

Seasonal Patterns and Treatment Outcomes of Severe Acute Malnutrition in Children in Aden, Yemen: A Facility-Based Study from Two Therapeutic Feeding Centers

Mohamed Salem Baazab

`Mohammed.baazab.medi@aden-univ.net`

University of Aden

Giovanni Messina

University of Campania "Luigi Vanvitelli"

Rita Polito

Pegaso Telematic University

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Abstract

Background:

Severe acute malnutrition (SAM) remains a leading cause of morbidity and mortality among children in low-income and conflict-affected settings. Yemen is currently facing one of the most severe humanitarian crises globally, yet limited evidence exists on facility-based patterns of SAM and treatment outcomes in Aden Governorate.

Objective:

To describe the age distribution, seasonal trends, and treatment outcomes of children admitted with SAM in two therapeutic feeding centers in Aden, Yemen, and to assess the relationship between admission caseload and treatment outcomes.

Methods:

A retrospective facility-based study was conducted using routinely collected program data from January to December 2024 at Alsadaqa Teaching Hospital and Alburaiqa Health Complex. Data included monthly admissions and treatment outcomes (recovery, death, and defaulter rates). Descriptive statistics were used to summarize patterns. The relationship between admission load and recovery rate was assessed using Pearson and Spearman correlation analyses.

Results:

A total of 1,003 children with SAM were admitted during the study period. Children aged 6–59 months accounted for 85.6% of admissions. The overall recovery rate was 91.8%, while mortality and defaulter rates were 1.8% and 6.5%, respectively, all within international Sphere standards. Two seasonal peaks in admissions were observed during June–August and October–November. Correlation analysis showed no significant association between admission load and recovery rate (Pearson $r = -0.02$, $p = 0.96$; Spearman $\rho = -0.14$, $p = 0.66$).

Conclusion:

SAM in Aden demonstrates clear seasonal patterns and primarily affects children under five years of age. Although treatment outcomes met international standards, variations in admission load were not significantly associated with changes in recovery outcomes. Strengthening seasonal preparedness and expanding community-based management may help sustain program performance during peak periods.

Trial registration

Not Applicable

1. Introduction

Severe acute malnutrition (SAM) remains one of the most critical public health challenges affecting children worldwide, particularly in low-income and conflict-affected countries. Malnutrition in early childhood is associated with increased morbidity, impaired physical and cognitive development, and elevated mortality risk. According to global estimates, nearly 20 million children under the age of five suffer from severe acute malnutrition each year, with the highest burden concentrated in South Asia and sub-Saharan Africa [1–3]. Children affected by SAM are up to nine times more likely to die than well-nourished children due to weakened immunity and increased susceptibility to infections such as diarrhea, pneumonia, and malaria [4–7].

The World Health Organization defines severe acute malnutrition as a weight-for-height z-score below –3 standard deviations of the WHO growth standards, a mid-upper arm circumference (MUAC) below 115 mm, or the presence of bilateral pitting edema of nutritional origin [2]. SAM represents the most severe form of undernutrition and requires urgent medical and nutritional intervention. Without appropriate treatment, children with SAM face a high risk of mortality and long-term developmental impairments [8, 9].

Yemen currently faces one of the most severe humanitarian crises in the world, characterized by prolonged armed conflict, economic instability, and widespread food insecurity. The conflict has significantly disrupted food production systems, healthcare infrastructure, and social protection mechanisms, thereby exacerbating the vulnerability of children to malnutrition and preventable diseases. According to UNICEF and the World Food Programme, millions of Yemeni children are estimated to be acutely malnourished, with a substantial proportion suffering from severe acute malnutrition requiring urgent treatment [10–12].

In humanitarian contexts such as Yemen, facility-based management of severe acute malnutrition plays a crucial role in reducing child mortality [13]. Therapeutic feeding programs implemented through stabilization centers and outpatient therapeutic programs are essential components of national nutrition strategies. These programs aim to provide specialized medical care and therapeutic feeding to children suffering from SAM, particularly those presenting with medical complications [14].

In Aden Governorate, therapeutic feeding centers such as Alsadaqa Teaching Hospital and Alburaiqa Health Complex provide critical services for the management of children with severe acute malnutrition. Alsadaqa Teaching Hospital serves as a tertiary referral facility and stabilization center for complicated SAM cases, while Alburaiqa Health Complex provides outpatient therapeutic feeding and basic inpatient care. Together, these facilities represent important components of the regional nutrition response system.

Understanding patterns of SAM admissions and treatment outcomes at the facility level is essential for improving program performance and ensuring efficient allocation of limited healthcare resources. Previous studies conducted in various low-income settings have demonstrated that treatment outcomes of SAM programs are influenced by multiple factors, including disease burden, seasonal food insecurity, healthcare accessibility, and program capacity [15, 16]. Seasonal variation in malnutrition has also been widely documented, often associated with agricultural cycles, fluctuations in household food availability, and increased transmission of infectious diseases during rainy seasons [17, 18].

Despite the large burden of childhood malnutrition in Yemen, limited published research has examined facility-level trends in severe acute malnutrition admissions, treatment outcomes, and seasonal patterns within southern regions of the country. Such information is important for identifying high-risk periods, improving preparedness for seasonal increases in caseload, and strengthening the effectiveness of therapeutic feeding programs [14].

Therefore, this study aims to analyze the age distribution, treatment outcomes, and seasonal trends of children admitted with severe acute malnutrition at two major treatment facilities in Aden Governorate during the year 2024. In addition, the study examines the relationship between admission caseload and treatment outcomes in order to better understand how variations in patient volume may influence program performance and clinical outcomes.

2. Methods

2.1 Study Design and Setting

A retrospective facility-based study was conducted using routinely collected program data from two therapeutic feeding centers in Aden Governorate, Yemen, covering the period from January to December 2024.

The study sites included:

- **Alsadaqa Teaching Hospital**, a tertiary referral hospital serving as a stabilization center for complicated severe acute malnutrition (SAM) cases.
- **Alburaika Health Complex**, a district-level facility providing outpatient therapeutic feeding services and basic inpatient care.

2.2 Study Population

The study included all children aged 0–14 years admitted with SAM during the study period.

SAM was defined according to World Health Organization (WHO) criteria as:

- weight-for-height/length z-score < −3 standard deviations,
- and/or mid-upper arm circumference (MUAC) < 115 mm,

- and/or presence of bilateral pitting edema.

2.3 Data Sources and Variables

Data were extracted from facility admission registers and monthly nutrition reports.

Variables included:

- Monthly number of admissions (caseload)
- Treatment outcomes:
 - recovered
 - deaths
 - defaulters

Outcome indicators were calculated monthly as:

- recovery rate
- mortality rate
- defaulter rate

2.4 Statistical Analysis

Statistical analysis was performed using **GraphPad Prism version 10.0 (GraphPad Software Inc., San Diego, CA, USA)**.

Descriptive statistics were used to summarize admission patterns and treatment outcomes. Results were expressed as frequencies, percentages, and rates.

Monthly trends were analyzed using graphical time-series methods.

Correlation Analysis

The relationship between admission load and recovery rate was assessed using both:

- **Pearson correlation**, to evaluate linear association
- **Spearman rank correlation (ρ)**, to assess monotonic relationships and reduce the influence of outliers

A two-sided p-value <0.05 was considered statistically significant.

2.6 Ethical Considerations

The study was a retrospective and used anonymized aggregated data without personal identifiers.

Approval for data use was obtained from the Aden Health Office of the Ministry of Public Health and Population as well as approval from the the Research and Ethics committee with Research Code: REC-277-2026. It should be clarified that the present study did not require the detailed approval of an ethics committee as it is based solely on the analysis of aggregated, anonymized data, which do not allow in any way the identification of participants.

3. Results

3.1 Overall admissions

During 2024, a total of **1,003 children** were admitted with severe acute malnutrition across the two study facilities in Aden. Of these, **521 cases (51.9%)** were treated at **Alsadaqa Teaching Hospital**, while **482 cases (48.1%)** were admitted to **Alburaika Health Complex**. These facilities represent important components of the regional therapeutic feeding program, providing both inpatient stabilization care and outpatient nutritional management for children with severe acute malnutrition.

3.2 Age distribution of admitted children

The majority of admissions occurred among children aged **6–59 months**, who represented **85.6% of all cases**. Infants younger than six months accounted for **11.7%** of admissions, while children aged **5–14 years represented only 2.0%** of cases.

Figure 1 shows age distribution highlights the increased vulnerability of young children during the early years of life, particularly during the transition from exclusive breastfeeding to complementary feeding and during periods of frequent exposure to infectious diseases.

3.3 Monthly admissions and seasonal trends

Figure 2 about monthly analysis of admissions revealed clear **seasonal variation in SAM cases**. Two major peaks in admissions were observed during the study period. The first occurred during **June–August**, while a second increase was recorded during **October–November**.

These seasonal increases may be associated with periods of reduced household food availability, rising food prices, and higher incidence of infectious diseases such as diarrhea and malaria, which are known to exacerbate child malnutrition.

Although both facilities showed similar seasonal patterns, **Alsadaqa Teaching Hospital generally reported slightly higher admission numbers**, reflecting its role as a tertiary referral center for complicated SAM cases.

3.4 Treatment outcomes

Figure 3 describe the treatment outcomes across both facilities, were generally favorable. The **overall recovery rate was 91.8%**, exceeding the minimum Sphere standard of **75%** for therapeutic feeding

programs. The **death rate was 1.8%**, while the **defaulter rate was 6.5%**, both remaining well below the recommended thresholds of **10%** and **15%**, respectively.

When outcomes were analyzed by facility, both centers demonstrated high recovery rates, although small differences were observed between them. Alsadaqa Teaching Hospital recorded a slightly higher number of deaths and defaulters compared with Alburaiqa Health Complex, which may reflect the more severe clinical conditions of patients referred to this tertiary-level hospital.

3.5 Monthly variation in recovery rates

Figure 4 shows recovery rates varied modestly across the months of the study period. Slight declines in recovery rates were observed during months with higher admission loads, may suggest a potential but non-significant trend.

Despite these fluctuations, recovery rates remained consistently above international minimum standards throughout the study period.

3.6 Adverse outcomes during the study period

Figure 5 describe adverse outcomes, including deaths and treatment defaulters, remained relatively low throughout the year. However, small increases in adverse outcomes were observed during months with higher admission numbers.

These findings suggest that periods of increased caseload may place additional strain on therapeutic feeding programs and may influence treatment continuity and patient monitoring.

3.7 Association between admission load and recovery rate

Correlation analysis

Pearson correlation analysis showed no significant linear association between admission load and recovery rate ($r = -0.02$, $p = 0.96$).

Similarly, Spearman rank correlation demonstrated a weak negative but non-significant association ($\rho = -0.14$, $p = 0.66$).

4. Discussion

This study examined patterns of severe acute malnutrition (SAM) among children admitted to two therapeutic feeding centers in Aden, Yemen, during 2024, focusing on age distribution, seasonal trends, and treatment outcomes.

The findings showed that the majority of SAM cases occurred among children aged 6–59 months, accounting for the largest proportion of admissions. This is consistent with existing literature indicating

that children in this age group are particularly vulnerable to malnutrition due to the transition to complementary feeding, increased exposure to infections, and underlying socioeconomic factors affecting food access and caregiving practices [19–22]. Similar age distributions have been reported in studies from other low-income and humanitarian settings [23].

Overall treatment outcomes in the two facilities were favorable and met internationally accepted Sphere standards [24, 25]. Recovery rates were consistently high, while mortality and defaulter rates remained within recommended thresholds. These results suggest that therapeutic feeding programs in Aden are functioning effectively despite the challenging context of conflict, limited resources, and health system constraints.

The study also demonstrated clear variability in monthly admissions, with higher caseloads observed during mid-year and later months. These patterns are likely associated with seasonal fluctuations in food availability, increased food prices, and higher incidence of infectious diseases, which are known to exacerbate the risk of malnutrition. Seasonal trends in SAM have been widely documented in similar settings and highlight the importance of anticipating periods of increased demand for nutritional services [17, 26].

In examining the relationship between admission load and treatment outcomes, both Pearson and Spearman correlation analyses showed weak negative associations between caseload and recovery rate; however, these relationships were not statistically significant. This suggests that variations in admission volume were not strongly associated with changes in recovery outcomes in this dataset.

The absence of a statistically significant association may be explained by several factors. First, the relatively small number of observations (monthly data points) limits statistical power to detect meaningful relationships. Second, variability in monthly reporting and potential carry-over of patients between months may have influenced outcome rates, as reflected by occasional inconsistencies in recovery rates. Third, therapeutic feeding programs may have maintained a relatively stable level of care despite fluctuations in caseload, indicating a degree of resilience within the health system [22].

Although no significant correlation was observed, the direction of association remained negative, suggesting that higher caseloads may still exert some operational pressure on service delivery. In practice, increased patient volumes can lead to overcrowding, staff workload challenges, and potential constraints in monitoring and follow-up, even if these effects were not statistically detectable in this study.

These findings underscore the importance of strengthening health system preparedness for predictable seasonal increases in SAM cases. Ensuring adequate staffing, maintaining sufficient supplies of therapeutic foods, and improving patient follow-up systems remain critical strategies to sustain program performance [27–29]. In addition, expanding community-based management of acute malnutrition (CMAM) may help reduce facility burden by enabling early detection and treatment at the community level [30, 31].

This study has several limitations. The use of aggregated monthly data limited the ability to perform patient-level analysis or adjust for potential confounding factors such as comorbidities, socioeconomic status, or feeding practices. The small sample size at the monthly level also limited statistical power for correlation analyses. Furthermore, inconsistencies in monthly outcome reporting may have influenced the precision of calculated rates.

Despite these limitations, the study provides valuable programmatic evidence on SAM management in a conflict-affected setting. The findings contribute to a better understanding of seasonal dynamics and program performance in Aden and may inform strategies to strengthen nutrition services in similar humanitarian contexts.

5. Conclusion

Severe acute malnutrition remains a major public health challenge in Aden, Yemen, particularly among children under five years of age, who represented the majority of cases admitted to the studied facilities. Although treatment outcomes at Alsadaqa Teaching Hospital and Alburaiqa Health Complex met internationally accepted standards, seasonal increases in admissions were associated with modest declines in recovery rates and slight increases in mortality and default rates. These patterns suggest that fluctuations in caseload, combined with seasonal food insecurity and increased infectious disease transmission, may place additional pressure on health services [32].

The findings highlight the importance of strengthening preparedness strategies before predictable seasonal peaks in severe acute malnutrition. Ensuring adequate staffing levels, maintaining sufficient therapeutic supplies, and expanding community-based screening and management programs are essential to reduce facility overcrowding and maintain the quality of care during high-burden periods. Improved follow-up and monitoring systems may also help reduce treatment default and improve continuity of care for affected children.

This study relied on aggregated facility-level data, which limited the ability to analyze patient-level determinants such as comorbidities, feeding practices, or socioeconomic conditions. Furthermore, correlation analysis does not imply causation, and additional contextual factors—such as staffing capacity, supply availability, and access barriers—may influence treatment outcomes. Future research incorporating patient-level clinical and socioeconomic data is recommended to better understand risk factors associated with poor treatment outcomes and to guide targeted interventions for improving child nutrition programs in Yemen.

Declarations

Ethics approval and consent to participate

The Ministry of Health in Yemen and Faculty of Medicine and Health Sciences, University of Aden, provided ethical approval to this study. This study was a retrospective review of routinely collected

medical records; therefore, the requirement for written informed consent was waived by the ethics committee. Data were extracted using anonymized identifiers, with no personal identifiers recorded, and confidentiality was strictly maintained throughout the study in accordance with relevant ethical guidelines and regulations.

Consent for publication

Not applicable

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

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Authors' contributions

MSB designed the study and collected the data and wrote the initial draft. GM analyzed and interpreted the data and wrote the initial draft. RP designed the study, participated in the writing of the initial draft and revised the draft. All authors read and participated in the writing of the draft and approved the final manuscript.

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Figures

Age distribution of SAM admissions in Aden, 2024

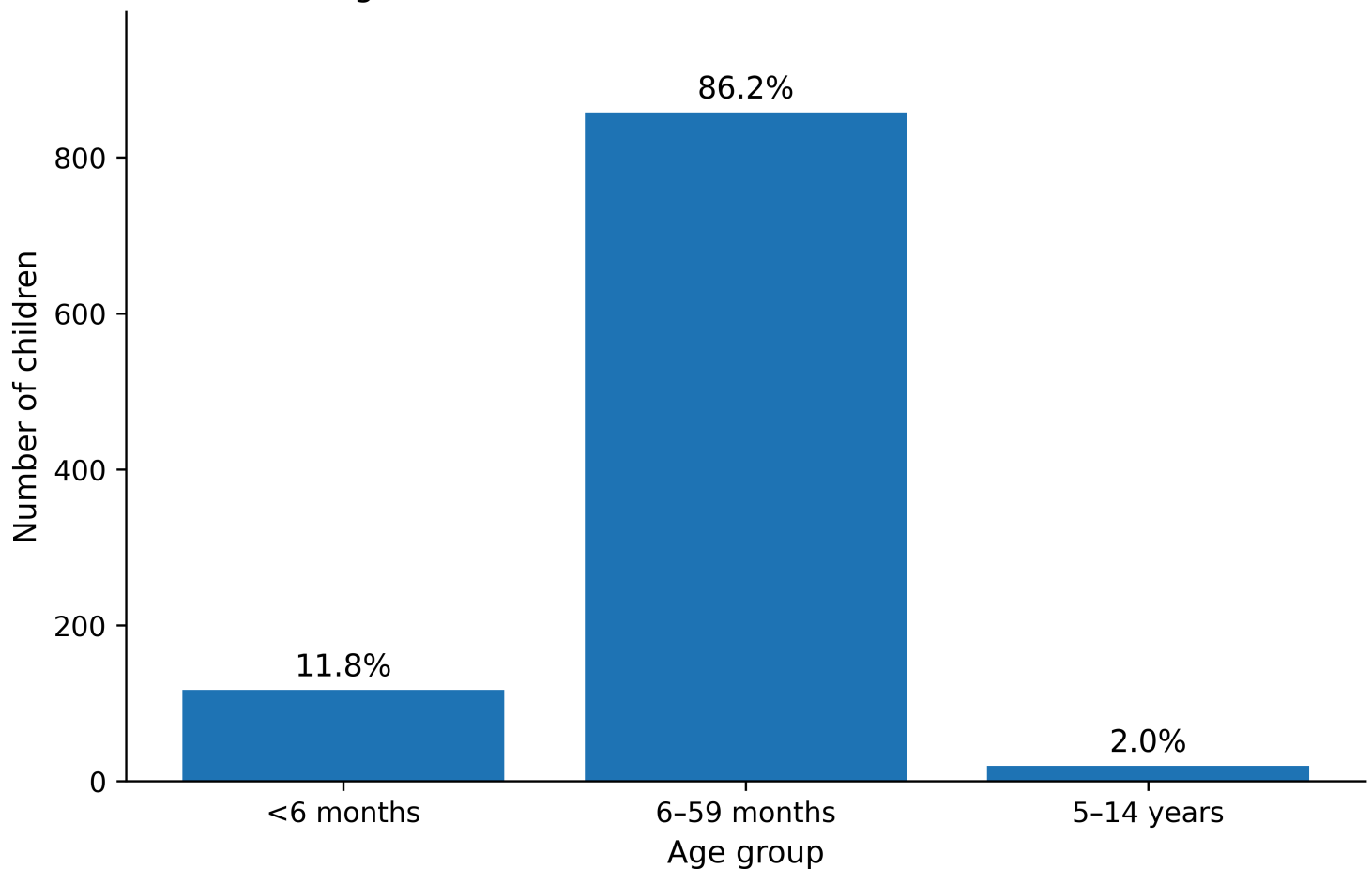


Figure 1

Age distribution of children admitted with severe acute malnutrition in Aden, Yemen, during 2024.

The majority of cases occurred among children aged 6–59 months, representing the most vulnerable age group for severe acute malnutrition. Infants younger than six months and children older than five years accounted for a smaller proportion of admissions.

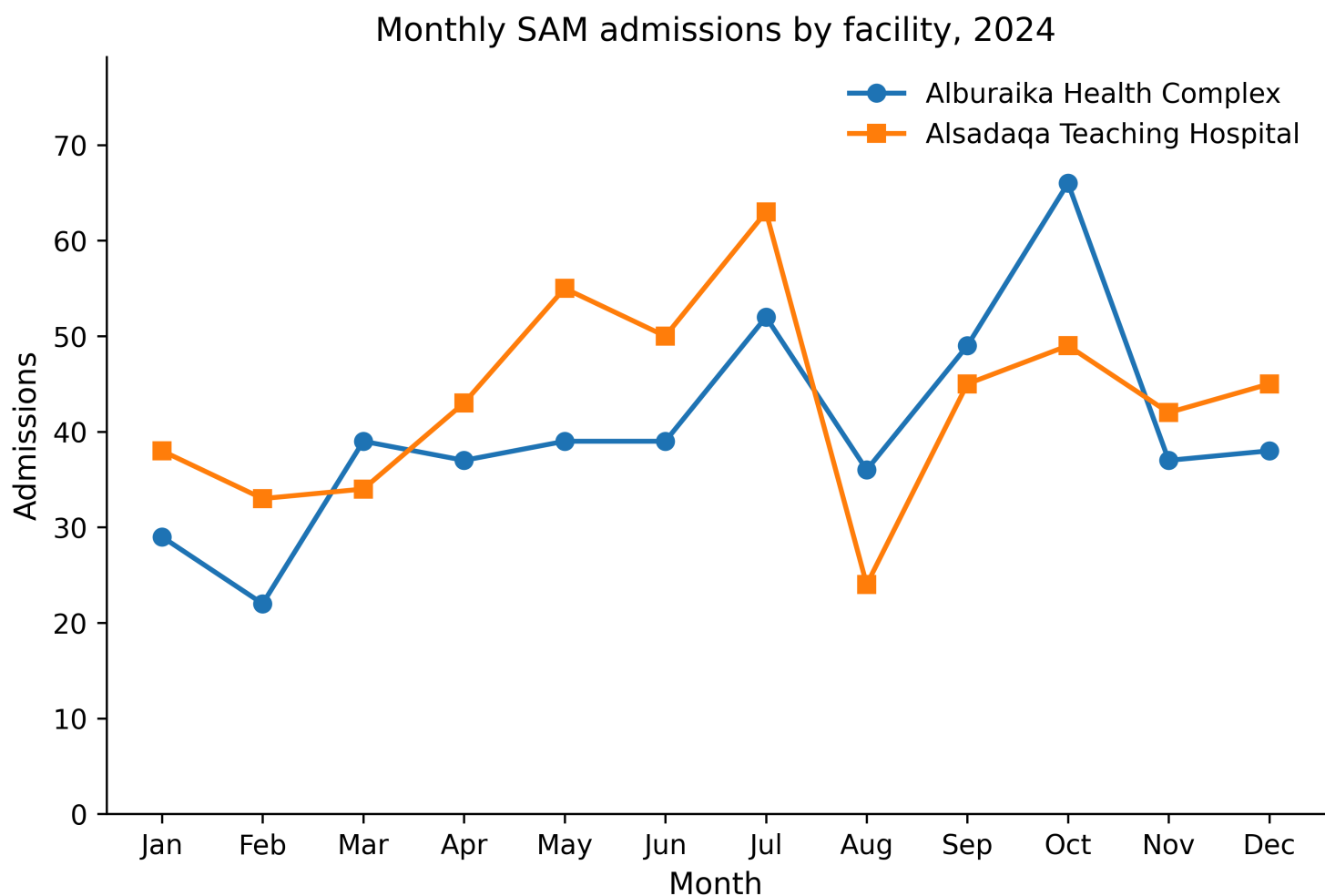


Figure 2

Monthly trend of severe acute malnutrition admissions in Alsadaqa Teaching Hospital and Alburika Health Complex, Aden, Yemen, 2024.

The figure illustrates the number of children admitted with severe acute malnutrition each month in the two facilities. Two seasonal peaks in admissions were observed during mid-year (June–August) and late-year (October–November), suggesting possible associations with seasonal food insecurity and increased transmission of infectious diseases.

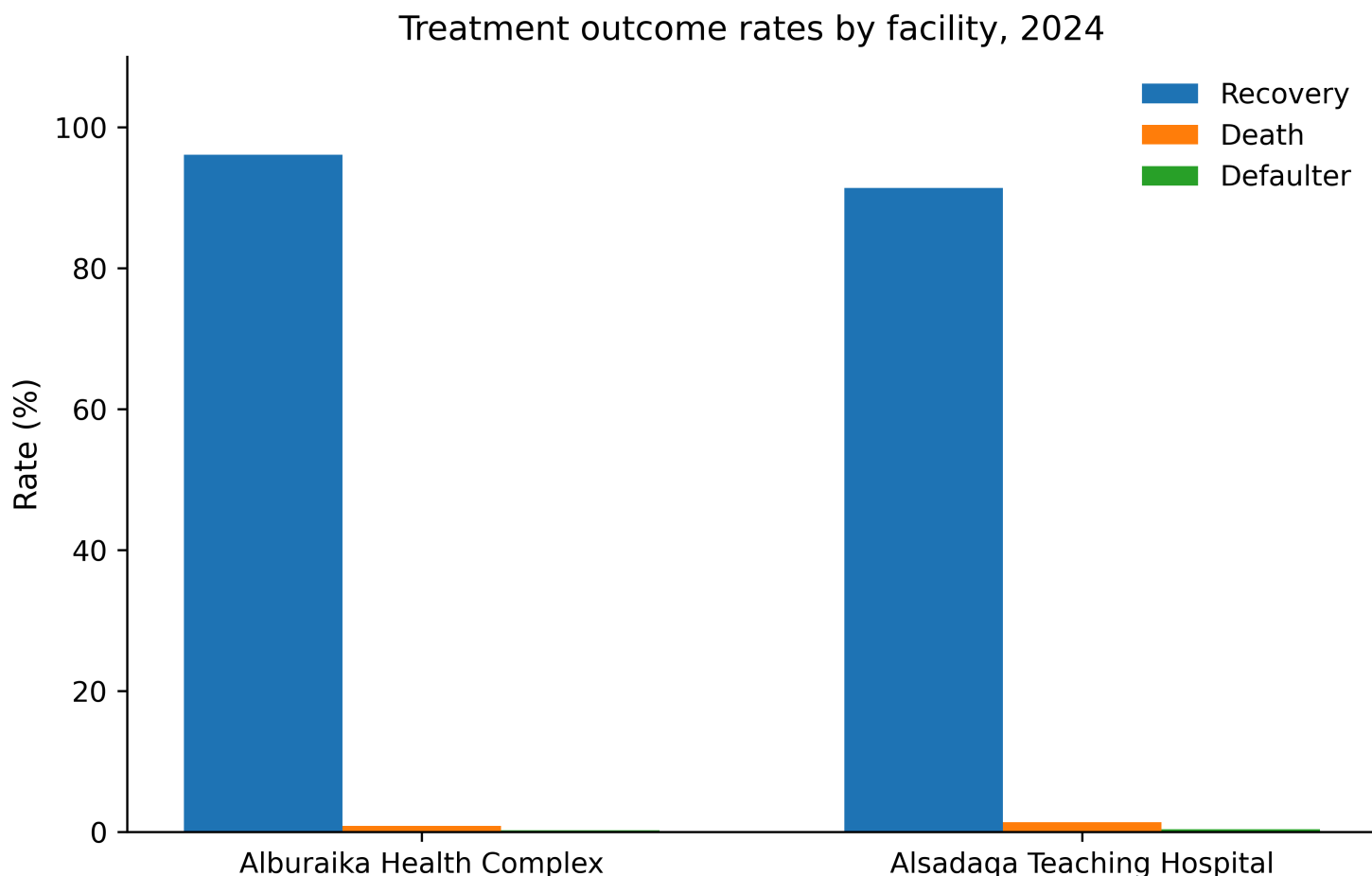


Figure 3

Treatment outcome rates among children admitted with severe acute malnutrition in Alsadaqa Teaching Hospital and Alburyaika Health Complex, Aden, Yemen, 2024.

Recovery, death, and defaulter rates are shown for both facilities. Recovery rates exceeded international Sphere standards for therapeutic feeding programs, while mortality and default rates remained within acceptable limits.

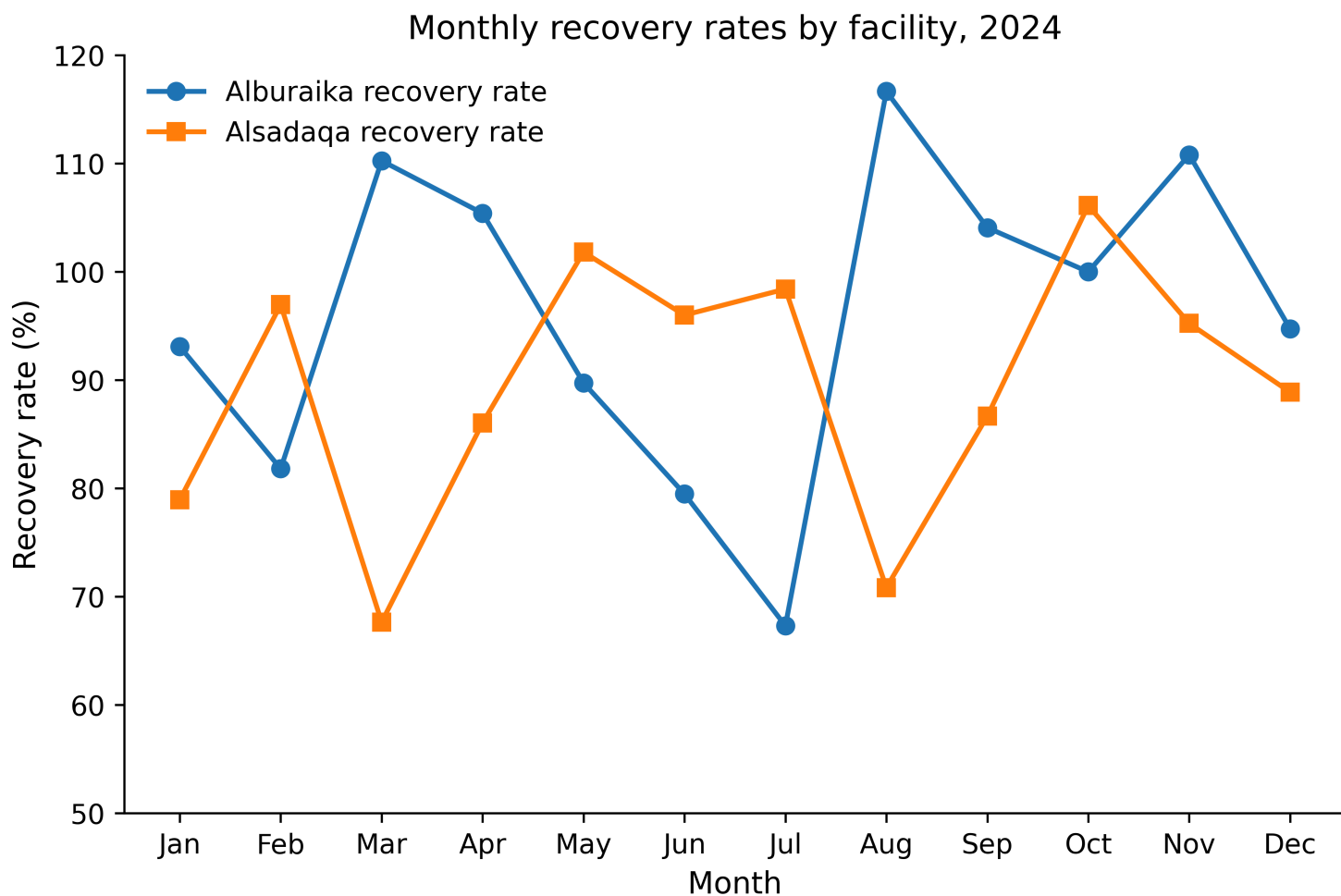


Figure 4

Monthly recovery rates among children treated for severe acute malnutrition in the two study facilities, Aden, Yemen, 2024.

The figure shows variations in recovery rates across months in Alsadaqa Teaching Hospital and Alburaiqa Health Complex. Slight declines in recovery rates were observed during periods of higher admission load.

Monthly adverse outcomes by facility, 2024

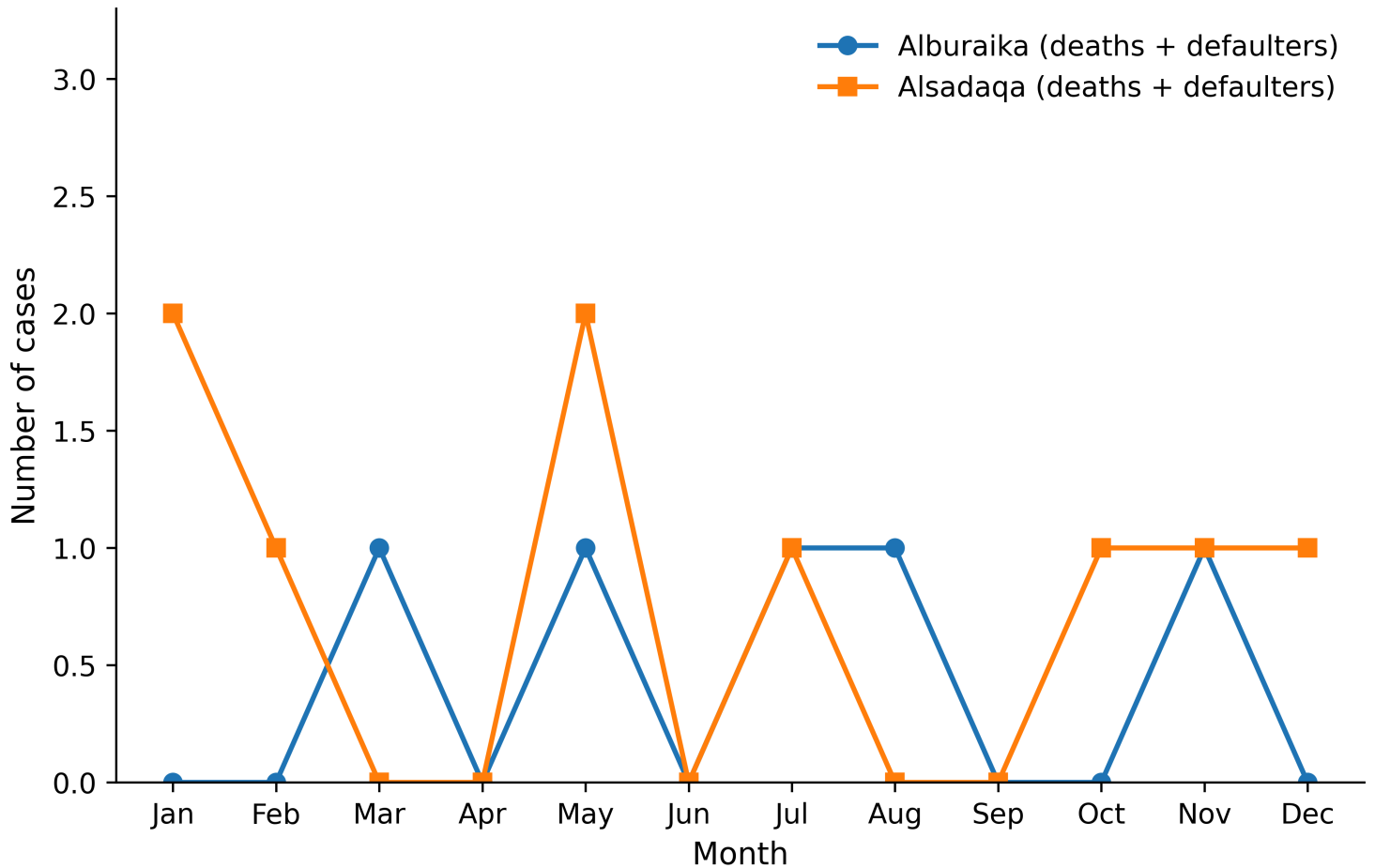


Figure 5

Monthly adverse outcomes (deaths and defaulters) among children treated for severe acute malnutrition in the study facilities, Aden, Yemen, 2024.

The figure presents the combined number of deaths and treatment defaulters recorded each month in both facilities. Slight increases in adverse outcomes correspond with periods of higher caseload.