitation did not exhibit significant rhythm disturbances, with the exception of a few cases: 16.6% had atrial fibrillation (AF), 15% had conduction disturbances, and 10% had left ventricular hypertrophy. This is similar to an Italian study where no significant ECG alterations were observed except in 22% of patients, who had ventricular ectopy. A European study found that 26% of patients had AF [18]. Cardiac arrhythmias, particularly AF, can affect a patient's work and self-sufficiency capacity [19]. The presence of rhythm disturbances is predictive of complications [18].
- **Echocardiography**: Echocardiographic data showed left ventricular dilation in 5% of cases, with a generally dry pericardium, except in 10% of cases. The presence of pericardial effusion necessitates regular re-evaluation until it resolves. The mean left ventricular ejection fraction (LVEF) was 42.5% ± 27.5%. A French study reported a mean LVEF of 53% ± 10%, and another European study showed that 82% of patients had an LVEF greater than 50% [12]. LVEF is a crucial factor to consider before designing an exercise program.
- **Cardiorespiratory Exercise Testing**: Our study found a significant improvement in VO2 max after the cardiac rehabilitation program, with a 1.75 ± 2 ml/min/m² increase. Similar improvements were observed in the studies by Popovic et al. [5] (from 17.7 to 20.9 ml/min/m²) and Rosa et al. [4]. A significant improvement in maximum workload was also observed, with a gain of 15 watts (from 95 ± 55 W to 110 ± 50 W), similar to the results of the Lesniak et al. study [3], although their maximum workloads were higher (111 to 130 watts). Regarding the training heart rate, it decreased from 119 bpm before the rehabilitation to 115 bpm after rehabilitation, showing a 3.47% improvement. There was a non-significant decrease in resting heart rate (from 76.5 ± 25.5 bpm to 68 ± 22 bpm), similar to the study by Popovic et al. [5] (from 74 to 70 bpm). These improvements in all parameters resulted in better aerobic capacity for the patients, which is associated with improved survival and prognosis, regardless of age. Furthermore, even modest improvements in VO2 max in chronic heart failure patients are linked to better prognosis.

In our study, the six-minute walk test showed a significant improvement in functional capacity, with the average distance covered increasing from 458.5 ± 185.5 meters before the rehabilitation program to 568 ± 217 meters afterward, an increase of 109 ± 31.5 meters.

An Italian study of 1370 patients reported an average distance of 304 ± 89 meters at the beginning of the program. In a subset of 348 patients who repeated the test after cardiac rehabilitation, the average distance covered was 281 ± 90 meters before the program and 411 ± 107 meters afterward [12]. The study by Lesniak reported similar results, with the walk distance increasing from 453 ± 90 meters to 526.9 ± 91.8 meters [20]. The walk distance is an important prognostic indicator in chronic heart failure patients, those with ventricular assist devices, and even stable coronary patients without left ventricular dysfunction.

## CONCLUSION

Cardiac rehabilitation is a relatively new concept in Morocco, with the rehabilitation service at the Mohamed V Military Instruction Hospital's Cardiology Center being the first of its kind in the country. It forms part of the therapeutic arsenal for various heart diseases, especially ischemic heart disease, heart failure, and post-cardiac surgery. Cardiac rehabilitation is a crucial secondary prevention tool, allowing for holistic and multidisciplinary management as emphasized in clinical guidelines [22]. It enables therapeutic optimization and education, as well as supervised physical training resumption.

Our study demonstrated the effectiveness of the cardiac rehabilitation program offered at the Cardiology Center of the Mohamed V Military Instruction Hospital in Rabat for young patients with heart disease. The program significantly improved the quality of life and functional capacity of the participants, leading to notable improvements in their prognosis. Other studies also highlight the program's benefit in reducing healthcare costs, regardless of the patient's social status or underlying heart condition.

However, a considerable portion of the population does not have access to this program due to various reasons, including lack of engagement, unawareness of the benefits of cardiac rehabilitation, logistical issues, and physical comorbidities. Financial barriers are also a significant predictor of non-adherence [24]. In Morocco, cardiac rehabilitation is covered by the Royal Armed Forces Mutual Fund and is under consideration by the National Health Insurance Agency (ANAM). It is, therefore, crucial to develop alternative solutions, including tele-rehabilitation, especially for low-risk patients. Cardiac rehabilitation emerges as a new entity aligned with the evolving healthcare system and its social challenges.

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**Author contribution:**

MB: Study concept, Data collection, Data analysis, Writing the paper.

RL: Study concept, Data collection, Data analysis.

RF: Study concept, Data analysis, Writing the paper.

NM: Supervision and data validation

IA: Supervision and data validation

AB: Supervision and data validation

All authors reviewed the final manuscript.

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**Competing interests:**

None.

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