



INSTITUTO DE HIGIENE E
MEDICINA TROPICAL
DESDE 1902

Universidade Nova de Lisboa

Instituto de Higiene e Medicina Tropical

Management of undernutrition in children under five years of age
with diarrhoea in Mozambique, 2015-2021

Júlia Sambo Abchande

Dissertation presented to fulfil the requirements necessary to obtain a Ph.D. degree in Global
Health and Tropical Medicine

January 2024



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Health and Tropical Medicine

Funding:

Fundação Calouste Gulbenkian

BICMINS – Building Institutional Capacity at the Mozambique INS

World Health Organization – Mozambique

SCIENTIFIC PRODUCTION ASSOCIATED WITH THIS STUDY

Papers published in peer reviewed international journals:

Sambo J, Cassocera M, Chissaque A, Bauhofer AFL, Roucher C, Chilaúle J, et al. Characterizing Undernourished Children Under-Five Years Old with Diarrhoea in Mozambique: A Hospital Based Cross-Sectional Study, 2015–2019. *Nutrients* [Internet]. 2022 Jan [cited 2022 Mar 18];14(6):1164. Available from: <https://www.mdpi.com/2072-6643/14/6/1164>

Sambo J, Bauhofer AFL, Boene SS, Djedje M, Júnior A, Pilale A, et al. Readiness of Mozambique Health Facilities to Address Undernutrition and Diarrhea in Children under Five: Indicators from 2018 and 2021 Survey Data. *Healthcare* [Internet]. 2022 Jun 27 [cited 2022 Jul 3];10(7):1200. Available from: <https://www.mdpi.com/2227-9032/10/7/1200>

Sambo J, Chicumbe S, de Deus N, Gonçalves L. Quality of routine data for monitoring nutrition and diarrhoea indicators of children under 5 in Mozambique: an ecological study over a 5-year period. *BMJ Open*. 2023 Jul 21;13(7):e073239. Available from: <https://bmjopen.bmj.com/content/13/7/e073239.abstract>

AGRADECIMENTOS

Um doutoramento vem sempre carregado de muita história, com momentos muito bons e outros nem tanto, para apimentar a história normal da maioria dos doutoramentos, eu faço parte do grupo que fez o seu doutoramento no meio de uma pandemia que condicionou muita coisa e alterou por completo vários planos.

Quero em primeiro lugar agradecer a Deus (Allah), “o que seria de mim se não fosse Deus”, aqui quero enaltecer duas figuras em quem acredito profundamente, Jesus Cristo e Nossa Senhora de Fátima de quem sou devota. Agradeço por toda a força a todo o momento, obrigada pela proteção por todo o ensinamento durante todo este processo, aprendi muito espiritualmente durante estes 4 anos e meio, obrigada por nunca me terem abandonado.

De seguida, o meu agradecimento vai aos meus pais (João e Ana Rosa), sou quem sou porque vocês fizeram de tudo, abdicaram de várias coisas para educarem-nos e garantirem o melhor possível dentro das vossas capacidades. Obrigada pelo amor incondicional, pelos ensinamentos e por terem incutido que a escola vinha em primeiro lugar.

A família que Deus (Allah) me concedeu a graça de constituir, não tenho palavras para agradecer, foram a minha maior torcida, foram os que mais sofreram com as ausências, desabafos, frustrações, o meu esposo (Abchande I. Abchande) foi meu terapeuta várias vezes (risos), obrigada por sonhar comigo, torcer por mim e pelos sacrifícios para que eu não desistisse dos meus sonhos. Minhas filhas (Kyannah e Allannah) que várias vezes tiveram de lidar com a minha ausência ou fraca presença, obrigada por terem sido pacientes e maravilhosas neste processo.

Meus amores, muito obrigada por existirem e serem quem são, *we did this together, it was a teamwork!*

Quero agradecer aos meus avós, conheci apenas os maternos e aproveitei e aproveito o máximo, ter avós é um grande privilégio. Muito obrigada pela conversa sobre a escola e conhecimento deste a tenra idade, obrigada por sempre torcerem por mim e apoiarem-me a todo o momento.

Agradeço a toda a minha família (Sambo, Matimele e Abchande) pelas orações, apoio e cuidado, muito obrigada.

Neste parágrafo quero agradecer a duas profissionais que me aceitaram e conduziram a bom porto neste processo, foram professoras, mentoras e muito mais, obrigada pela paciência, ensinamentos, obrigada pelo tempo dedicado dentro do universo de actividades e outros aspetos das vossas vidas pessoais. Professora Nilsa de Deus e Professora Luzia Gonçalves muito obrigada, continuem o belo trabalho que vem realizando, agradeço as vossas famílias por partilharem-vos com os inúmeros estudantes.

Agradeço também de forma especial alguns amigos, colegas de trabalho e de faculdade: obrigada Nédio Mabunda e Nádia Siteo, pelo apoio e força, as nossas sessões, a cobrança de produção científica fez toda a diferença para o alcance dos objectivos deste trabalho. Obrigada, Adilson Bauhofer, Assucênio Chissaque e Marta Cassocera (em memória) pelo trabalho conjunto, partilha, apoio e muito aprendizado.

Um agradecimento especial ao Dr. Sérgio Chicumbe, sem o seu apoio não teria conseguido nem metade do que aqui está, muito obrigada. Agradeço-lhe pelas ideias de luz quando eu estava perdida, agradeço pela paciência, por me ter ensinado sobre os aspetos de avaliação de sistemas de saúde aqui apresentados, obrigada pela mentoria nesta área.

Obrigada aos Chefes que tive durante esta caminhada (Nédio Mabunda, Sónia Enosse e Sérgio Chicumbe), que dentro do possível facilitaram muito este processo ajudando a tentar criar um equilíbrio saudável entre o trabalho e a formação. Obrigada a todos os meus colegas de sector (Direcção de Pesquisa em Saúde e Bem-Estar, Departamento de gestão e Coordenação da Investigação em Saúde do Instituto Nacional de Saúde) que várias vezes seguraram as pontas para que eu pudesse me dedicar a este projeto de formação. Um especial agradecimento ao António Júnior e Isabel Mahumane que se calhar são os que mais sofreram nas minhas ausências.

Obrigada a todos os professores que contribuíram para a minha formação desde pequena até aqui.

Obrigada, Kxanimambo, Thank You!

ACKNOWLEDGMENTS

A doctorate always comes laden with much history, with very good moments and others not so much. To spice up the normal story of most doctorates, I am part of the group that pursued their doctorate in the midst of a pandemic that conditioned many things and completely altered various plans. All of this makes me have much to be thankful for.

First and foremost, I want to thank God (Allah), “what would I be without God.” Here, I want to highlight two figures in whom I deeply believe, Jesus Christ and Nossa Senhora de Fátima, to whom I am devoted. Thank you for all the strength at every moment, thank you for the protection and for all the teachings throughout this process. I learned a lot spiritually during these 4 and half years. Thank you for never abandoning me.

Next, my thanks go to my parents (João e Ana rosa), I am who I am because you did everything, you gave up various things to educate us and ensure the best possible within your capabilities. Thank you for the unconditional love, for the teaching, and for teaching us that school comes first.

To the family that God (Allah) has granted me the grace to build, I have no words to thank you, you were my biggest supports, you were the ones who suffered the most with my absences, outbursts, frustrations. My husband (Abchande I. Abchande) was my therapist many times (laughs), thank you for dreaming with me, cheering for me, and for the sacrifices you made so that I wouldn’t give up on my dreams. My daughters (Kyannah and Allannah), who several times had to deal with my absence or weak presence, thank you for being patient and wonderful in this process.

My loves, thank you so much for existing and being who you are, we did this together, it was a teamwork!

I want to thank my grandparents, I only met the maternal ones and I take full advantage, having grandparents is a great privilege. Thank you very much for the conversation about school and knowledge from an early age, thank you for always cheering for me and supporting me at every moment.

I thank all my family (Sambo, Matimele and Abchande) for the prayers, support, and care, thank you very much.

In this paragraph, I want to thank two professionals who accepted me and led me to a safe harbour in this process, they were teachers, mentors, and much more, thank you for the patience, teaching, thank you for the time dedicated within the universe of activities and other aspects of your personal lives. Professor Nilsa de Deus and Professor Luzia Gonçalves, thank you very much, continue the beautiful work you have been doing, I thank your families for sharing you with countless students.

I also want to specially thank some friends, work colleagues, and college classmates: thank you Nédio Mabunda and Nádia Siteo, for the support and strength, our sessions, the demand for scientific production made all the difference in achieving the objectives of this work. Thank you, Adilson Bauhofer, Assucênio Chissaque, and Marta Cassocera (in memory) for the joint work, sharing, support, and much learning.

A special thanks to Dr. Sérgio Chicumbe, without your support I would not have achieved even half of what is here, thank you so much. I thank you for the enlightening ideas when I was lost, thank you for the patience, for teaching me about the aspects of evaluating health systems presented here, thank you for mentoring in this area.

Thank you to the bosses I had during this journey (Nédio Mabunda, Sónia Enosse, and Sérgio Chicumbe), who, as much as possible, greatly facilitated this process by helping to try to create a healthy balance between work and training. Thank you to all my colleagues in the sector (Health Research and Well-Being Directorate, Health Research Management and Coordination Department at Instituto Nacional de Saúde) who several times held the fort so that I could dedicate myself to this training project. Special thanks to António Júnior and Isabel Mahumane who probably suffered the most in my absences.

Thank you to all teachers who contributed to my education from a young age until now.

Obrigada, Kxanimambo, Thank You!

DEDICATÓRIA

Dedico este trabalho a minha família (esposo e filhas), que sirva de inspiração para que lutem para realizarem os seus sonhos e alcancarem os seus objectivos.

Dedico também a todas as crianças deste meu Moçambique, que esta gota que coloco no oceano do conhecimento sirva para ajudar a melhorar de alguma forma a saúde destas crianças para que tenham o futuro grandioso que merecem.

DEDICATION

I dedicate this work to my family (husband and daughters), may it serve as inspiration for them to fight to achieve their dreams and reach their goals.

I also dedicate this to all the children of my Mozambique. May this drop that I place in the ocean of knowledge help to somehow improve the health of these children, so that they may have the great future they deserve.

‘Education is the most powerful weapon which you can use to change the world.’

Nelson Mandela

“He who has health has hope, and who has hope has everything.”

Arab Proverb

“Investing in early childhood nutrition is a very surefire strategy. The returns are incredibly high.”

Anne M. Mulcahy

RESUMO

Introdução: Em países de baixa e média renda, a alta prevalência de desnutrição e diarreia em crianças menores de cinco anos de idade é um problema de saúde pública. Essas duas doenças estão geralmente associadas tendo impacto na alta morbidade e mortalidade. Fatores sociodemográficos e clínicos contribuem para uma alta vulnerabilidade das crianças. A organização mundial da saúde destaca a importância da prestação de serviços e a falta de unidades sanitárias adequadas, por estarem ligadas à alta prevalência destas doenças nas crianças. É crucial implementar serviços de qualidade, orientados por dados fiáveis. Os sistemas de saúde devem colher, monitorar, gerir e utilizar dados de qualidade para a planificação e formulação de políticas para o combate eficaz da desnutrição e diarreia.

Objetivo: Avaliar o manejo de casos de desnutrição em crianças menores de cinco anos de idade, tratadas com diarreia em Moçambique entre 2015 e 2021.

Métodos: Um primeiro estudo de base hospitalar foi implementado de Janeiro de 2015 a Dezembro de 2019 em cinco unidades sanitárias de Moçambique. Foi feita a colheita de dados sociodemográficos e clínicos incluindo medidas antropométricas de crianças menores de cinco anos. O segundo estudo consistiu na análise de 1644 unidades sanitárias do país com base nos dados do *Service Availability and Readiness Assessment* de 2018. Em 2021, uma avaliação específica dos serviços de nutrição foi realizada em cinco unidades sanitárias ao longo do país. Para a terceira análise foi realizado um estudo ecológico longitudinal usando dados de 2017 a 2021 para avaliar indicadores de nutrição e diarreia nas componentes de completude, consistência, presença de *outliers* e tendências sazonais. Estes dados são de todas unidades sanitárias do país, extraídos do sistema de informação de saúde de Moçambique.

Resultados: Uma análise foi realizada em 963 crianças menores de cinco anos com diarreia no primeiro estudo. A frequência de desnutrição nestas crianças foi de 54,1% (IC 95%: 50,9-57,2), com 32,5% (IC 95%: 29,6-35,5) para o baixo peso, 26,6% (IC 95%: 23,9-29,6) para desnutrição aguda, e 24,7% (IC 95%: 22,1-27,5) para a desnutrição crónica. Crianças da província de Nampula apresentaram 4,7 vezes mais chances de ter baixo peso em comparação com as de Maputo ($p = 0,016$). Além disso, crianças com cuidadores sem habilitações literárias tiveram 5,4 vezes mais chances de estar abaixo do peso recomendado ($p < 0,001$). A estação chuvosa estava associada a 1,70 vezes mais chances de desnutrição aguda entre as crianças (p

= 0,012). Crianças que nasceram pesando menos de 2500 gramas enfrentaram 2,8, 2,9 e 2,6 vezes mais chances de estar com baixo peso, desnutrição aguda e desnutrição crônica, respetivamente. Além disso, crianças com status HIV-positivo apresentaram 2,6 vezes mais chances de ter baixo peso ($p = 0,006$) e 3,4 vezes mais chances de ter desnutrição crônica ($p = 0,004$). A disponibilidade de serviços de nutrição e diarreia para crianças é baixa, com uma pontuação inferior a 75%, numa escala de 0 a 100%. Maior indisponibilidade foi observada nas dimensões de recursos humanos, diretrizes e treinamento. Foi observada uma diferença estatisticamente significativa ($p < 0,001$) entre a pontuação de prontidão de serviço de diarreia (mediana (IQ): 72,2% (66,7 a 83,3)) e a pontuação de prontidão de nutrição (mediana (IQ): 57,1% (52,4 a 57,1)). Os serviços de nutrição apresentaram uma associação positiva com a prontidão do serviço de diarreia, e ambos foram associados à prontidão dos serviços de malária e HIV ($p < 0,05$). Na avaliação da qualidade dos dados de rotina, a vacina contra rotavírus mostrou melhor completude de dados em comparação com outras métricas analisadas. Foram observados *outliers* na desparasitação e vacina contra rotavírus, particularmente nas províncias de Nampula e Zambézia. Um padrão consistente ao longo do tempo foi evidente antes da pandemia de COVID-19 para todos os indicadores em várias províncias. No entanto, indicadores de Desnutrição Aguda Moderada e casos recuperados de Desnutrição Aguda Moderada mostraram mais problemas de inconsistência ao longo do tempo durante os períodos de 2017-2019 e 2018-2021.

Conclusão: Moçambique tem uma alta frequência de desnutrição em crianças menores de cinco anos e fatores sociodemográficos e clínicos estão associados à mesma. O sistema de saúde do país enfrenta obstáculos significativos, como infraestrutura insuficiente, escassez de recursos humanos, problemas de financiamento e problemas no acesso. Uma abordagem holística é imperativa, englobando investimento em infraestrutura, treinamento, financiamento e melhoria do acesso, juntamente com a integração de intervenções específicas, com foco particular em doenças em crianças menores de cinco anos de idade. Melhorar a qualidade dos dados de saúde colhidos rotineiramente é vital para a formulação de políticas informadas e melhores resultados de saúde, com atenção urgente necessária para melhorar a qualidade e prontidão do serviço para o manejo integrado de doenças em crianças menores de cinco anos de idade.

Palavras-Chave: desnutrição, diarreia, crianças menores de cinco anos, prontidão de serviço, dados rotineiros, Moçambique.

ABSTRACT

Introduction: In low-middle-income countries the high prevalence of undernutrition and diarrhoea among children under-five is a significant health concern. These conditions often coexist and are associated with increased illness and mortality rates. Sociodemographic factors and clinical conditions further contribute to the vulnerability of children. The world health organization highlights the importance of service delivery, and the lack of adequate healthcare facilities is linked to the prevalence of these diseases among children. Implementing data-driven, quality healthcare services targeting undernutrition and diarrhoea is vital. Health systems must collect, monitor, manage, and utilize data for planning and policymaking across all levels of healthcare to effectively combat these conditions.

Objective: Assess the management of undernutrition cases in children under-five years of age treated with diarrhoea in Mozambique between 2015 and 2021.

Methods: A hospital-based study was conducted from January 2015 to December 2019 in five sentinel hospitals in Mozambique. The study included the collection of sociodemographic and clinical information, along with anthropometry data from children under-five. An analysis of 1644 public health facilities across the country was carried out based on the 2018 service availability and readiness assessment. In 2021, an specific nutrition services assessment was conducted in five health facilities across the country. Additionally, a longitudinal ecological study was carried out using secondary data from 2017 to 2021 to evaluate nutrition and diarrhoea health indicators, completeness, consistency, presence of outliers, and seasonal trends. This data was collected from all health facilities at the district level using the Mozambican health information system.

Results: A comprehensive analysis was carried out on 963 children under-five years of age with diarrhoea, for the first study. The frequency of undernutrition among the children was 54.1% (95%CI: 50.9-57.2), with 32.5% (95% CI: 29.6–35.5) stunting, 26.6% (95% CI: 23.9–29.6) wasting and 24.7% (95% CI: 22.1–27.5) underweight. Children in the Nampula province exhibited 4.7 times greater odds of being stunted compared to those in Maputo, with a significance level of $p = 0.016$. Additionally, children who were under the care of illiterate caregivers had 5.4 times more odds to be underweight ($p < 0.001$). The wet season was

associated with 1.70 times increased odds of wasting among the children ($p = 0.012$). Children born weighing less than 2500 grams faced 2.8, 2.9 and 2.6 times increased odds of being underweight, wasted, and stunted, respectively. Furthermore, children with HIV-positive status had 2.6 times higher odds of being underweight ($p = 0.006$) and 3.4 times higher odds of stunting ($p = 0.004$).

The availability of nutrition and diarrhoea services for children is low, scoring under 75%. There was a notable lack in human resources, guidelines, and training dimensions. There was a significant difference ($p < 0.001$) between the diarrhoea service readiness score (median (IQ): 72.2% (66.7 to 83.3)) and nutrition readiness score (median (IQ): 57.1% (52.4 to 57.1)). Nutrition services had a positive association with diarrhoea service readiness, and both were associated with malaria and HIV service readiness ($p < 0.05$). Rotavirus vaccine indicators displayed better data completeness in comparison to other metrics under review. Extreme outliers were observed in deworming and rotavirus vaccine, particularly in Nampula and Zambézia provinces. A consistent pattern over time was evident prior to the COVID-19 pandemic for all the indicators across various provinces. However, indicators of Moderate Acute Malnutrition and Recovered cases from Moderate Acute Malnutrition, showed more inconsistency issues over time during both 2017-2019 and 2018-2021 periods.

Conclusion: Mozambique has a high frequency of undernutrition in children under-five and sociodemographic and clinical factors are associated with the high frequency. The county healthcare system faces significant hurdles such as insufficient infrastructure, workforce shortages, funding issues, and limits access. A holistic approach is imperative, encompassing investment in infrastructure, training, financing, and access improvement, along with integrating targeted interventions, particularly focusing on children under-five years of age. Upgrading the quality of routinely collected health data is vital for informed policymaking and better health outcomes, with urgent attention needed to enhance service quality and readiness for integrated disease management in children under-five years of age.

Keywords: undernutrition, diarrhoea, children under-five, service readiness, routine data, Mozambique.

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LIST OF ABBREVIATIONS

AIDS	– Acquired Immunodeficiency Syndrome
ARI	– Acute Respiratory tract infections
DALYs	– Disability-Adjusted Life Years
DHS	– Demographic Health Survey
DHS-2	- District Health Information System, version 2
DQR	– Data Quality Review
HALE	– Health Life Expectancy
HAZ	– Height-for-Age z-score
HMIS	- Health Management Information System
HCM	– Hospital Central de Maputo
HCN	– Hospital Central de Nampula
HF	– Health Facility
HGJM	– Hospital Geral José Macamo
HGM	– Hospital Geral de Mavalane
HGQ	– Hospital Geral de Quelimane
HIV	– Human Immunodeficiency Virus
IMASIDA	- Survey of Immunization, Malaria and HIV/AIDS Indicators in Mozambique
IMCI	- Integrated Management of Childhood Illness
LMIC	- Low-middle income countries
MAM	– Moderate Acute Malnutrition
NHS	– National Health System
NSA	– Nutrition Service Assessment
PAMRDC	- Plan for the Reduction of Chronic Malnutrition in Mozambique
PEPFAR	- President’s Emergency Plan for AIDS Relief
PMI	- President’s Malaria Initiative
SARA	- Service, Availability and Readiness Assessment
SDG	– Sustainable Development Goals
SDI	– Socio-Demographic Index
SIS-MA	- Sistema de Informação de Saúde para Monitoria e Avaliação
SPSS	- Statistical Package for Social Sciences
UN	– United Nations
UNICEF	- United Nations Children's Fund

WAZ – Weight-for-Age z-score

WHO – World Health Organization

WHZ – Weight-for-Height z-score

1. INTRODUCTION

1.1. Child Health in Mozambique

1.1.1. Mozambique socio-economic context

Mozambique is located in the eastern sub-Saharan Africa. It shares borders with Eswatini and South Africa to the south, Zimbabwe to the west, and Malawi and Zambia to the northwest, with Tanzania to the north. The eastern border is the Indian Ocean. As of 2023, the country has a population of 32,419,747,00 with a demographic density of 33.5 habitants per km² (1). Mozambique has eleven provinces and 163 districts. The majority of its population, 66.6% based on the 2017 census, lives in the rural areas. Nampula and Zambézia are the most populous provinces, with 5.8 million and 5.2 million, respectively, as depicted in Figure 1 (2).

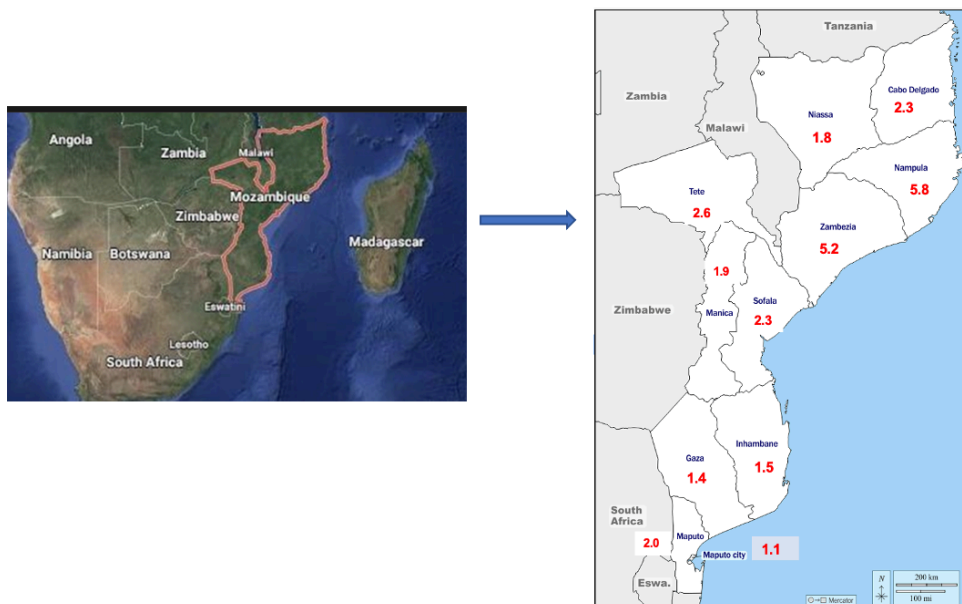


Figure 1: Mozambique population in millions by province

Source: (2). Map adapted from source (3,4)

Mozambique has a low Socio-Demographic Index (SDI), and is classified as low-income country by the World Bank, 46% of the population lives below the poverty line (5).

(5). It has a young population, with more than half (53%) aged 0 to 17 years, being 46.7% from 0 to 14 years old (2). The crude birth rate is 37.9/1000 habitants, 38 children are born in each 1000 habitants, and the crude mortality rate is 11.8/1000 habitants, with high infant mortality rate, 67.3% (2).

The country has seen an increase in life expectancy at birth, from 52.6 (51.3-54.1) to 62.0 (59.4-64.5) for female, and from 48.0 (46.7-49.4) to 54.8 (52.7-57.0) for male, from 1990 to 2017. However, this is still below the global average and the overall life expectancy at birth in countries with low SDI, as shown in Table 1 (6). Although an increase was also observed in health life expectancy (HALE) at birth, there remains a significant gap between the life expectancy and HALE at birth, being almost 10 years for women and around 7 years for men (6).

Table 1: Life expectancy and HALE by SDI regions and Mozambique, by sex in 1990 and 2017.

Source: (6)

Region	Life Expectancy at Birth				HALE at Birth			
	Females		Males		Females		Males	
	1990	2017	1990	2017	1990	2017	1990	2017
Global	68.0 (67.8-68.3)	75.6 (75.3-75.9)	63.2 (62.9-63.4)	70.5 (70.1-70.8)	58.4 (55.7-60.8)	64.8 (61.7-67.4)	55.6 (53.5-57.5)	61.8 (59.4-64.0)
Low SDI	54.8 (54.3-55.4)	67.3 (66.7-67.9)	53.0 (52.4-53.6)	64.5 (63.8-65.1)	46.4 (44.0-48.5)	57.3 (54.5-59.8)	46.1 (44.1-47.9)	56.2 (53.9-58.4)
Low-middle SDI	61.9 (61.5-62.3)	70.1 (69.5-70.7)	59.0 (58.5-59.4)	66.3 (65.7-66.9)	52.6 (50.0-55.0)	59.8 (56.9-62.4)	51.5 (49.3-53.5)	58.0 (55.6-60.1)
Middle SDI	70.0 (69.7-70.3)	77.4 (77.1-77.7)	65.7 (65.3-66.1)	71.7 (71.4-72.1)	60.8 (58.2-63.1)	67.0 (64.1-69.5)	58.4 (56.3-60.2)	63.6 (61.2-65.6)
High-middle SDI	73.1 (72.9-73.4)	79.4 (79.1-79.7)	66.8 (66.5-67.0)	73.3 (73.0-73.7)	63.1 (60.4-65.5)	68.5 (65.4-71.1)	59.0 (56.9- 61.0)	64.7 (62.2-66.8)
High SDI	79.3 (79.3-79.3)	83.7 (83.5-83.9)	72.6 (72.5-72.6)	78.5 (78.3-78.6)	67.9 (64.6-70.7)	71.1 (67.6-74.2)	63.8 (61.3-66.0)	68.2 (65.4-70.8)
Mozambique	52.6 (51.3-54.1)	62.0 (59.4-64.5)	48.0 (46.7-49.4)	54.8 (52.7-57.0)	45.3 (42.8-47.5)	53.4 (50.2-56.6)	41.6 (39.4-43.6)	47.9 (45.2-50.4)

The illiteracy rate is estimated at 39%, with a higher rate in rural areas (50.7%). Women in face a higher illiteracy rate both in rural and urban areas, 62.4% and 25.7% respectively (2). In Mozambique, 47.4% of the population lives in hut houses, 51.3% drinks untreated water, 54.2% do not have a latrine in their house (2).

Mozambique gain independence from Portugal in 1975. However, from 1977 to 1992, the country experienced a civil war, which destructed massively all kinds of infrastructure (7). Additionally, there was an armed conflict in the central region 2013 to 2019. Since 2017, the province of CABO Delgado in the north has been under terrorism attack.

Poverty remains a significant issue in this southern Africa country. The latest Household Budget Survey, conducted in 2019/2020, revealed that the majority of households heads are peasants, constituting 61.3% of the population. Seven out of eleven provinces have a monthly income below the national average (8).

1.1.2. Population and child health in Mozambique

As a low-income country, the access to basic social services is low, Mozambique health context is determined by economic, political, and social aspects. The high maternal and child mortality is mainly a consequence of poor service delivery and low quality of care (9). Apart from the poor service delivery, the country is disposed to outbreaks and natural disasters, floods, cyclones, which accentuates the health problems (9).

Globally child health is of major concern, the first years of life are crucial to shape the adult that the child will become. A child health can be determined by different and multisectoral factors, in the conceptual framework bellow (Figure 2) is represented the “problem tree” that facilitates to understand the factors. There are represented three levels: outcomes, intermediate and fundamental determinants, the top represents the realization of child’s rights (those pertaining to final outcomes or impacts and those concerning access to basic services), the bottom of the tree represents parameters for progress at a “deep societal level”, and in the middle of the tree are parameters that link the fundamental societal parameters with access to services (9).

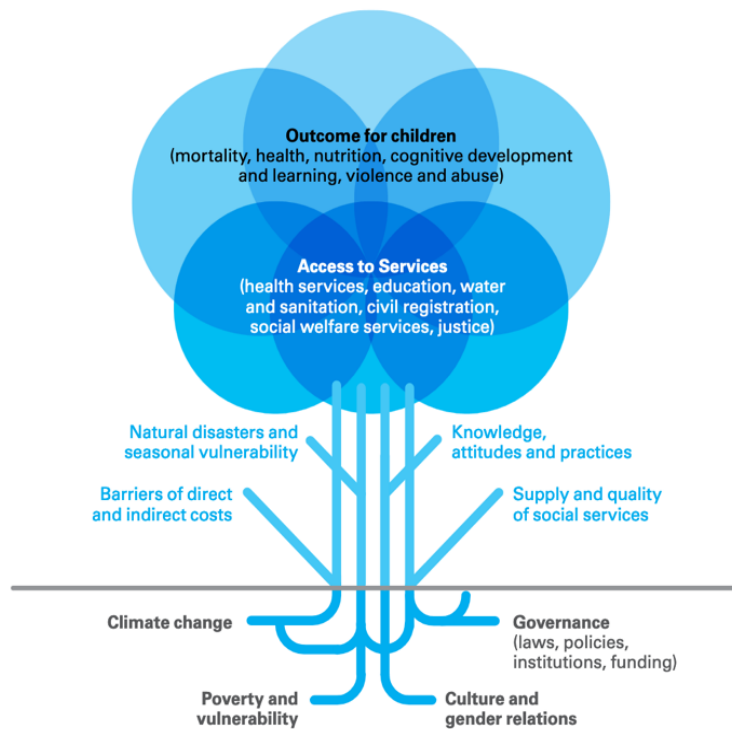


Figure 2: UNICEF conceptual framework on immediate and underlying determinants of child well-being

Source: (9).

The concern on child health is higher when it comes to Low-middle income countries (LMIC), due to the burden of disease observed in these countries (6). As represented in Figure 3, most of the deaths either neonatal death or child deaths are caused by preventable and treated diseases or cases, these diseases are linked to poverty, quality of care and access to health services (6,10).

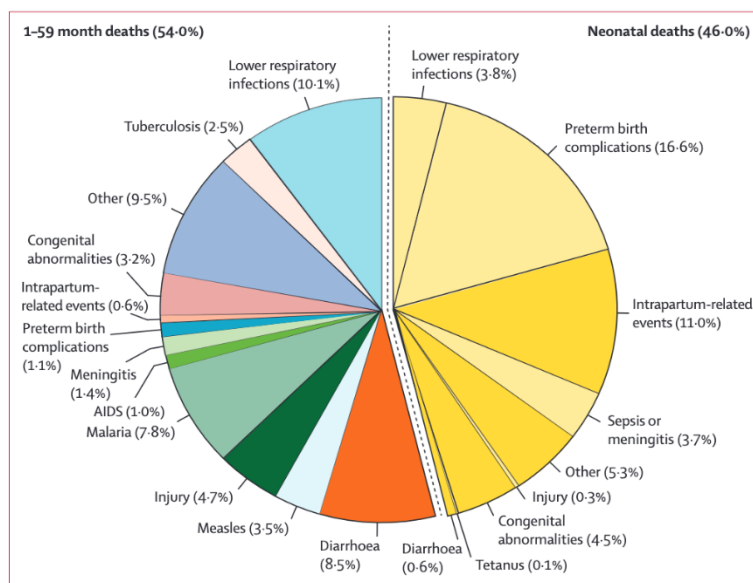


Figure 3: Global children Under-five causes of death in 2019. Neonates (0-27 days) are on the right-hand side and children (1-59 months) are on the left-hand side.

Source: (11).

In Mozambique, high child mortality rate is observed with 53 infant deaths per 1000 live births of deaths in children under-five. The main cause of death are malaria, HIV/AIDS, acute respiratory infection and diarrhoeal diseases (9), and undernutrition is the main underlying cause of death in the country (12). The child survival depends on the mother health, the education, access, and quality of healthcare during pregnancy and at the birth moment, also play an important role on child survival. A UNICEF report highlights that only 48% of births are attended by skilled health workers in the country (12).

A child born in Mozambique has to leave in a challenging context, facing poor healthcare, low access to quality early learning services, child marriage, child labour and absolute poverty (12).

1.2.Undernutrition in children

1.2.1. Causes of Undernutrition

Malnutrition is a state in which an individual physical function is impaired, and can no longer maintain adequate body performance process, such as growth, pregnancy, lactation, physical work, resistance and disease recovery, and is related to negative outcomes for patients (13,14). In children under-five years of age malnutrition can impact the child development being responsible for morbi-mortality in this age group and limits the capacity and ability for the child to become a capable and independent adult that contributes for his country development. Malnutrition includes both, undernutrition and overnutrition (13).

Undernutrition occurs when there is insufficient nutrient intake and/or an increase of nutrient needs that prevents effective utilization of nutrients, consequently affecting the ability to maintain good health (15). Some authors define undernutrition as an outcome of insufficient quantity and quality of food and frequent episodes of infectious disease (16). Nutritional requirements are defined by, Macronutrients: needed in large amounts and include protein, carbohydrate and fat; and Micronutrients: needed in much smaller amounts and include vitamins and minerals (13).

Rates of underweight, wasting and stunting are used to estimate undernutrition in children (13,15).

Underweight is when a child weight less than the average weight for children of the same age and sex. It is therefore a composite indicator, reflecting either acute or chronic undernutrition without distinguish between the two (13,16). It frequently goes unnoticed (13).

Wasting is characterized by rapid and extreme weight loss and/or bilateral swelling, is usually a consequence of insufficient food intake or incidence of infectious disease, it can impair a whole range of bodily functions, in the early stages can be reversed through adequate food and health care (13,16).

Stunting is a slow, cumulative process that develops over the long-term as a result of inadequate intake or repeated infections, or both, it refers to children that suffer from growth retardation

(16). The presence of stunting does not necessarily mean that current dietary intake or health is inadequate – the growth failure may have occurred at some time in past (13). By the age of two it may be irreversible.

Underweight had the major contribution for disability-adjusted life years (DALYs) in 2004 in low income countries with 9.9% of total DALYs within the accessed risk factor, which included among others, unsafe water, sanitation, hygiene (6.3%), unsafe sex (6.2%) and suboptimal breastfeeding (4.1%) (17).

Undernutrition has multisectoral causes and should be addressed as such, as a multisectoral concern is related to multiple targets from the Sustainable Development Goals (SDGs), covering sectors. The main causes of child undernutrition can be categorized in three groups; basic, underlying and immediate causes (18), Figure 4. The basic causes are more related to socio cultural, economic and political context, the underlying causes are mainly related to food security, household environment and health services, and the immediate causes are inadequate dietary intake and diseases (18–20).

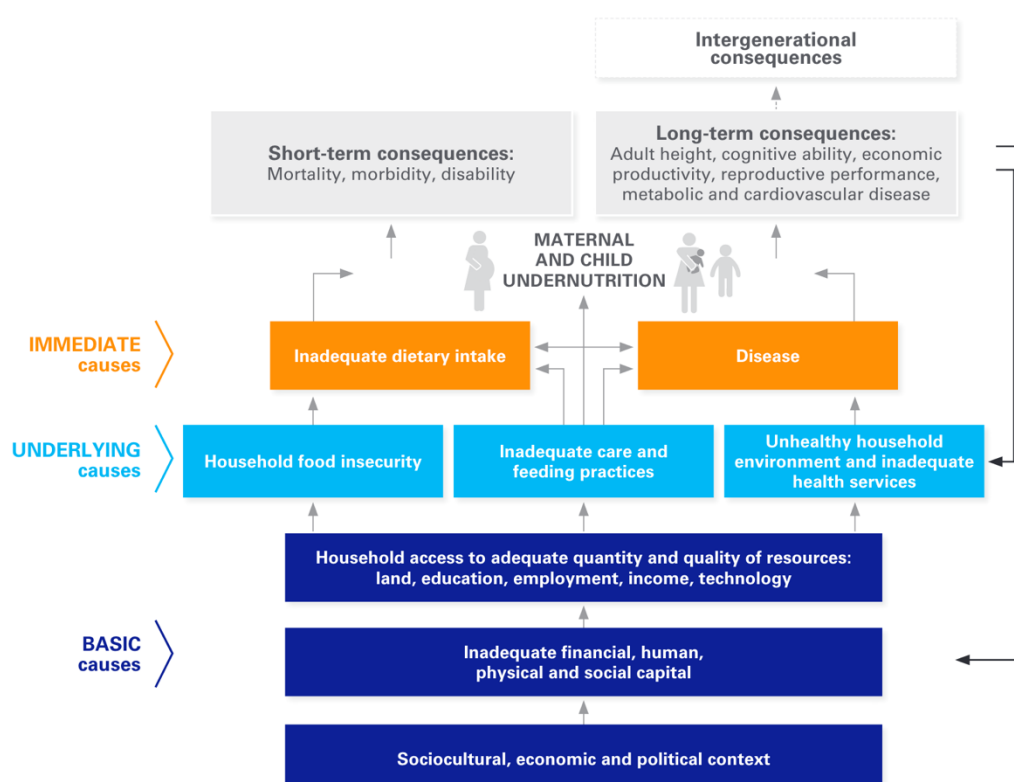


Figure 4: Determinants of Child Undernutrition, UNICEF Conceptual Framework.

Source: (18).

Basic Cause

The basic causes of undernutrition are mainly related to, sociocultural, economic including financial, quantity and quality of resources, political context and organizational resources (18). The social component strongly highlighted in this group of causes determine relations and resources distribution between different groups in society. The basic causes are related to the SDG1, end poverty in all its forms everywhere, and SDG8 promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all (21).

Underlying causes

Household food insecurity

Food insecurity – lack of regular access to enough safe and nutritious food for normal growth, development and an active health life (22).

“Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life”, cited by (23).

Food security is mainly divided into 4 pillars, food availability, accessibility, utilization, and stability:

Food availability: enough food of appropriate quality.

Accessibility: access to adequate resources for acquiring appropriate foods for a nutritious diet.

Utilization: through adequate diet, clean water, sanitation, and health care to reach a state of nutritional well-being where all physiological needs are met.

Stability: access to adequate food always.

Inadequate care and feeding practices

They depend on resources which includes, income and time, cultural factors, health services, water, and sanitation. The economic power impacts on dietary variety and feeding frequency, the time the mother has available to be the primary caregiver influences the mental development and the quality of care provided to the child and finally a good sanitation and the supply of improved drinking water has a strong impact on disease spread (19,24–26).

Unhealth household environment and inadequate health services

Poor sanitation and unimproved drinking water have also impact on incidence of infections in the family and community, which can also reduce the capacity to work and influence the economic power of the adult. Access to affordable and good quality health services is a key element of good health (19,26,27).

The underlying causes are related to SDG 2, end hunger, achieve food security and improved nutrition and promote sustainable agriculture, SDG3, ensure health lives and promote well-being for all at all ages and SDG6, ensure availability and sustainable management of water and sanitation for all (21).

Immediate causes of undernutrition

Inadequate dietary intake and Disease

Energy and essential nutrients are key to ensure normal growth, a diet that provides all the key elements for child development should be available and provided, from breastmilk to complementary food adequate in terms of quality, diversity, and quantity.

Usually, infections occur at the same time with undernutrition and there is a vicious cycle between both (18,28). The immediate causes are related to SDG 3, ensure health lives and promote well-being for all at all ages (21).

1.2.2. Epidemiology of undernutrition

It was estimated that globally, 1 in 9 people is hungry or undernourished (29).

Low- and middle-income countries have the highest burden of undernutrition across the globe, in 2011, 34 countries had the highest burden of undernutrition and together they accounted for 90% of the global undernutrition (30).

In 2018 it was estimated that 49.5 million children were wasted with a prevalence of 7.3% and 149.0 million were stunted with a prevalence of 21.3% worldwide (31,32), and Africa contributed with one third of the global cases of stunting, Figure 5 (32).

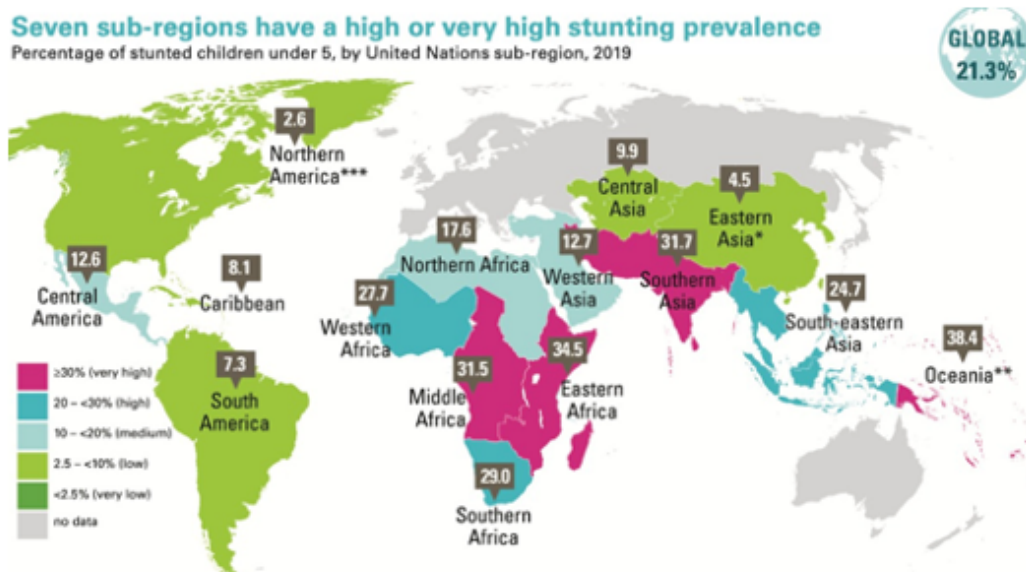


Figure 5: Stunting in children under-five by United Nations sub-region, 2019.

Source: (32)

Although nutrition is one of the key goals in the sustainable development Goals, and is strongly highlighted in goal 2, end hunger, achieve food security and improved nutrition and promote sustainable agriculture, is far from achieving the target (33). The 2022 SDG report refers that 14.2 million children under-five suffer from stunting in 2020, and to reduce stunting in children by 50% by 2030, the annual decline rate must double from 2.1% to 3.9% per year (34).

1.2.3. Undernutrition in Mozambique

In 2022-2023, 15.4% of children under-five were underweight, 3.8% were wasted and 36.7% were stunted in Mozambique, Figure 6 (35–38). In Mozambique little progress was made to reduce stunting (9).

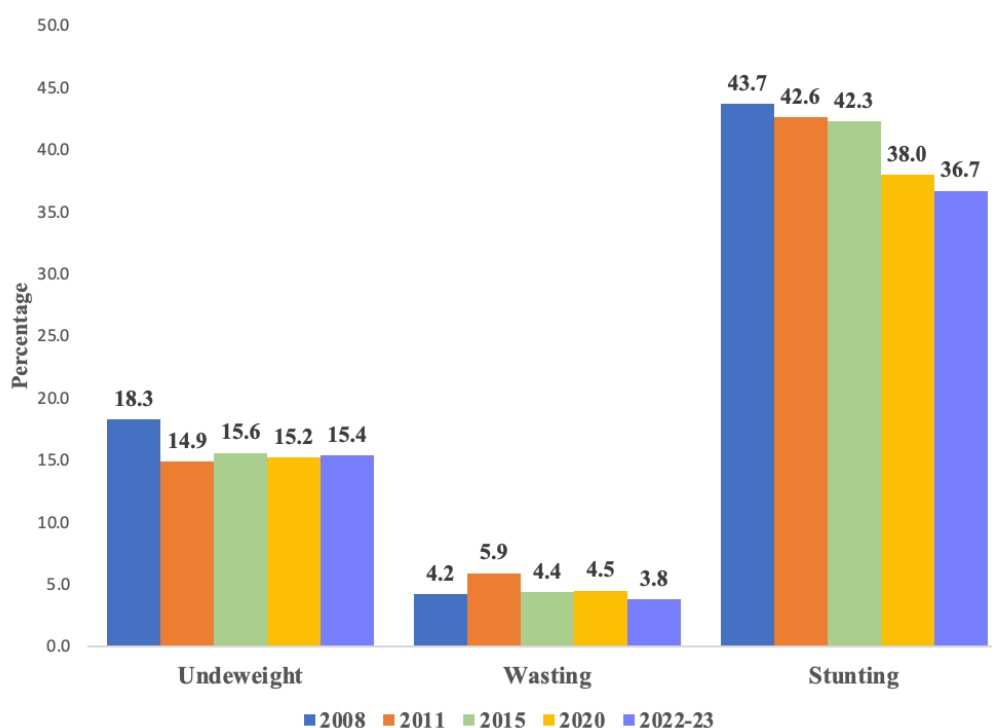


Figure 6: Prevalence of child undernutrition across the years (2008-2023) in Mozambique.

Data source: (35–38)

Stunting remains the type of undernutrition most prevalent in the country in children under-five years old. Nampula, Cabo Delgado, Zambézia and Manica are the provinces with the highest prevalence of stunting, and above national level (36.7%), with 46.7%, 44.7%, 43.7% and 39.1%, respectively, Table 2 (38). Undernutrition was among the principal cause of death in under-five children in Mozambique between 2018 and 2021 at health facility level (39).

Table 2: Prevalence of undernutrition (Underweight, Wasting, and Stunting) in Mozambique by age and by province, 2022-2023.

Data source: (38)

Characteristic	Underweight < -2 SD	Wasting < -2 SD	Stunting < -2 SD
Age in months			
<6	10.3	7.5	15.8
6-11	14.6	7.0	20.2
12-23	20.0	5.5	41.8
24-35	16.5	2.4	46.9
36-47	14.8	1.9	42.7
48-59	13.6	1.8	35.4
Province			
Niassa	17.4	6.5	35.9
Cabo Delgado	18.2	3.3	44.7
Nampula	18.0	3.7	46.7
Zambézia	23.7	6.8	43.7
Tete	12.5	3.4	35.9
Manica	13.9	0.9	39.1
Sofala	12.2	2.8	29.5
Inhambane	6.0	0.3	15.8
Gaza	6.5	1.9	17.7
Maputo Province	1.8	1.2	8.6
Maputo City	4.4	1.5	10.8
Country	15.4	3.8	36.7

SD: Standard Deviation

CI: Confidence Interval

1.2.4. Nutrition Assessment

Undernutrition is mainly observed by weight loss/ growth deficit, repeated infections, reduced appetite, poor concentration, and tiredness.

Different methods can be used to assess the nutrition status, these include clinical assessment, biochemical markers, and anthropometric measurements. In low settings including in emergencies context, the diagnosis of malnutrition (undernutrition and overnutrition) is usually made based on anthropometric examinations. The use of anthropometric examination in the assessment of the nutritional status of individuals is based on the evidence that the growth and maintenance of body dimensions require the presence of optimal nutritional conditions, especially regarding the intake and biological use of calories and proteins (40). Anthropometric indicators can detect cases of malnutrition with reasonable sensitivity and is non-invasive and less expensive (41,42).

Anthropometry is used to monitor the child growth. WHO has defined the standards of child growth according to the age and sex. A multicentric study was implemented from July 1997 to December 2003 to determine the reference values of growth, to the study there were enrolled children from different regions and context across the world (Davis, California, USA; Muscat, Oman; Oslo, Norway; Pelotas, Brazil; neighbourhoods of Accra, Ghana and South Delhi, India), using a longitudinal (sample size of 1737 children) and cross-sectional (sample of 6669) studies (43). The standards obtained from the global study determined the cut-offs based on z-scores (44). Considering the normal distribution, the z-score is measured in terms of standard deviation from the mean. In the matters of anthropometric assessments, the z-score describes a child's measurement in relation to the mean of a standard measurement obtained from the study that was previously explained. Essentially, it indicates how many standard deviations above or below the mean a particular child's measurement is.

The anthropometric measures include:

Weight-for-age, most used index of childhood undernutrition for growth monitoring. Its continuous nature is recoded into categories, using the cut-offs defined in the Table 3, to highlight the underweight in three forms: Severe, Moderate and Mild.

Weight-for-height, a continuous measure of current nutritional status that can be recoded, using the standards cut-offs to highlight the wasting.

Height-for-age, a continuous measure of long-term or chronic nutritional status in children, also classified into categories, highlighting the stunting.

The cut-offs are represented in the Table 3 bellow.

Table 3: WHO cut-off on types of undernutrition based on z-score.

Source (43).

Indicator		z-score cut-off		
		Z-score < -3	-3 Z-score < -2	-2 Z-score < -1
Underweight	Weight-for-Age (WAZ)	Severe	Moderate	Mild
Wasting	Weight-for-Height (WHZ)	Severe	Moderate	Mild
Stunting	Height-for-Age (HAZ)	Severe	Moderate	Mild

In Mozambique additionally to the anthropometric measurements the child clinical conditions also guide the diagnostic and classification of the type of undernutrition. Severe wasting can be classified as following (45,46):

- Marasmus: the most prevalent, here the child is cachectic.
- Kwashiorkor: characterized mainly by the presence of bilateral oedema.
- Marasmic kwashiorkor: the combined form of protein energy malnutrition, characterized by the bilateral oedema presence in a cachectic child.

To ensure that treatment is provided, and rehabilitation is effective the Mozambican Ministry of Health created the nutritional rehabilitation program, as presented in Figure 7 bellow.

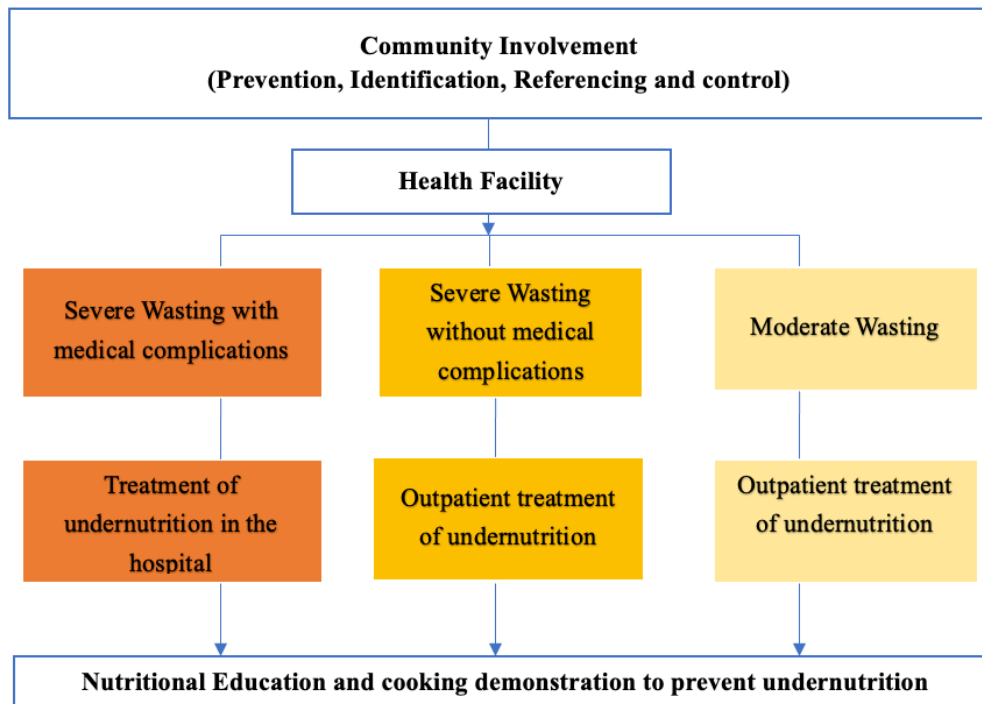


Figure 7: Framework for the nutritional rehabilitation program.

Source: (45)

1.2.5. Actions to achieve better child nutrition

Undernutrition treatment depends on the type and the presence or not of other infections. Prevention of cases is the optimal approach, a wild list of action to achieve optimum nutrition and development status has been discussed over the years. In 2013, black and collaborators proposed a framework on actions to achieve optimum foetal and child nutrition and development.

The framework presents three groups of actions that are directly related to causes of undernutrition, the first group is building an enabling environment. This actions are related to basic causes of undernutrition, the second group is nutrition sensitive programmes and approaches and is related to underlying causes and the last group that is related to immediate causes, is nutrition specific interventions and programmes (25,47).

1.3.Diarrhoea in Children and the association with Undernutrition

1.3.1. Causes of Diarrhoea

“Diarrhoea is defined as the passage of three or more loose or liquid stools per day (or more frequent passage than is normal for the individual). Frequent passing of formed stools is not diarrhoea, nor is the passing of loose, “pasty” stools by breastfed babies” (48).

Diarrhoea can be caused by different microorganisms, parasites, bacteria and virus, the leading cause of diarrhoea in under-five children is Rotavirus (49).

Clinical diarrhoea can be divided into types:

Acute watery diarrhoea (includes cholera) – lasts several hours or days, can cause dehydration and weight loss.

Acute bloody diarrhoea – also called dysentery, can damage the intestinal mucosa, causing sepsis, undernutrition and dehydration.

Persistent diarrhoea – lasts 14 days or longer.

Diarrhoea with severe undernutrition: the main danger is systematic infection, dehydration, heart failure and vitamin and mineral deficiency (48).

There are three main groups of determinants of diarrhoea, socio-demographic, environmental, and behavioural determinants, as represented in Figure 8 (50).

The pathogens that cause diarrhoea are transmitted through various means, including the faecal-oral route, contaminated food and water, person-to-person contact, contact with animals and pets, and touching contaminated surfaces. Therefore, the disease can be prevented through water, sanitation and hygiene (WASH) interventions (51).

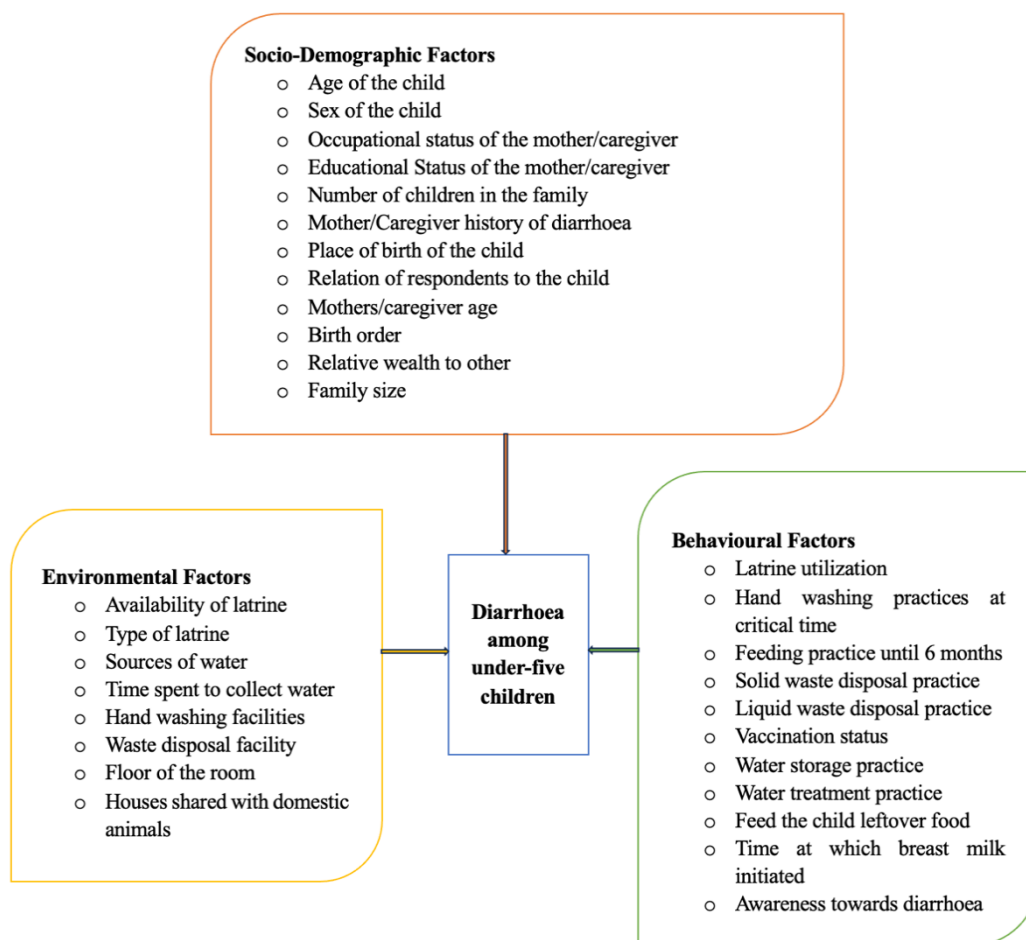


Figure 8: Conceptual framework on determinants of diarrhoea in children under-five.

Source: (50)

1.3.2. Diarrhoea Epidemiology

Although worldwide it has been observed a decrease on under-five child mortality due to diarrhoea between the years of 2000 and 2019, from 12.6% (12.0 - 13.1) to 9.1% (7.9 - 9.9), in 2019 diarrhoea was the second primarily attributable cause of death in children aged 1 to 59 months with 15.7% of deaths [0.45 million (0.37 - 0.51)] (11). It is estimated that every year it kills approximately 525 million under-five children worldwide (52).

Overall, the prevalence of diarrhoea decreased from 2003 to 2022-23, from 14.1% to 9.0%, a huge decrease was observed from year 2008 to year 2011, from 17.6% to 11.1%, in

Mozambique, Figure 9 (35,36,38,53,54). In 2015 it was estimated that the prevalence of diarrhoea in children under-five in Mozambique was 11.0%, being Niassa and Zambézia the provinces with the highest prevalence in the country with 17.2% and 16.9% respectively, and the ages between 6 and 23 months the ones with higher prevalence with a total of 37.5% (55), Table 4.

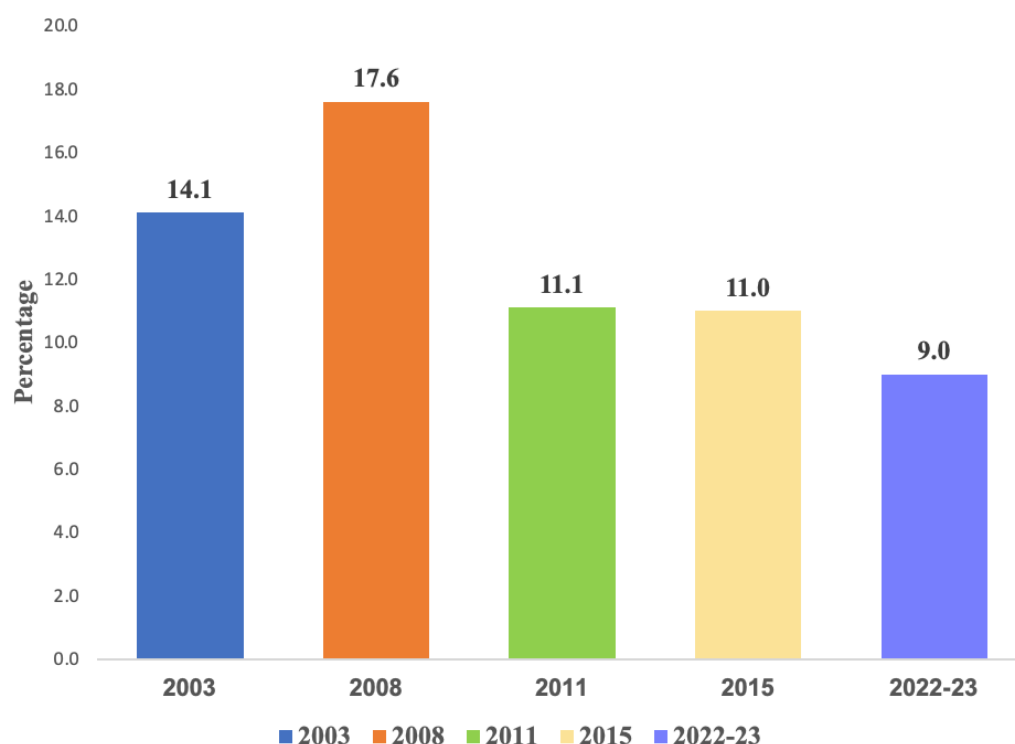


Figure 9: Prevalence of reported diarrhoea in children under-five years old in Mozambique across the years (2003-2023).

Source: (35,36,38,53,54).

Table 4: Prevalence of reported diarrhoea in children under-five in Mozambique, by age and by province, 2015.

Source (54).

Characteristic	Prevalence (%)
<i>Age in months</i>	
<6	5.7
6-11	18.4
12-23	19.1
24-35	10.4
36-47	6.8
48-59	5.6
<i>Province</i>	
Niassa	17.2
Cabo Delgado	9.9
Nampula	11.2
Zambézia	16.9
Tete	6.8
Manica	8.8
Sofala	8.3
Inhambane	7.1
Gaza	11.7
Maputo Province	8.1
Maputo City	10.0
Country	11.0

1.3.3. Disease association impact in LMIC

In low-middle income countries where the prevalence of infectious diseases is higher special in children under-five, it is frequently observed the presence of various infections in the same child.

Based on the analysis performed for the period of 1990 to 2017, undernutrition is a risk factor for leading causes of disease burden, such as, lower respiratory infections, diarrhoea, and neonatal disorders in low SDI countries (6). Undernutrition reduces the ability to fight infections in children under-five, increasing as a consequence the risk of death from preventable and treatable diseases such as malaria, pneumonia and diarrheic diseases (19,56).

As an important underlying cause of death in children under-five years old, undernutrition contributed to 73% of deaths in children with diarrhoea, 47% of deaths in children with measles, 45% of deaths in children with severe neonatal infection and 44% of deaths in children with pneumonia worldwide in 2004 (17).

1.3.4. Undernutrition and diarrhoea infection

Two thirds of deaths in children are attributed to the diarrheic diseases associated with malnutrition worldwide (57). A death from diarrhoea in a child is frequently an indicative of an underlying undernutrition. The relationship between these two pathologies is often described as bidirectional, that is, diarrheic disease significantly affects the nutritional status interfering in intestinal absorption of nutrients, increasing catabolism and sequestration of nutrients necessary for development, it increases the body requirements for nutrients. On the other hand, undernutrition can be a factor that predisposes to the emergence of diarrheic diseases, and this can create a vicious cycle of undernutrition and diarrhoea, Figure 10 (19,28,57,58).

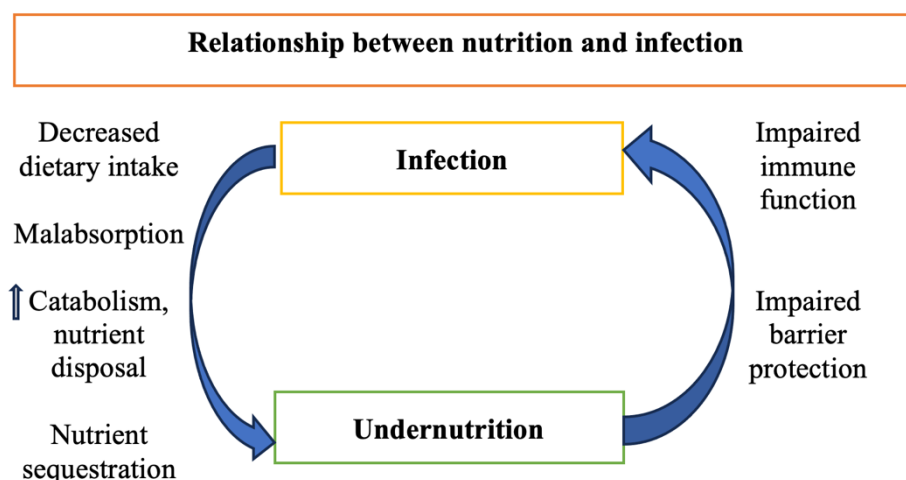


Figure 10: Relationship between nutrition and infection.

Source: (28)

The specific relationship between undernutrition and other infection may vary depending on the infection/illness as illustrated in Table 5.

On a child, the risk of stunting is increased when there are repeated episodes of diarrhoea in the first 2 years (60,61).

Repeated attacks of diarrhoea and infections are reflected in the effectiveness of health interventions to prevent and control diarrhoea itself, general infections and undernutrition (19).

As a consequence of repeated attacks of diarrhoea and other infections, there is an increase in the cost of care provided by the health system (59).

Table 5: Relationship between undernutrition and Acute Respiratory tract Infection (ARI), Diarrhoea, HIV and Malaria.

Infection	Undernutrition effect on infection	Infection effect on undernutrition
Acute Respiratory tract Infection (ARI)	Increasing severity. Increasing risk of death.	Reducing appetite. Increasing metabolic rate resulting in muscle breakdown.
Diarrhoea	Increasing duration.	Reducing absorption. Reducing appetite.
HIV	Increasing severity.	Alteration on metabolic activity.
Malaria	Increasing severity in deficiencies of vitamin A and zinc.	Reducing appetite. Increasing metabolic rate. Destroying red blood corpuscles leading to anaemia. Impairing foetal development leading to low birth weight.

Malnourished children with impaired immunity are most at risk of life-threatening diarrhoea (48).

In Mozambique, diarrhoea and undernutrition in children are an important public health problem, coupled with this, limited access to adequate water and sanitation. In a report

produced by the United Nations Children's Fund (UNICEF) in 2010, it was observed that 51% of children in Mozambique who had low height for age (stunting) had diarrhoea in the two weeks before the research (62). Studies conducted in specific areas of the country reported diarrhoea as a risk factor for child mortality in children under-five and have also highlighted a high burden of diarrhoea and undernutrition as comorbidities in children under-five (63,64).

Although improvements in the survival rate of children have been observed in the last three decades and a reduction in infant mortality of around 59%, from 96 deaths per 1,000 live births in 1990 to 38 deaths in 2019, the number of deaths from diarrhoea remains high and, treatment, correct and timely diagnosis and prevention of undernutrition are pointed out as one of the key factors to prevent a high number of deaths (63,66). As it is observed in undernutrition and diarrhoea separately, socio-economic and clinical factors also play any important role when it comes to co-infection between undernutrition and diarrhoea (31,32).

1.4.The role of health system on child health

1.4.1. Health Systems in Health

Health system, “consists of all organizations, people and actions whose primary intent is to promote, restore or maintain health” (67,68). A health system are all the efforts to influence health determinants, it includes a mother caring for a sick child at home; private providers; behaviour change programmes; vector-control campaigns; health insurance organizations; occupational health and safety legislation, and it includes intersectoral action by health staff (68).

In the SDG 3, ensure health lives and promote well-being for all at all ages, on target 3.8, achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all, it’s clearly addressed the goal for 2030 reinforcing the impact of healthcare and health systems (21). The universal health coverage could prevent 8.6 million deaths per year (10).

Worldwide there are being implemented different models of health systems which are highly context specific, so a model that works in one setting might not work in another one (68). Although different models can be used, WHO proposed a framework that explains what the six building blocks of any health system are because inadequate health systems are an obstacle to scall-up intervention that can make the SDGs achievable (68,69).

On his health systems framework, WHO lists six system building blocks, namely, *i.* service delivery which refers to effective, safe and quality health intervention; *ii.* health workforce that should be responsive, fair, and efficient; *iii.* health information system that ensures production, analysis, dissemination, and use of reliable and timely information; *iv.* medical products, vaccines and technologies that should be of equitable access, high quality, safety, effective and cost-effective; *v.* financing, ensure funds for health; and *vi.* leadership/governance that involves ensuring the existence of strategic policy frameworks (68).

The quality of health systems has a direct impact on population mortality rate, from the 8.6 million deaths that were estimated as amenable to health care in LMIC, 5 million are associated

with poor quality of health care and 3.6 million due to non-utilization of health care (10,69). For health system performance assessment there have been proposed different methods across the years, in each of them having few specificity based on the objective of the assessment (70).

In LMIC such as Mozambique, health systems are far from the desired quality and the lack of care can increase disease morbi-mortality including undernutrition, thus health system quality assessment is crucial to monitor service deliver to ensure quality of care and improve population health (14,69,71).

The capacity and quality of health services is verified by evaluating the availability and readiness of services (72). The evaluation of availability is based on the verification of the existence of services, properly trained human resources, standards, equipment, diagnostic capacity and indicative medicines (73). Readiness is the proper combination of human resources, updated standards of care, and the existence of standards, equipment, diagnostic capacity, and tracer medicines (73).

Over the years, in the field of health system and quality improvement, the Donabedian's framework has been widely used as it has been consider one of the complete models for quality of services assessment (74–76). The model classifies the quality of care in three categories, namely: structure (human resources, infrastructure, guidelines), process (as is done the administration/provision of the health service) and outcome (user satisfaction) (73,74).

Kruk et al, suggested a new conceptual framework for high-quality health systems informed on previous framework in the field of health system and quality improvement and in the field of maternal quality of care (69). The Kruk conceptual framework presents three key domains, namely, foundations, process of care and quality impact (69). The foundations domain includes population, governance, platforms, workforce and tools, the process of care domain includes, competent care and systems, positive user experience, the domain on quality impact includes better health, confidence in system and economic benefit, Figure 11 (69).

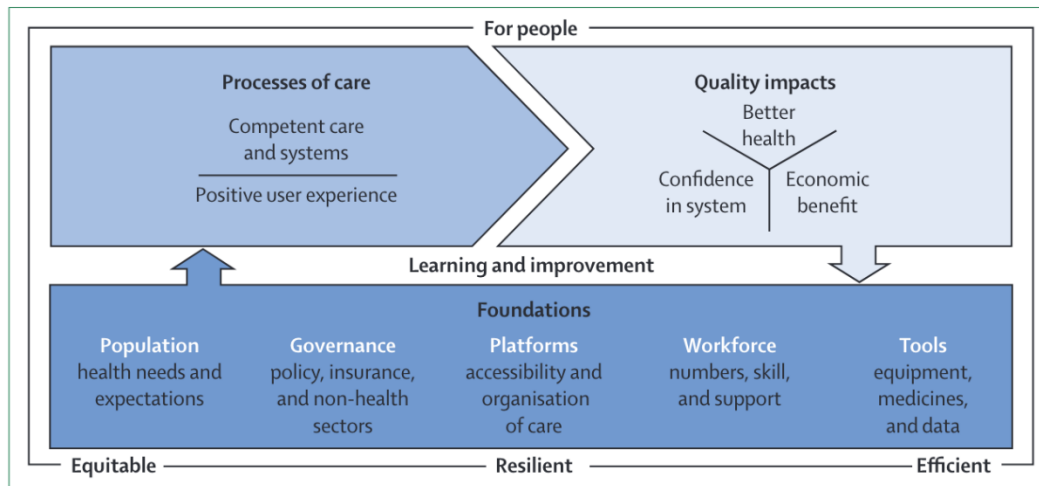


Figure 11: High-quality health system framework.

Source (69).

1.4.2. Mozambique Health System

As a low-income country, access to basic social services in Mozambique remains very low (77). Neonatal mortality in the country accounted for 40% of infant mortality rate in 2016, and its mainly associated with the country's poor health system (77). Additionally, a history of civil war, natural disasters, armed conflict, terrorism, and, more recently the COVID-19 pandemic, exacerbate service disruption in the country, making even more difficult to improve the quality of healthcare system (7,78). In 2019, the government launched the "One District One Hospital" initiative as a strategy to increase the healthcare coverage for the population, in alignment with SDG 3. However, as of May 2023, only 46 out of the 154 districts in the country have a hospital (79,80).

The country health care system has a hierarchical structure in which health facilities are structured in four levels; Primary level, health centers, Secondary level, rural and district hospitals, Tertiary level, general and provincial hospitals and Quaternary level, central hospitals (81). The health centers are classified has urban (with three types based on services provided: type A, B and C) and rural, two types (with two types of services provided I and II) (81).

As per the Alma-Acta declaration, in 1978 Mozambique adopted the primary health approach, and health system governance decentralization started in 2007 (82). According to the service

availability and readiness assessment report from 2018 inventory, there were 1651 registered public health facilities in the country, from the 1643 included in the inventory, 92% provide nutrition diagnosis and treatment services (83). In terms of human resources, it was reported a ratio of six health workers per 10.000 habitants, being nurses the most available category with 87% (83).

It was reported that the access and utilization of health facilities increased in the country from 2014/15 to 2019/20, being higher in the urban area and for people in the wealth quintile 5 (8).

The resource for the health sector is allocated by the Ministry of Finance and the Ministry of Health. The sector is also characterized by a multiplicity and diversity of multilaterals and bilateral partners (77,84).

Health aid is mainly supported by vertical programs and, consequently, vertical funding. Diseases with high burden in the country, such as malaria, HIV and tuberculosis, are prioritized in this type of aid funding (85–87). Although many concerns are raised around disease-centered programs due to the fact that these programs often focus on specific diseases or conditions and present potential drawbacks related to the need for significant resources allocation, fragmented care, lack of a holistic approach, inequity in healthcare, and unsustainable funding, and they might fail to address complexity of patients by ignoring comorbidities, they can still have an impact toward equitable distribution of maternal, neonatal and child health outcomes (85,86,88).

In 1992, the World Health Organization (WHO) and UNICEF created Integrated Management of Childhood Illness (IMCI), a strategy that seeks to improve management skills of the main causes of morbidity and mortality in children, improve the health system and address the issue of family and community practices for health. Mozambique is one of the countries implementing this strategy. The strategy is mainly based on primary health care and has become a fundamental strategy for the survival of children in almost all countries in the African region who are implementing the strategy (89,90). As pictured in Figure 12 the strategy has three components, organizational, clinical, and community. These components are related to the availability of essential medicines, supplies and strategy supervision, staff training, monitoring and vocation, and mother and caregiver education and community promotes, all aimed to reduce mortality and improve health including nutrition (89,91).

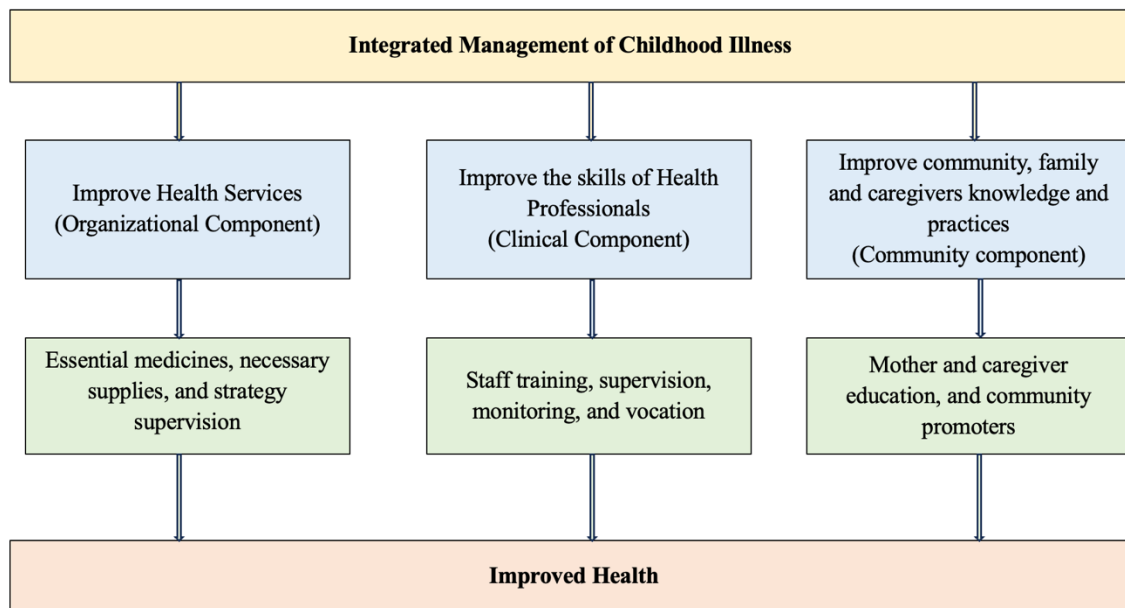


Figure 12: Outline of the integrated management for childhood illness impact model.

Source (89).

In April 2021, the government approved the country health policy that incorporates global health agenda principles, the policy has three pillars, well-being and lifestyle, access and utilization of health services and health in all policies (92).

All type of strategies and/or actions need to be monitored for quality assessment and accountability. As stated in the WHO health system building blocks, a well-functioning information system that ensures the production, analysis, dissemination and use of reliable and timely information on health determinants, health systems performance and health status is crucial for monitoring health indicators and influence health determinants (68,69).

In terms of source of information survey and specific assessments, are one of the best study design to obtain reliable information on quality of health system, but due to the workload, time consuming an high cost associated to them, their yearly implementation it's not feasible (93,94).

In Mozambique, the health information system has hierarchical design. In 2018, 80% of the districts had electronic health information system, the national health management information system (HMIS) was first designated *Módulo Básico*. In 2016 the information system

transitioned to DHIS-2, District Health Information System, version 2, named *Sistema de Informação de Saúde para Monitoria e Avaliação* (SIS-MA) (95). Both systems were implemented to provide Mozambican routine data for health services monitoring and improvement (96,97).

One of the major concerns on routine data is the quality of the data. In order to assess the quality, and overcome the issue, WHO has designed guidelines on routine data quality review, these guidelines allow to assess the quality of data focusing in three modules, i. framework metrics, ii. desk review of data quality and iii. data verification and assessment system (98–100).

1.5. Justification

There is a growing interest in combating all types of undernutrition worldwide, and especially in developing countries. This includes ensuring that cases of undernutrition are treated effectively to secure full recovery and, where possible, without any long-term complications. For the proper management of cases, it is crucial that the diagnosis of pathologies in children are accurately and promptly made, as undiagnosed undernutrition increases the risk of complications and entails increased costs for the health system (90–92).

Mozambique has developed and approved guidelines for the treatment of undernutrition and nutritional rehabilitation for children and adults (26). To reduce the impact of undernutrition, Mozambique has endorsed both single- and multisectoral action plans and strategies. One of the primary action plans is the Multisectoral Action Plan for the Reduction of Chronic Malnutrition in Mozambique 2010-2015/2020 (PAMRDC), which was approved by the Ministry of Health (102). This plan outlines seven strategic objectives, including (i). nutritional activities directed to children in the first two years of life, and (ii). strengthen the capacity of human resources in nutrition (102).

These strategies aim to support the achievement of the SDGs, with a focus on targets for eliminating all forms of undernutrition and eliminating preventable deaths in children under-five by 2030.

One strategy that is expected to have a significant impact on reducing mortality in children under-five years of age in Mozambique is the integrated management of diseases in this age group. Consequently, it is important to assess the effective implementation of the strategy in routine hospital care in Mozambique (89,91,103).

A study conducted in Tanzania showed that health professionals rarely manage diseases in an integrated manner. In most cases, health professionals focus solely on the cause of disease identified in the primary diagnosis (106). Another concern is that some undernourished patients are undertreated because their condition is not recognized by physicians, while other hospital patients in critical condition are difficult to treat (20). Barker et al. recommend implementing mandatory nutritional screening to effectively reduce the incidence of undernutrition (14).

Furthermore, health systems should be of high quality in providing health services, which includes being well-prepared and having robust monitoring systems that can help inform decision-making (69). The quality of health systems directly reflects the health of the population (10). A LMIC with a high burden of disease often faces limitations on quality of services provided across all dimensions.

The points stated here underscore the importance to evaluating the management of diseases that are commonly associated, such as undernutrition and diarrhoea, in children under-five years of age, ranging from the burden of the association to the quality of care.

Through this study, it will be possible to determine the frequency of undernutrition in children under-five years of age with diarrhoea and identify commonly associated factors to ascertain the significance of the disease. Additionally, the study will provide evidence on the capacity of the national health system to provide care for the management of undernutrition in children treated for undernutrition and/or diarrhoea. Finally, the study will offer insights into whether the health indicators can be used to monitor health services and develop strategies to improve the management of these two diseases.

1.6. Research Questions

- a. What is the frequency of undernutrition and associated in children under-five years of age with diarrhoea, treated at health facilities in Maputo, Zambezia and Nampula province?
- b. What is the capacity of health facilities across the country to manage cases of undernutrition in children under-five years of age associated or not with diarrhoea?
- c. Can Mozambican routine data be used to monitor nutrition and diarrhoea services for children under-five?

1.7.Objectives

1.7.1. General Objective

Assess the management of undernutrition cases in children under-five years of age treated with diarrhoea in Mozambique between 2015 and 2021.

1.7.2. Specific Objectives

- i. Estimate the frequency of undernutrition cases and associated factors in children under-five years of age with diarrhoea treated at health facilities in Maputo, Zambezia and Nampula provinces, from 2015 to 2019.
- ii. Assess the capacity of health facilities across the country to manage cases of undernutrition in children under-five years of age associated on not with diarrhoea.
- iii. Estimate the quality of routine data to monitor nutrition and diarrhoea services for children under-five.

1.8. Thesis Framework

In Figure 13, is represented the thesis framework, establishing the relationship between the general and specific objectives, the research question, and the studies/papers that address these questions and objectives. The first research question was answered by analysing data from the national surveillance of diarrhoea, which included data from the provinces of Maputo, Zambézia, and Nampula, collected between 2015 and 2019. These analyses were conducted to assess the burden of undernutrition in children under-five years of age, who have diarrhoea, across five sentinel sites throughout the country. These sites represent the three main regions of the country, and the analysis focused on potential factors that might be associated with undernutrition. A paper detailing the results of these analyses has been published and showed that the frequency of undernutrition in children with diarrhoea was high, being the province, caregiver education level, the wet season, child's birthweight and HIV status the factors associated with undernutrition with diarrhoea.

The second research question was addressed by using data from the Service Availability and Readiness Assessment conducted in 2018 across all public health facilities from Mozambique, as well as data from a Nutrition Service Assessment carried out in 2021 in the provinces of Maputo, Zambézia, and Nampula. A paper was published that aimed to assess the structural availability and readiness of health facilities to provide nutrition and diarrhoea services to children suffering from undernutrition and/or diarrhoea. The results showed that nutrition services are positively associated with diarrhoea service readiness, and none of the health facilities can be considered ready (100%).

The third research question was answered through an analysis of routine data from the period of 2017 to 2021 from across the country, which was obtained from the Mozambican Health Information System. A paper with the results was published. The analysis aimed to evaluate the quality of routine data on nutrition and diarrhoea services for children under-five years of age in Mozambique. The analysis revealed significant deficits in quality of routine data for selected indicators, underscoring the need for improved data monitoring and evaluation, as well as the development of strategies to maintain quality.

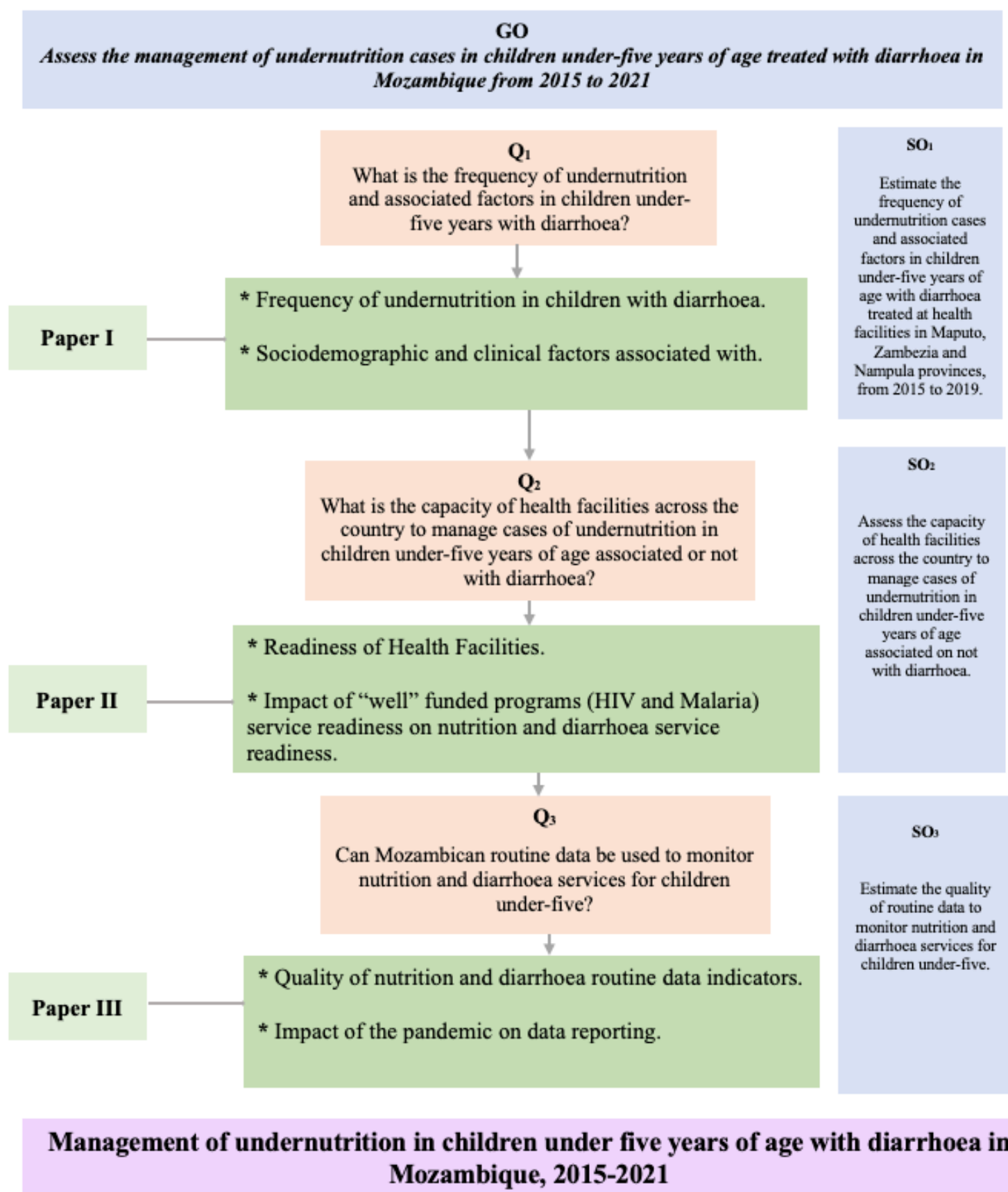


Figure 13: Thesis framework (objectives, research question and papers/manuscripts).

GO: General Objective; **SO:** Specific Objective; **RQ:** Research Question.

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2. RESULTS

RESULTS

2.1.Paper I. Characterizing Undernourished Children Under-Five Years Old with Diarrhoea in Mozambique: A Hospital Based Cross-Sectional Study, 2015–2019

Reference:

Sambo J, Cassocera M, Chissaque A, Bauhofer AFL, Roucher C, Chilaúle J, et al. Characterizing Undernourished Children Under-Five Years Old with Diarrhoea in Mozambique: A Hospital Based Cross-Sectional Study, 2015–2019. *Nutrients* [Internet]. 2022 Jan [cited 2022 Mar 18];14(6):1164. Available from: <https://www.mdpi.com/2072-6643/14/6/1164>

Article

Characterizing Undernourished Children Under-Five Years Old with Diarrhoea in Mozambique: A Hospital Based Cross-Sectional Study, 2015–2019

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Citation: Sambo, J.; Cassocera, M.; Chissaque, A.; Bauhofer, A.F.L.; Roucher, C.; Chilaúle, J.; Cossa-Moiane, I.; Guimarães, E.L.; Manhique-Coutinho, L.; Anapakala, E.; et al. Characterizing Undernourished Children Under-Five Years Old with Diarrhoea in Mozambique: A Hospital Based Cross-Sectional Study, 2015–2019. *Nutrients* **2022**, *14*, 1164. <https://doi.org/10.3390/nu14061164>

Academic Editor: Ya-Jun Chen

Received: 24 January 2022

Accepted: 6 March 2022

Published: 10 March 2022

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Abstract: Diarrhoea is associated with undernutrition and this association is related to increased morbidity and mortality in children under-five. In this analysis we aimed to assess the frequency and associated factors of undernutrition in children under-five with diarrhoea. A hospital-based cross-sectional study was conducted from January 2015 to December 2019 through a surveillance system in five sentinel hospitals in Mozambique. Sociodemographic and clinical information was collected, including anthropometry. A total of 963 children were analysed. The overall undernutrition frequency was 54.1% (95% CI: 50.9–57.2), with 32.5% (95% CI: 29.6–35.5) stunting, 26.6% (95% CI: 23.9–29.6) wasting and 24.7% (95% CI: 22.1–27.5) underweight. Children from Nampula province had 4.7 ($p = 0.016$) higher odds for stunting compared with children from Maputo. Children whose caregiver was illiterate had higher odds of being underweight 5.24 ($p < 0.001$), and the wet season was associated with higher odds 1.70 ($p = 0.012$) of being wasted. Children born under 2500 g of weight had 2.8 ($p = 0.001$), 2.9 ($p < 0.001$) and 2.6 ($p = 0.010$) higher odds for being underweight, wasted and stunted, respectively. The HIV positive status of the children was associated with higher odds of being underweight 2.6 ($p = 0.006$), and stunted 3.4 ($p = 0.004$). The province, caregiver education level, wet season, child's birthweight and HIV status were factors associated with undernutrition in children with diarrhoea. These findings emphasise the need for additional caregiver's education on the child's nutrition and associated infectious diseases. More studies are needed to better understand the social context in which a child with diarrhoea and undernutrition is inserted.

Keywords: children; diarrhoea; undernutrition; associated factors; Mozambique

1. Introduction

Diarrhoea is one of the main causes of child morbidity and mortality in developing countries [1] and undernutrition is one of the most important risk factors for this illness

globally [2]. In 2019, diarrhoea was the third leading cause of death in children under-five years old with 9.9% of deaths worldwide [3]. In Mozambique, diarrhoea remains a great public health challenge, despite the efforts to reduce its burden in the last two decades [4]. In 2017, it was the fourth major cause of mortality in children under-five years old and responsible for approximately 6.9% of deaths in this age group [4,5]. According to data from a health survey conducted in Mozambique in 2015, the national prevalence was estimated at 11% and higher percentages were observed in children aged 6–11 months and 12–23 months with 18.4% and 19.1%, respectively [6].

Undernutrition in children was shown to increase the risk of occurrence of infectious diseases, death and delayed cognitive development, that can lead to low adult incomes, poor economic growth and an intergenerational transmission of poverty [7]. Globally in 2019, it was estimated that 149 million (21.9%) under-five years old children were stunted and 49.5 million (7.3%) were wasted [8,9]. In 2018, it was estimated that Africa contributed with one third of the stunted cases in children under-five [9]. In Mozambique, in 2015, it was estimated that 42.3% of children under-five years old were stunted, 15.6% were underweighted and 4.4% wasted [10–12].

Undernutrition and diarrhoea have a bidirectional association [13]. Diarrhoeal disease significantly affects the nutritional status by interfering with the intestinal absorption of nutrients, and, on the other hand, undernutrition might be a predisposing factor to the onset of diarrhoeal diseases by inducing an alteration of the host's immunity [13,14]. Both pathologies in the same child significantly increases the risk of a child's death [7,15,16].

Many socio-economic and clinical factors can contribute to the development of diarrhoeal disease and undernutrition [14,16,17]. In Mozambique, in 2014, 48% of the population was living in poverty [18]. In 2010, UNICEF, reported that 51% of Mozambican children under-five years old with a low height for age (stunting) had diarrhoea in a maximum period of two weeks prior to the data collection [19]. Moreover, studies conducted in the Manhica district, a rural area of southern Mozambique, reported a high burden of diarrhoea and undernutrition in under-five years old children [20]. Diarrhoea was also identified as one of the risk factors for mortality in children severely undernourished [14].

Several factors have been related to child undernutrition such as the level of education of the caregiver [17]. Moreover, several studies have reported that poor access to clean water and unimproved sanitation are factors associated with undernutrition and diarrhoea, increasing the probability of the child's death [7,15,16].

Clinical factors such as birth weight are commonly described as being associated with diarrhoeal infection and undernutrition [8,21]. In 2015, 20.5 million (14.6%) children were born with a low birth weight [8]. Besides a low birth weight, parasitic infection is also associated with undernutrition in children [1,22]. Another clinical factor to consider when studying diarrhoea and undernutrition is the Human Immunodeficiency Virus (HIV) infection. HIV is one of the leading health problems in Mozambique [14,20] and in 2009, the prevalence of HIV was 2.3% in children under 12 months of age and 1.7% in children between 1 to 4 years old [23]. A study conducted in 2010 in the Manhica district, southern Mozambique, showed that stunting (57%), and developmental delay (44%) were high in children under-fifteen years old who were HIV positive, compared to those HIV negative [24]. Another study in children under-five, in the same area, showed that the occurrence of moderate-to-severe diarrhoea among HIV positive patients carried a worse prognosis [14].

In Mozambique, diarrhoea and undernutrition in children are major public health problems [14,20]; however, most of the studies conducted in the country estimated the occurrence of diarrhoea and undernutrition in the south of the country, or only reported an association between undernutrition and diarrhoea caused by a specific pathogen [14,20,22,24,25].

Our study aims to assess the burden of undernutrition in children under-five with diarrhoea in five sentinel sites across the country, representing the three main regions of the country and the potential factors that might be associated with undernutrition conditions.

2. Materials and Methods

2.1. Study Design and Population

This study uses the data of children under-five enrolled in the National Surveillance of Diarrhoea (ViNaDia). The data was collected from January 2015 to December 2019 in five sentinel sites across the three regions of the country. In the Southern region, Hospital Geral de Mavalane (HGM), Hospital Geral José Macamo (HJM) and Hospital Central de Maputo (HCM) in Maputo city; in the Centre, Hospital Geral de Quelimane (HGQ), in the Zambézia province; and in the North, Hospital Central de Nampula (HCN), in the Nampula province.

Children from 0 to 59 months admitted as inpatients or outpatients with diarrhoea disease were invited to the surveillance through their caregiver. Diarrhoeal disease was defined as the passage of three or more loose or liquid stools in the last 24 h [22,25,26].

2.2. Case Report Form

For all eligible children whose legal guardian consented to their inclusion in the surveillance, a case report form (CRF) was filled with sociodemographic and clinical variables. The socio-demographical information of the children was obtained from the child's caregiver, and the clinical data (malaria, pneumonia, child's HIV status, and others) was collected from the patient report filled by the clinicians and collected from the child health card.

2.3. Anthropometric Measurements

Anthropometric measurements (weight and height/length) were performed on each child by trained nurses. Children's weight was taken naked or in light clothing. For children under two years of age, weight was measured while the child was lying down or by subtracting the weight of the mother from the weight of the mother with her child when the appropriate scale for babies was not available in the health facility. The length of children under two years or those unable to stand alone, was measured in a recumbent position lying down. The height of children aged two or older was measured while standing.

Undernutrition was defined as (i) stunting (height-for-age (HAZ) z-score < -2), (ii) wasting (weight-for-height (WHZ) z-score < -2), and (iii) underweight (weight-for-age (WAZ) z-score < -2), according to the World Health Organization (WHO) guidelines [27]. Children were considered well-nourished or overweight if their z-scores for WAZ, HAZ, and WHZ were ≥ -2 . Children who presented outlier Z-scores were excluded from the analysis [28].

2.4. Sample Collection and Laboratory Procedures

A single faecal sample was collected per child for laboratory analysis to test the presence of intestinal parasites. The samples were collected from children to the sample collector receptacle, kept refrigerated in cooler boxes, and then sent to the parasitology reference laboratory at the *Instituto Nacional de Saúde* (INS) in Maputo. Faecal specimens from sentinel sites outside Maputo province were kept at $-20\text{ }^{\circ}\text{C}$ until shipment for laboratory analysis.

The presence of parasites was examined by light microscopy using a formol-ether concentration method (protozoans and helminths) and the Modified Ziehl–Neelsen stain was used for opportunistic parasites, namely, *Cryptosporidium* spp., *Cyclospora cayetanensis* and *Cystoisospora belli* [29]. A child was considered positive if at least one parasite was detected by either method. Microscopy results were validated after the slides were read by two independent technicians. In the case of disagreement, an additional reading was made by a third laboratory technician.

2.5. Statistical Analysis

The CRF data and the laboratory results were introduced in Epi Info™ V3.5.1 (Centers for Disease Control and Prevention, Atlanta, GA, USA, 2008) by double entry, and exported

to IBM SPSS software (Statistical Package for the Social Science, Armonk, NY, USA: IBM Corp, 2011, version 27.0, Chicago, IL, USA). To assess the nutritional status of the children, the Z-scores were calculated using the software, Anthro V.3.2.2, recommended by the WHO [30]. The proportions of stunting, wasting and underweight were estimated through a 95% confidence interval (95% CI) based on the Wilson method, using the EpiTools [31]. Descriptive analyses for qualitative variables were summarized by absolute (n) and relative (%) frequencies. The asymmetric quantitative variables (e.g., the child's age) were described using median and interquartile intervals. Stunting, wasting and underweight were also used as dependent variables in multiple logistic regression models. The fitted models included explanatory variables (caregiver education level, mother's marital status, child's caregiver, caregiver age, type of house, piped water, treated water, season, number of family members, birthweight, someone with diarrhoea at home in prior seven days, malaria, pneumonia, parasitic infection, immunization, and child HIV) with a *p*-value below 0.20 in chi-square/Fisher's exact tests or other relevant epidemiological variables (child's age, child's sex, province, and study year). The Hosmer–Lemeshow test was used for goodness of fit for the logistic regression models. Cox and Snell R square coefficients were calculated to fitted multiple models. Adjusted Odds ratios, with a corresponding 95% CI, were obtained to quantify the magnitude of the associations. A *p*-value < 5% was fixed as the criteria for statistical significance.

3. Results

During the study period, 2256 children from 0 to 59 months old with diarrhoea were enrolled, from which 1010 were excluded due to a lack of data to calculate the z-score (sex, weight, or height) to identify their nutritional status. Based on the children's anthropometric measurements, the Anthro software by the WHO flagged a total of 283 z-score outliers, and they were also excluded from the analysis. The overall final sample size was 963 children (Figure 1). From the 963 children included, 59.6% (574/963) were male, and the median age was 12 months (IQR 9.0–19.0). The overall frequency of undernutrition was 54.1% ((521/963); 95% CI: 50.9–57.2).

Among the 963 children, 32.5% ((313/963); 95% CI: 29.6–35.5) were stunted, 26.6% ((256/963); 95% CI: 23.9–29.6) wasted and 24.7% ((238/963); 95% CI: 22.1–27.5) underweight (Figure 1). An overlap was observed, with 5.7% ((55/963); 95% CI: 4.4–7.4) between underweight, wasting and stunting, 9.4% ((85/963); 95% CI: 7.8–11.5) between underweight and wasting, and 8.3% ((85/963); 95% CI: 7.1–10.8) between underweight and stunting.

3.1. Frequency of Undernutrition Status across Years and Sociodemographic Characteristics

Although no significant differences were found in the proportion of children with undernutrition by year, decreases of the percentage of underweight [30.0% (36/120) in 2015 to 25.2% (35/139) in 2019], wasted [32.5% (39/120) to 20.9% (29/139)] and stunted [35.0% (42/120) to 32.4% (45/139)] were observed in children between 2015 and 2019, respectively. For stunting, the decrease was 2.6% in this period (Figure 2).

Among the provinces, significant differences were found regarding the percentage of underweight (*p* < 0.001) and stunted (*p* < 0.001) children (Figure 3). Compared with Maputo (20.4%; 127/624), the Zambézia and Nampula provinces presented higher frequencies of underweight children—35.9% (28/78) and 31.8% (83/261), respectively—and of stunting—47.4% (37/78) and 49.0% (128/261), respectively. Frequencies of wasting were similar among the three provinces (*p* = 0.660) (Figure 3).

Table 1 gives a general description of the sociodemographic characteristics from the children with diarrhoea per type of undernutrition; underweight, wasting, and stunting. Additionally, for the children's age (in months), a median of 13 months was obtained in all types of undernutrition (IQR 9.0–20.0 for underweight and for stunting), (IQR 8.0–20.0 for wasting).

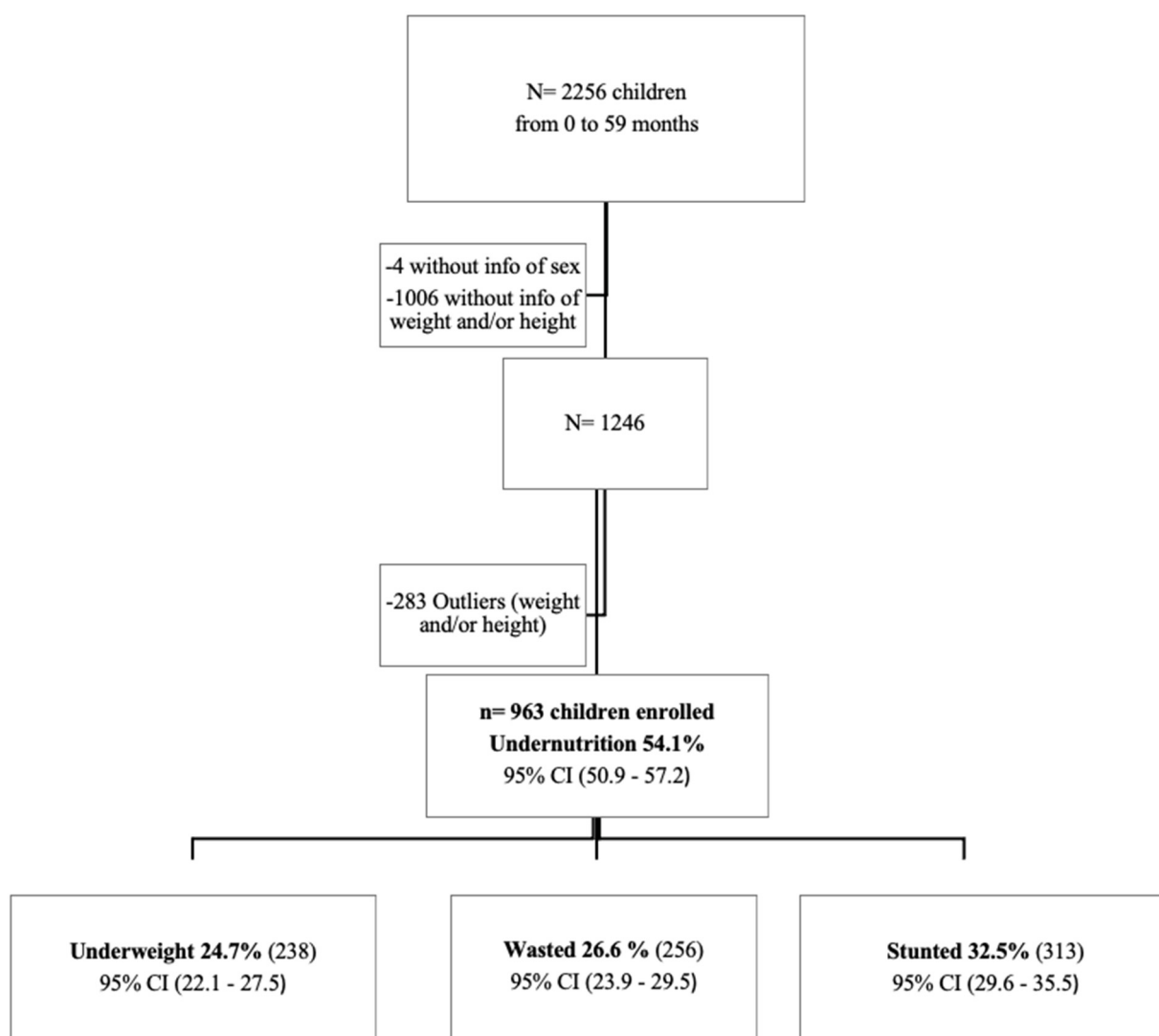


Figure 1. Flow diagram of children enrolled for the analysis and their nutritional status.

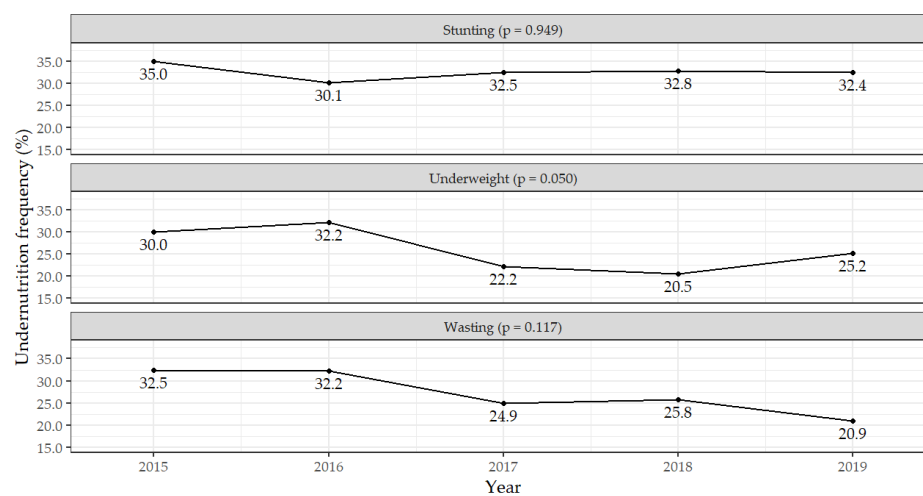


Figure 2. Frequency of undernutrition type in children by year of admission.

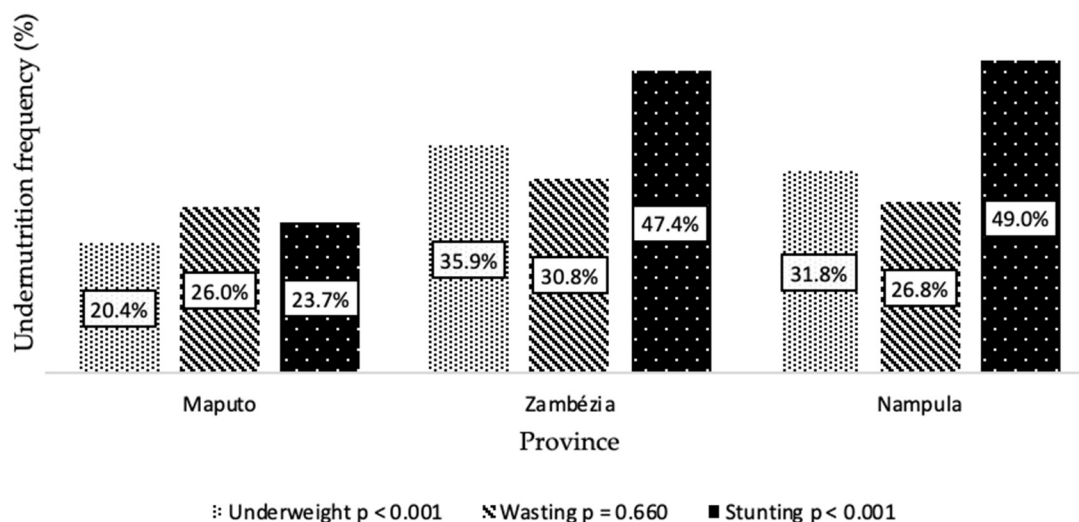


Figure 3. Frequency of different undernutrition status in children by provinces.

As presented in Table 1, underweight was more frequent in children whose caregiver was illiterate (48.4%, $p < 0.001$), and in children living in a house made of other types of material than reed, mud and brick (66.7%, $p < 0.001$). Underweight was also more frequent in children living in a household with no piped water (30.7%, $p < 0.001$).

Similarly, wasting was observed more frequently in children whose caregiver was illiterate (38.5%, $p = 0.019$), living in a house made of other types of material (55.6%, $p = 0.045$) different from reed, mud and brick. Wasting was also more frequent during the wet season (31.4%, $p = 0.003$).

Stunting was more frequent in children whose caregiver had no formal education (48.4%, $p = 0.002$), married/co-habitation mothers (35.6%, $p = 0.005$), and children living in a house made by mud (52.1%, $p < 0.001$). Stunting was also more frequent in children without access to piped water (40.8%, $p < 0.001$), and children living in a household with five or more family members (35.5%, $p = 0.047$) (Table 1).

3.2. Clinical Characteristics

Table 2 shows that underweight (38.4%, $p < 0.001$) and wasting (39.3%, $p = 0.001$), were more frequent in children born with low weight than children born with normal weight (≥ 2500 g). Underweight (52.2%, $p < 0.001$), wasting (47.8%, $p < 0.001$) and stunting (55.2%, $p < 0.001$) were more frequent in children HIV positive than in children HIV negative. Underweight was also more frequent in children with an enteric parasitic infection (35.5%, $p = 0.028$).

3.3. Factors Associated with Nutritional Status in Children with Diarrhoea

Table 3 shows the selected models for each type of undernutrition. Cox and Snell R square values were 0.146 for underweight, 0.091 for wasting, and 0.151 for stunting.

Children from the Nampula province had 4.7 (OR: 4.68, 95% CI: 1.63–13.41; $p = 0.016$) higher odds for stunting compared to children from Maputo.

Children whose caregiver had no formal education were 5.2 times (OR = 5.16, 95% CI: 2.39–11.13; $p < 0.001$) more likely to become underweight when compared with those whose caregiver had a secondary or higher education. Children whose caregiver was younger (<21 years) were less likely to be wasted (OR = 0.45, 95% CI: 0.22–0.91; $p = 0.044$).

The wet season was associated with 1.7 (OR = 1.70, 95% CI: 1.12–2.56; $p = 0.012$) higher odds for wasting when compared to the dry season.

Table 1. Sociodemographic characteristics of the study children for the total sample and frequencies of underweight, wasting, and stunting for each category.

Characteristic		Total		Underweight		<i>p</i> -Value	Wasting		<i>p</i> -Value	Stunting		<i>p</i> -Value
Total		n	(%)	n	(%)		n	(%)		n	(%)	
		963	100	238	24.7		256	26.6		313	32.5	
Sex						0.350 ^a			0.813 ^a			0.733 ^a
	Male	574	59.6	148	25.8		151	26.3		189	32.9	
	Female	389	40.4	90	23.1		105	27.0		124	31.9	
Child age group (in months)						0.398 ^a			0.866 ^a			0.080 ^a
	0–5	65	6.7	13	20.0		20	30.8		12	18.5	
	6–11	365	37.9	84	23.0		94	25.8		120	32.9	
	12–23	374	38.8	95	25.4		99	26.5		124	33.2	
	24–59	159	16.5	46	28.9		43	27.0		57	35.8	
Caregiver Education Level						<0.001 ^a			0.019 ^a			0.002 ^a
	No education	91	9.4	44	48.4		35	38.5		44	48.4	
	Primary	369	38.3	95	25.7		99	26.8		122	33.1	
	Secondary/higher	495	51.4	98	19.8		120	24.2		146	29.5	
	Missing	8	0.8	-	-		-	-		-	-	
Mother's marital status						0.544 ^b			0.788 ^b			0.005 ^b
	Single	287	29.8	65	22.6		80	27.9		72	25.1	
	Married/co-habitation	637	66.1	163	25.6		167	26.2		227	35.6	
	Divorced/widower	13	1.3	4	30.8		4	30.8		4	30.8	
	Missing	26	2.7	-	-		-	-		-	-	
Child's caregiver						0.333 ^a			0.567 ^a			0.213 ^a
	Mother	870	90.3	220	25.3		235	27.0		289	33.2	
	Others	83	8.6	17	20.5		20	24.1		22	26.5	
	Missing	10	1.0	-	-		-	-		-	-	
Caregiver age (in years)						0.319 ^a			0.129 ^a			0.253 ^a
	<21	162	16.8	43	26.5		43	26.5		61	37.7	
	21–30	537	55.8	121	22.5		130	24.2		166	30.9	
	>30	241	25.0	65	27.0		75	31.1		75	31.1	
	Missing	23	2.4	-	-		-	-		-	-	
Type of house						<0.001 ^b			0.045 ^b			<0.001 ^b
	Reed	45	4.7	20	44.4		16	35.6		16	35.6	
	Mud	219	22.7	77	35.2		65	29.7		114	52.1	
	Brick	674	70.0	132	19.6		167	24.8		175	26.0	
	Others	9	0.9	6	66.7		5	55.6		3	33.3	
	Missing	16	1.7	-	-		-	-		-	-	
Piped water						<0.001 ^a			0.101 ^a			<0.001 ^a
	Yes	540	56.1	106	19.6		131	24.3		141	26.2	
	No	407	42.3	125	30.7		119	29.1		167	40.8	
	Missing	16	1.7	-	-		-	-		-	-	
Treated water						0.452 ^a			0.094 ^a			0.145 ^a
	Yes	349	36.2	89	25.5		80	22.9		122	35.0	
	No	503	52.5	117	23.3		141	28.0		152	30.2	
	Missing	111	11.5	-	-		-	-		-	-	
Season						0.066 ^a			0.003 ^a			0.911 ^a
	Wet	424	44.0	117	27.6		133	31.4		137	32.3	
	Dry	539	56.0	121	22.4		123	22.8		176	32.7	
Family members in household						0.794 ^a			0.563 ^a			0.047 ^a
	<5	435	45.2	110	25.3		115	26.4		127	29.2	
	≥5	422	43.8	110	26.1		119	28.2		150	35.5	
	Missing	106	11.0	-	-		-	-		-	-	

^a: Chi-square test; ^b: Fisher's exact test; Bold: Significant *p*-values.

Table 2. Clinical characteristics of children and frequency of undernutrition status by category.

Characteristic	Total		Underweight		p-Value	Wasting		p-Value	Stunting		p-Value
Total	N	(%)	N	(%)		N	(%)		N	(%)	
	963	100	238	24.7		256	26.6		313	32.5	
Birthweight					<0.001^a			0.001^a			0.116 ^a
<2500 g	112	11.6	43	38.4		44	39.3		43	38.4	
≥2500 g	749	77.8	165	22.0		179	23.9		232	31.0	
Missing	102	10.6	-	-		-	-		-	-	
Someone with diarrhoea at home (Last 7 days)					0.255 ^a			0.582 ^a			0.603 ^a
Yes	113	11.7	33	29.2		33	29.2		38	33.6	
No	763	79.2	185	24.2		204	26.7		238	31.2	
Missing	87	9.0	-	-		-	-		-	-	
Malaria					0.080 ^a			0.159 ^a			0.544 ^a
Yes	58	6.0	20	34.5		20	34.5		21	36.2	
No	887	92.1	215	24.2		231	26.0		287	32.4	
Missing	18	1.9	-	-		-	-		-	-	
Pneumonia					0.784 ^b			1.000 ^b			0.343 ^a
Yes	18	1.9	5	27.8		5	27.8		4	22.2	
No	930	96.6	230	24.7		247	26.6		305	32.8	
Missing	15	1.6	-	-		-	-		-	-	
Parasitic Infection					0.028^a			0.254 ^a			0.194 ^a
Positive	93	9.7	33	35.5		30	32.3		37	39.8	
Negative	661	68.6	164	24.8		176	26.6		218	33.0	
Missing *	209	21.7	-	-		-	-		-	-	
Immunization					0.226 ^a			0.548 ^a			0.615 ^a
Yes	801	83.2	193	24.1		211	26.3		259	32.3	
No	157	16.3	45	28.7		45	28.7		54	34.4	
Missing	5	0.5	-	-		-	-		-	-	
Child HIV status					<0.001^a			<0.001^a			<0.001^a
Positive	67	7.0	35	52.2		32	47.8		37	55.2	
Negative	630	65.4	127	20.2		148	23.5		166	26.3	
Missing	266	27.6	-	-		-	-		-	-	

* Sample was not analysed due to quality issue, or no sample was collected. ^a: Chi-square test; ^b: Fisher's exact test; Bold: Significant p-values.

Children whose birthweight was less than 2500 g were 2.8 (OR = 2.75, 95% CI: 1.53–4.95; $p = 0.001$), 2.7 (OR = 2.73, 95% CI: 1.57–4.76; $p < 0.001$) and 2.6 (OR = 2.64, 95% CI: 1.26–5.50; $p = 0.010$) times more likely to be underweighted, wasted and stunted, respectively, than children whose birthweight was 2500 g or more.

The odds of being underweighted and stunted were 2.6 (OR = 2.64, 95% CI: 1.33–5.26; $p = 0.006$) and 3.4 (OR = 3.37, 95% CI: 1.46–7.80; $p = 0.004$) times higher for HIV positive children than for those with a negative status for HIV, respectively.

Table 3. Adjusted odds ratio and corresponding confidence interval obtained through multiple logistic regression models for each undernutrition status of children.

Characteristic	Underweight		Wasting		Stunting	
	OR (95% IC)	p-Value	OR (95% IC)	p-Value	OR (95% IC)	p-Value
Year		0.100		0.223		0.126
2015	4.71 (1.40–15.83)	0.012	3.30 (0.97–11.22)	0.560	4.76 (1.11–20.42)	0.036
2016	1.32 (0.63–2.79)	0.466	1.55 (0.75–3.22)	0.238	0.68 (0.28–1.61)	0.380
2017	0.95 (0.50–1.80)	0.882	1.08 (0.59–1.99)	0.802	1.40 (0.71–2.79)	0.332
2018	0.96 (0.49–1.87)	0.906	1.49 (0.80–2.78)	0.205	1.40 (0.56–3.48)	0.457
2019	Ref.		Ref.		Ref.	

Table 3. Cont.

Characteristic	Underweight		Wasting		Stunting	
	OR (95% IC)	<i>p</i> -Value	OR (95% IC)	<i>p</i> -Value	OR (95% IC)	<i>p</i> -Value
Province		0.127		0.919		0.016
Maputo	Ref.		Ref.		Ref.	
Zambézia	2.65 (0.99–7.10)	0.052	1.21 (0.45–3.23)	0.704	2.99 (0.82–10.87)	0.097
Nampula	2.00 (0.82–4.88)	0.128	1.03 (0.43–2.45)	0.954	4.68 (1.63–13.41)	0.004
Sex		0.749		0.424		0.437
Male	1.08 (0.68–1.70)		1.19 (0.78–1.81)		0.82 (0.49–1.36)	
Female	Ref.		Ref.		Ref.	
Child age group (in months)		0.052		0.882		0.253
0–5	Ref.		Ref.		Ref.	
6–11	2.19 (0.69–6.94)	0.184	0.81 (0.35–1.90)	0.630	3.22 (0.95–10.98)	0.061
12–23	2.64 (0.84–8.23)	0.095	0.92 (0.40–2.10)	0.835	3.54 (1.03–12.15)	0.044
24–59	4.36 (1.31–14.47)	0.016	1.08 (0.43–2.67)	0.874	3.04 (0.81–11.39)	0.099
Caregiver Education Level		<0.001		0.079		0.141
No education	5.16 (2.39–11.13)	<0.001	2.06 (0.97–4.36)	0.060	1.41 (0.56–3.57)	0.467
Primary	1.39 (0.85–2.28)	0.195	0.88 (0.56–1.39)	0.585	1.73 (1.00–2.97)	0.049
Secondary/above	Ref.		Ref.		Ref.	
Mother's marital status						0.792
Single					Ref.	
Married/co-habitation					0.84 (0.14–5.01)	0.846
Divorced/widower					0.69 (0.12–3.99)	0.680
Care giver age (in years)		0.327		0.044		
<21	0.89 (0.44–1.82)	0.757	0.45 (0.22–0.91)	0.026		
21–30	0.68 (0.26–1.72)	0.150	0.62 (0.39–0.99)	0.046		
>30	Ref.		Ref.			
Type of house		0.685		0.888		0.611
Reed	Ref.		Ref.		Ref.	
Mud	0.50 (0.16–1.53)	0.224	1.08 (0.34–3.42)	0.900	1.30 (0.35–4.85)	0.697
Brick	0.67 (0.26–1.72)	0.406	1.34 (0.50–3.60)	0.561	0.70 (0.22–2.29)	0.559
Others	-	-	2.19 (0.10–46.32)	0.614	0.55 (0.03–9.35)	0.682
Piped water		0.931		0.054		
Yes	Ref.		Ref.		Ref.	0.526
No	1.03 (0.58–1.82)		1.66 (0.99–2.79)		0.81 (0.41–1.57)	
Treated water		1.000		0.125		0.774
Yes	1.00 (0.62–1.62)		0.70 (0.45–1.10)		1.08 (0.63–1.85)	
No	Ref.		Ref.		Ref.	
Season		0.269		0.012		
Wet	1.29 (0.82–2.02)		1.70 (1.12–2.56)			
Dry	Ref.		Ref.			
Family members in household						0.178
<5					Ref.	
≥5					0.675 (0.38–1.20)	
Birthweight		<0.001		<0.001		0.010
<2500 g	2.75 (1.53–4.95)		2.73 (1.57–4.77)		2.64 (1.26–5.50)	
≥2500 g	Ref.		Ref.		Ref.	
Malaria		0.415		0.415		
Yes	0.61 (0.18–2.10)		1.55 (0.54–4.46)			
No	Ref.		Ref.			
Parasitic Infection						0.882
Positive					1.06 (0.49–2.32)	
Negative					Ref.	
Child HIV status		0.006		0.061		0.004
Positive	2.64 (1.33–5.26)		1.88 (0.97–3.63)		3.37 (1.46–7.80)	
Negative	Ref.		Ref.		Ref.	

The blank cells in the table mean that the variable did not satisfy the entry criteria to the final models; Bold: Significant *p*-values.

4. Discussion

In this analysis, we assessed the frequency and risk factors of undernutrition in children with diarrhoea living in three regions of Mozambique. The overall frequencies of underweight, wasting and stunting were 24.7%, 26.6% and 32.5%, respectively. These values are higher, compared with the prevalence of underweight and wasting in the same age group in other studies in children without diarrhoea, in other settings in Mozambique [10–12].

Although the frequency of stunting was lower than the prevalence observed in the same age group in Mozambique at the national level, (43.0% in 2011 and 42.5% in 2015) it was the higher frequency of undernutrition in children with diarrhoea described so far [10–12,32]. The results of the present analysis for the three types of undernutrition are aligned with the overall data from the country that shows that stunting is the most frequent type of undernutrition in children under-five [10–12,32].

Despite the fact that the prevalence of people living in poverty fell from 59% (2008) to 49% (2014) according to a report on the food crisis in 2019, Mozambique is still one of the 55 countries living with food insecurity [18]. Over the last 20 years, the country has been fustigated by cyclones, floods and droughts that lead to agricultural losses and thus food unavailability, and factors such as extreme weather and conflicts that are known to lead to food insecurity in low and middle income countries [18]. All these factors could help to explain the frequencies of undernutrition observed in the present analysis across the country.

Our results from the Nampula province (49%) for stunting, corroborates with the Demographic Health Survey (DHS) conducted in the country in 2011, where the province presented the highest prevalence (55.3%) of stunted children [32]. Conditions such as food insecurity, high population density, poor health indicators and the highest percentage of poverty (44%) may explain the higher prevalence observed in this province, compared with Maputo and Zambézia [33]. In Nampula, 61.9% of the population consume water from unsafe sources, 46% of the population do not have access to improved latrines and approximately 50% of the population takes 30 to 60 min to access basic services, such as a water source, public transportation, and food markets [34].

Children whose caregiver were illiterate were significantly associated with being underweighted, when compared to those whose caregiver had a secondary or higher education level. Studies conducted in Bangladesh, Nigeria, Kenya, Tanzania, Ethiopia and Mozambique presented the same relation between the mother's education level and a child's nutritional status, although those studies were conducted in children without diarrhoea [17,35–40]. This association can be explained by the fact that, during formal education, a woman can gain knowledge on health subjects, including nutrition aspects that could help her to better address health issues in her family and community [35,40]. Additionally, formal education could allow a better understanding of how to implement correctly the health advice given by health workers [35,40].

The results of this analysis suggest that children whose caregiver was younger (<21 years) were less likely to be wasted, but this needs to be interpreted carefully as some studies found different associations between undernutrition and a caregiver's age [36,41]. Another result from the present analysis that must be carefully interpreted is the higher frequency of stunting observed in children whose mother was married/co-habiting, reminding us that in the present multivariate analysis no association was observed between a mother's marital status and undernutrition. For undernutrition and the mother's marital status, Fernandes et al. found that a child not living with their father was less likely to be undernourished while Amadu et al. found that children whose mother was married were more likely to be wasted and stunted [41,42]. Both associations, caregiver age and mother's marital status, should be evaluated using a specific study design that includes the analysis of cofounders to better understand the relationship.

The frequency of undernutrition in children with diarrhoea was higher in children without access to piped water, although no association was observed, but the higher

frequency observed can be easily explained by the quality of water from non-piped sources. Non-piped water sources tend to be contaminated with pathogens that can cause diarrhoea. The relation between the quality of water and undernutrition is indirect but well known with poor water quality being associated with stunting and thinness [43].

Drinking unimproved water was not significantly associated with any type of undernutrition. This could be explained by the fact that in some families even with treated water available, the members of the family would rather drink the untreated water because some treatment methods can change the taste of the water [44]. Another plausible justification would be the incorrect implementation of known methods to treat drinking water [16]. The results of the present analysis were similar to those found in studies conducted in Ghana and Tigray [16,45]. On the contrary, a study conducted in children aged 5–24 months in Cameroon showed that unimproved drinking water was associated with underweight, wasting and stunting [36]. Another study also revealed an association with stunting in the Democratic Republic of Congo [46]. The higher risk of undernutrition due to drinking unsafe water is related to water borne diseases by exposure to enteric pathogens [47].

A significant difference was observed between the wet and dry season with wasting. Children aged under-five with diarrhoea had higher odds of being wasted in wet compared with dry seasons. During the wet season, diarrhoea diseases are more frequently observed which is already known as a risk factor for undernutrition [16] due to food insecurity, food access and availability [48].

The number of family members has been reported as a risk factor for the occurrence of undernutrition in children under-five with diarrhoea [16]. Although in the present analysis no association was observed, the association between these two factors is justified through aspects related to hygiene, sanitation, family income, food access and availability [49].

Although the results of this study were not statistically significant for the association between malaria and undernutrition in children under-five, malaria is commonly reported to be a predictor for the occurrence of undernutrition [50].

There was a positive association between all type of undernutrition and low birthweight in the present analysis. A child born with a low weight has indeed a higher risk of developing wasting, underweight and stunting, than a child born with a normal weight [21,51]. For example, using Malawian DHS data, it was shown that a child born with a low weight is at risk of remaining undernourished during the first years of their life [51]. Additionally, low birthweight is described as a factor associated with an increased vulnerability to diarrhoeal infection [21].

In the public health literature, HIV is one of the factors identified as being associated with undernutrition [14,52,53]. Thus, many studies have showed that the frequency of underweight, wasting and stunting is higher in HIV positive children compared to HIV negative children. HIV positive children have a higher risk of developing undernutrition, and especially, underweight and stunting [52,53]. Studies have showed that the association between undernutrition and HIV in children under-five years of age, results from a reduction of food intake and poor absorption of nutrients, that is common in children HIV positive with diarrhoea [20,52,53].

Since the data analysed were from a hospital-based surveillance, and the health workers collected all the data during the routine treatments, there are two identified limitations. The first limitation is the missing information related to the independent and dependent variables that reduced the sample size, from an initial 2256 to 963 for the analysis. The second limitation is inherent to cross-sectional studies that does not allow to establish a direct cause–effect relation between the collected variables and undernutrition in these children with diarrhoeal disease. Despite the limitations, due to the lack of data on the subject in our country, this analysis brings important data on factors associated with undernutrition in children with diarrhoea that can guide future studies, design actions for prevention and can improve childcare.

5. Conclusions

The frequency of stunting varied across the provinces, being higher in the Nampula province. The mother's education level (illiterate) was associated with being underweight. The wet season was associated with being wasted. Children born with a low birthweight were related to the three types of undernutrition, and a HIV positive status was related to underweight and stunting.

The findings of this analysis emphasise the need for additional caregiver education activities on children's health with a focus on diarrhoea and undernutrition and infectious diseases frequently associated with diarrhoea. Our results highlight the need to address the efforts during the antenatal care and children's health visits to disseminate and promote actions that can help prevent the development of any type of undernutrition. The findings of this analysis also highlight the importance of the integrated management of childhood illness, which can help reduce the morbi-mortality in children due to health conditions associated with undernutrition.

Studies to understand better the social context of children with diarrhoea and undernutrition are also recommended to evaluate the strength and weakness of the health system to implement an integrated management of diseases in children.

Author Contributions: N.d.D., J.S., M.C., J.C., J.S.L., D.M.B., I.C.-M. and E.L.G. designed the study; J.S., M.C. and A.F.L.B. performed data analysis and the manuscript first draft; A.C., L.G. and N.d.D. reviewed data analysis accuracy; C.R., A.C., K.P., L.G. and N.d.D. reviewed the manuscript writing; J.S., M.C., J.C., A.C., A.F.L.B., I.C.-M. and E.A. performed data collection and validation; A.C., J.S.L., J.C., E.A., I.C.-M., E.L.G., L.M.-C., D.M.B. and A.F.L.B. were involved in laboratory procedures; N.d.D. proceeded with funds acquisition; M.C. passed away before the submission of the final version of this manuscript; J.S. accepts responsibility for the integrity and validity of the data collected and analysed. All authors have read and agreed to the published version of the manuscript.

Funding: The National Diarrhoea Surveillance was supported by a Senior Fellowship awarded to Nilsa de Deus by the European Foundation Initiative for African Research into Neglected Tropical Diseases (EFINTD, grant number 98539), World Health Organization (WHO). The World Health Organization: MOZ-19#792. The Global Alliance for Vaccine and Immunization through the Health System Strengthening (HSS) project. The Flandres Government, BICMINS project. The Calouste Gulbenkian Foundation from where Júlia Sambo, Marta Cassocera and Assucênio Chissaque have a PhD fellowship.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the National Bioethical Committee for Health from Mozambique (IRB00002657, reference No: 348/CNBS/13).

Informed Consent Statement: Written informed consent was obtained from the parents or guardians of all subjects involved in the study.

Data Availability Statement: The data from this study is not publicly available due to restrictions present in the consent forms. The data presented in this study are available on request from the corresponding author.

Acknowledgments: We would like to thank the parents or guardians who consented for their children to be enrolled in the surveillance and all ViNaDia team for their dedication and effort with recruitment, data collection and shipment of specimens to the central laboratory in Maputo: Miguel Bambo, Carlos Guilamba, Celina Nhamuave, Mércia Nhaca, Judite Salência, Hermínio Cossa, Félix Gundane, Aunésia Marurele, Angelina Pereira, Mulaja Kabeya Étienne, Celso Gabriel, Titos Maulate, Julieta Ernesto, Siasa Mendes, Hércio Simbine, Susete de Carvalho, Marcos Joaquim, Elvira Sarguene, Fernando Vilanculos, Felicidade Martins, Dulce Graça, Edma Samuel, Vivaldo Pedro, Lúcia Matabel, Aida Junta, Gilda Maria Safrina, Natércia Abreu, Vanessa da Silva, Nazareth Mabutana, Delcio Muteto, Benilde Munlela and Carolina Conjo. A special thank you also to Timothy Kellogg for all the guidance during the initial data analysis process.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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RESULTS

2.2.Paper II. Readiness of Mozambique Health Facilities to Address Undernutrition and Diarrhoea in Children under Five: Indicators from 2018 and 2021 Survey Data

Reference:

Sambo J, Bauhofer AFL, Boene SS, Djedje M, Júnior A, Pilale A, et al. Readiness of Mozambique Health Facilities to Address Undernutrition and Diarrhea in Children under Five: Indicators from 2018 and 2021 Survey Data. Healthcare [Internet]. 2022 Jun 27 [cited 2022 Jul 3];10(7):1200. Available from: <https://www.mdpi.com/2227-9032/10/7/1200>

Article

Readiness of Mozambique Health Facilities to Address Undernutrition and Diarrhea in Children under Five: Indicators from 2018 and 2021 Survey Data

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Citation: Sambo, J.; Bauhofer, A.F.L.; Boone, S.S.; Djedje, M.; Júnior, A.; Pilale, A.; Gonçalves, L.; Deus, N.d.; Chicumbe, S. Readiness of Mozambique Health Facilities to Address Undernutrition and Diarrhea in Children under Five: Indicators from 2018 and 2021 Survey Data. *Healthcare* **2022**, *10*, 1200. <https://doi.org/10.3390/healthcare10071200>

Academic Editors: Khoa Truong and Marco Dettori

Received: 21 April 2022

Accepted: 23 June 2022

Published: 27 June 2022

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Abstract: The World Health Organization's systems framework shows that service delivery is key to addressing pressing health needs. Inadequate healthcare and the lack of healthcare services are factors associated with undernutrition and diarrhea in children under five, two health conditions with high morbi-mortality rates in Mozambique. The aim of the analysis was to determine the readiness score of nutrition and diarrhea services for children under five and the influence of malaria and HIV (Human Immunodeficiency Virus) service readiness on the readiness of these two services. A total of 1644 public health facilities in Mozambique were included from the 2018 Service Availability and Readiness Assessment. Additionally, a cross-sectional study was conducted to determine the availability and readiness scores of nutrition services in 2021 in five referral health facilities. The availability of nutrition and diarrhea services for children is low in Mozambique, with both scoring below 75%. Major unavailability was observed for human resources, guidelines, and training dimensions. Diarrhea (median (IQ): 72.2% (66.7 to 83.3)) and nutrition service readiness (median (IQ): 57.1% (52.4 to 57.1)) scores were significantly different ($p < 0.001$), while it is desirable for both services to be comprehensively ready. Nutrition services are positively associated with diarrhea service readiness and both services are associated with malaria and HIV service readiness ($p < 0.05$). None of the health facilities had all tracer items available and none of the facilities were considered ready (100%). There is a persisting need to invest comprehensively in readiness dimensions, within and across child health services.

Keywords: health services; readiness; undernutrition; diarrhea; children; Mozambique

1. Introduction

The morbi-mortality rate in children under five is a strong indicator of a country's health condition, the quality of its health systems, and access to health services [1–3]. Although the globe recorded a decline in child mortality by almost half from 2000 to 2019, addressing the causes of poor child health and mortality remains a major challenge [4]. In low- and middle-income countries (LMIC), diseases such as undernutrition, diarrhea, malaria, and HIV present a high burden in children under five [4–7]. Undernutrition increases the risk of the severity of diarrhea and also the risk of death from diarrhea [8–10]. In 2011, two thirds of the deaths worldwide were attributed to diarrhea associated with

undernutrition [8,9]. Specifically, diarrhea was considered the third leading cause of death in 2019, accounting for 9.9% of the deaths of children under five globally [4]. In 2018, 21.9% of children under five globally were estimated to be stunted and 7.3% were estimated to be wasted [11,12]. In Mozambique, in 2015, the prevalence of diarrhea in children under five was 11.0% and 41.7% were stunted, 4.4% were wasted, and 15.6% were underweight [13–16]. A Mozambican hospital-based cross-sectional study reported a frequency of 54.1% for undernutrition among children under five with diarrhea [17]. The child's nutritional status is an important diarrhea determinant and vice versa, as undernutrition is associated with a greater incidence and duration of diarrhea, and undernutrition is worsened by diarrhea [18–21].

Among factors associated with undernutrition and diarrhea, inadequate healthcare and a lack of health services are described in the literature [2,22,23]. These factors result in undernutrition and/or diarrhea being improperly diagnosed and treated, which increases the risk of clinical complications and as a consequence, increases the costs to the health system [23,24]. In Mozambique, most of the healthcare is delivered by the public sector. Service delivery is one of the key building blocks for improving health and strengthening the health system according to the World Health Organization's (WHO) systems framework, and this has been highlighted since the 2000s [2,25]. A waste of resources is observed when health services are delivered without quality, which is also unethical [1]. The quality of healthcare includes the health workforce, service delivery, financing, leadership and governance, information, the population and their health needs and medical products, vaccines, and technologies [1,2]. Donabedian describes how the quality of care can be classified and assessed under three domains: structure, processes, and outcomes [26].

In LMIC, health services are still lacking desired qualities [1,2,27]. Assessing the availability and readiness of health services allows for the verification of a critical health service's quality dimension [28]. The assessment of service availability is based on the direct verification of the standards of healthcare, the existence of human resources updated to apply the standards, as well as the existence of equipment, diagnostic capacity, and tracer medicines [1,26,29]. Health service readiness refers to a proper combination of human resources, updated standards of care, and the existence of standards, equipment, diagnostic capacity, and tracer medicines [29]. Service assessments are important for accountability and to inform the improvement of services and are also important for guiding the design and implementation of strategies to improve the quality of service [1,30]. Billah et al. conducted a study on nutrition service assessment in Bangladesh, finding that equipment and training domains had lower scores and could increase nutrition service delivery [29]. Another study conducted in Mozambique in 2000/2001 highlighted that there was room to improve nutrition service delivery for women and children [31]. HIV and malaria are primary healthcare programs that are the highest strategic priorities for the Ministry of Health due to the high burden of these diseases [4,6,13]. HIV and malaria programs benefit from significant specific global funding for service strengthening [32,33].

Few studies in LMIC assess the readiness of nutrition services and diarrhea services for children under five, as well as the influence of malaria and HIV service readiness on nutrition and diarrhea service readiness. This study assesses the structural availability and readiness of health facilities to provide nutrition and diarrhea services for children with undernutrition and/or diarrhea.

2. Materials and Methods

2.1. Data Source and Collection

The present analysis used data from two studies, i.e., study 1, a secondary analysis of the Service Availability and Readiness Assessment (SARA) implemented in 2018 in Mozambique, and study 2, a field assessment adapted from the Donabedian model and focused on structural readiness, named, nutrition service assessment (NSA), which was a cross-sectional study carried out in three provinces of Mozambique in 2021. SARA 2018 is

a representative cross-sectional survey, the NSA 2021 was an assessment implemented in selected sites which were also covered by SARA 2018.

2.1.1. Service Availability and Readiness Assessment (SARA), 2018

The 2018 SARA in Mozambique applied a structured data collection tool to comprehensively verify, at each included health facility, the existence of healthcare standards, human resources, equipment, diagnostic capacity, and tracer medicines of general and specific services, including nutrition services. Mozambique's SARA data collection tool was designed based on the WHO SARA questionnaire and was validated prior to survey implementation [30]. Data collection was performed using the CSPro application installed on tablets [34]. Details on the SARA methodology have been described elsewhere [30,35].

2.1.2. Nutrition Service Assessment (NSA) in Three Provinces of Mozambique, 2021

Interviews were administered to all health professionals available at the health facilities during the assessment period who were responsible for the management of undernutrition in children under five years of age who were admitted to the hospitals with undernutrition and/or diarrhea. This structured data collection allowed us to assess the availability and readiness of human resources, materials, and infrastructure. The readiness of nutrition services was assessed using a framework adapted from the Donabedian model (Table 1) [36,37].

Table 1. Structural readiness of the nutrition health service assessment (adapted from the Donabedian model).

Pillar	Indicators	Data Collection Method	Respondents
Structural Readiness	Human resources, Infrastructure (by interview and observation), Equipment (including observation), Screening for malnutrition in children with diarrhea as a routine, Clinical meetings to discuss child health management, Guidelines.	Structured questionnaire including a checklist Observation of the existence of functional equipment and materials.	Nurse in charge, nutritionist, and pharmacist.
	Academic profile of health professionals, Experience, Training in the last two years, Supervisions.	Interview using a structured questionnaire.	All health professionals in the pediatric wards who are responsible for the care and monitoring of malnourished children were interviewed.

The checklist and two module questionnaires were designed to capture the essential human power, materials, and infrastructure needed to manage undernutrition according to Mozambique's standards, as well as international standards, using SARA tools [30,34,38].

Data were collected at five health facilities. The first questionnaire module was administered to health workers and collected information on the academic degree, years of working experience, competency refreshment, and supervision received. Another questionnaire module collected information on the health facility's human power in terms of numbers and duty profiles, as well as material and equipment availability to manage undernutrition cases, as described in Table 1.

Questionnaires were programmed electronically in Open Data Kit, ODK, version 1.30.1 (University of Washington, Seattle, WA, USA) and administered by the study staff using tablets. Data were stored in ODK Collect and synchronized to the Instituto Nacional de Saúde (INS) ODK Aggregate server.

2.2. Study Design and Population

2.2.1. Service Availability and Readiness Assessment—SARA, 2018

Mozambique's 2018 SARA followed a census approach of public health facilities countrywide, which included 1644 health facilities [34]. The inventory covered health units, namely health posts, health centers, hospitals, other infrastructures of interest to the health sector such as public pharmacies, laboratories, warehouses for medicines and medical commodities, health science institutes, research institutes or equivalents, and other training institutes for health professionals [30,34].

2.2.2. Nutrition Service Assessment—NSA, 2021

A descriptive cross-sectional study was conducted in April 2021 in five health facilities, namely Hospital Central de Maputo (HCM), Hospital Geral José Macamo (HGJM), and Hospital Geral de Mavalane (HGM) in the southern region of Mozambique, Hospital Geral de Quelimane (HGQ) in the central region, and Hospital Central de Nampula (HCN) in the northern region. These are quaternary and tertiary-level healthcare facilities and were purposely selected for the study based on the level of services provided in terms of inpatient care.

2.3. Data Analysis

The SARA data allowed us to assess the availability and readiness of nutrition, diarrhea, malaria, and HIV services for children under five. We also analyzed the relationship between the readiness of these four services, specifically whether malaria and HIV service readiness interacts with nutrition and diarrhea service readiness. For the 2021 NSA conducted in three provinces, only the availability and readiness of nutrition services for children were specifically assessed. Readiness scores were defined as the unweighted mean of the availability of human power, guidelines, commodities, diagnosis, and tracer medicine items per service.

For the present analysis, the readiness score was categorized as low (<75%), intermediate (75 to 99%), and ready (100%), based on the relative frequency of the unweighted score capturing the availability of tracer commodities, guidelines, human power, diagnosis, and medicine items [39].

2.4. Statistical Analysis

First, descriptive statistics were used to report the availability of tracer items, using absolute and relative frequencies. The readiness percentage score for both datasets was computed, based on the availability score of tracer items for each service, namely undernutrition, diarrhea, HIV, and malaria. Readiness scores were further standardized on a scale from zero to one. The availability scores per services' tracer items are displayed in Table 2.

Additionally, for the 2018 SARA dataset, we applied second (median) and third quantile regression models to analyse the association between independent variables (e.g., rural/urban areas; facilities with or without inpatient services; readiness scores for HIV and malaria) with the readiness scores for undernutrition and diarrhea services. Simple and multiple quantile models were chosen because the assumptions to perform linear regression models were not satisfied by our data [40]. Friedman's two-way analysis of variance by ranks was used to compare distributions of readiness by service type, stratified by areas and inpatient services. Post-hoc multiple comparisons were applied when a significant difference was seen. Readiness was summarized in median and interquartile intervals (IQ), i.e., Q1–Q3. We used R version 4.1.0 (Vienna, Austria) to conduct descriptive statistics and the Statistical Package for Social Sciences (SPSS) software version 26.0 to conduct the inferential analysis. *p*-values lower than 5% were considered statistically significant.

Table 2. Availability of items for diarrhea, nutrition, malaria, and HIV services. Data source: SARA 2018.

Variables	Diarrhea % (n/N)	Nutrition % (n/N)	Malaria % (n/N)	HIV % (n/N)
Guidelines				
Guidelines for the integrated care of childhood illness (IMCI)	55.5 (867/1561)	55.5 (867/1561)	-	55.5 (867/1561)
Guidelines on growth monitoring	53.1 (829/1561)	53.1 (829/1561)	-	-
IMCI checklist	-	55.9 (873/1561)	-	-
Malaria guidelines for diagnostics and treatment	-	-	60.3 (939/1556)	-
Equipment				
Stadiometer/Altimeter	100.0 (1423/1423)	100.0 (1423/1423)	-	-
Growth curve form	-	58.7 (916/1561)	-	-
Pediatric scale	98.8 (1448/1466)	98.8 (1448/1466)	98.8 (1448/1466)	98.8 (1448/1466)
MUAC tape	93.2 (1455/1561)	93.2 (1403/1498)	-	-
Thermometer	-	-	98.8 (1328/1344)	-
Differential diagnosis				
HIV rapid test	95.1 (1425/1498)	95.1 (1425/1498)	-	95.1 (1425/1498)
Malaria rapid test	93.7 (1403/1498)	93.7 (1403/1498)	-	-
Malaria rapid test or microscopy	-	-	97.6 (1462/1498)	-
Blood collection on filter paper	-	-	-	71.3 (1068/1498)
Medicine/supplies				
Oral rehydration salt	97.6 (1492/1528)	97.6 (1492/1528)	-	-
Zinc sulfate	41.5 (634/1528)	41.5 (634/1528)	-	-
Vitamin A	91.5 (1398/1528)	91.5 (1398/1528)	-	-
Amoxicillin	85.7 (1309/1528)	85.7 (1309/1528)	-	-
Cotrimoxazole	88.1 (1346/1528)	88.1 (1346/1528)	-	-
Albendazole/Metronidazole *	91.0 (1390/1528)	97.2 (1485/1528)	-	-
Coartem (artemeter and lumefantrina)	-	-	93.3 (1421/1523)	-
Injectable or rectal artesunate	-	-	58.8 (896/1523)	-
Quinine	-	-	62.4 (951/1523)	-
Paracetamol or Ibuprofen	-	-	88.9 (1359/1528)	-
Nevirapine syrup (NVP) or Lopinavir (LVP) + Ritonavir (RTV)	-	-	-	95.6 (821/859)
Zitovudina (AZT) or Abacavir (ABC)	-	-	-	42.9 (600/1399)
Lamivudine (3TC)	-	-	-	7.4 (104/1399)
Human resources and training				
Training on IMCI in the last two years	46.1 (720/1561)	46.1 (720/1561)	-	-
Training in growth monitoring services in the last two years	35.0 (546/1561)	35.0 (546/1561)	-	-
General clinicians	7.2 (113/1561)	7.2 (113/1561)	7.2 (113/1561)	7.2 (113/1561)
General nurses	50.9 (795/1561)	50.9 (795/1561)	59.2 (924/1561)	-
Nutritionists	-	8.8 (117/1330)	-	-
Maternal and child health nurses	87.4 (1365/1561)	87.4 (1365/1561)	-	87.4 (1365/1561)
Medical technicians	-	-	55.1 (860/1561)	55.1 (860/1561)
Overall items' relative availability	73.0	68.6	72.3	58.0
Health facilities with all items	1.2 (15/1295)	0.0 (0/1295)	4.0 (48/1214)	0.6 (8/1301)

* Albendazole's availability was only evaluated for nutrition services; n: number of units in the subgroup; N: total number of units.

3. Results

3.1. Service Availability and Readiness Assessment—SARA, 2018

For the present analysis, a total of 1644 health facilities were covered in the Mozambique SARA 2018 database, of which 1561 (95.0%) provided services to children under five years of age. From the 1561 health facilities included in the analysis, 85.8% (1339/1561) were in urban areas and 14.0% (218/1561) had inpatient services.

3.1.1. Availability and Readiness

The overall service availability score was 68.6% for nutrition, 73.0% for diarrhea, 72.3% for malaria, and 58.0% for HIV (Table 2). Only 1.2% (15/1295) of the health facilities had all tracer items available for diarrhea, and none presented all tracer items for nutrition services. For malaria, 4.0% (48/1214) of the health facilities had all tracer items available and 0.6% (8/1301) of health facilities had all HIV service tracer items available (Table 2).

The percentage score of service readiness differed depending on the service; it was highest for malaria (median (IQ): 75.0 (66.7 to 83.3)), followed by diarrhea (median (IQ): 72.2 (66.7 to 83.3)), nutrition (median (IQ): 57.1 (52.4 to 57.1)) and then HIV (median (IQ): 55.6 (44.4 to 66.7)), at $p < 0.001$, with malaria being considered intermediate and all other services considered low (Figure 1).

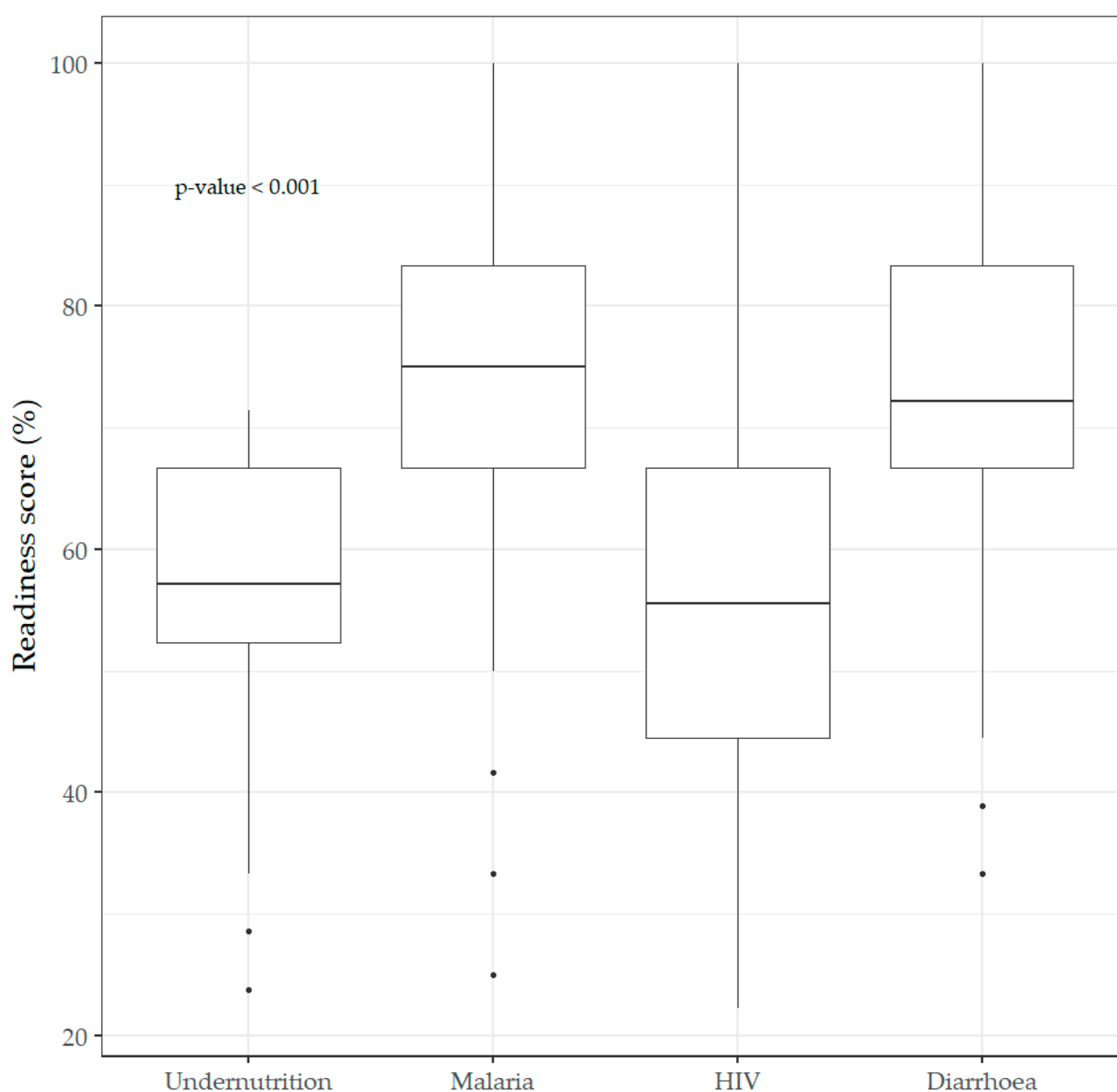


Figure 1. Readiness scores for nutrition, malaria, HIV, and diarrhea services, represented in box plots.

For nutrition services, 49.9% (646/1295) of the health facilities had readiness scores equal to or higher than the mean (58.4%), and higher availability was observed for the dimension of diagnosis capacity (mean = 94.4%). For diarrhea services, 48.3% (625/1295)

of the health facilities had a readiness equal to or higher than the mean (74.1%), and higher availability was observed for the equipment dimension (mean = 97.3%). Concerning malaria services, 59.1% (718/1214) of the health facilities had a readiness score equal to or higher than the mean (73.5%), and higher availability was observed for equipment (mean = 98.8%). For HIV services, 48.3% (628/1301) of the health facilities had a readiness score equal to or higher than the mean (60.2%), and higher availability was observed for the equipment dimension (98.8%), but only one item was considered a tracer for this latter assessment.

Figure A1 in Appendix A illustrates the differences in service readiness scores between rural and urban areas. The readiness percentage score differed depending on the services in rural areas and was highest for malaria (median (IQ): 75.0 (66.7 to 83.3)), followed by diarrhea (median (IQ): 72.2 (66.7 to 83.3)), nutrition (median (IQ): 57.1 (52.4 to 66.7)), and HIV services, which presented the lowest readiness percentage score (median (IQ): 55.6 (44.4 to 66.7)) at $p < 0.001$. Only malaria services were considered intermediate, whereas the other services were considered low. The readiness score also differed depending on the services in urban areas, and was highest for malaria (median (IQ): 83.3 (75.0 to 91.7)), followed by diarrhea (median (IQ): 77.8 (72.2 to 84.7)), HIV (median (IQ): 66.7 (55.6 to 77.8)), and nutrition, which presented the lowest readiness score (median (IQ): 61.9 (52.4 to 66.7)) at $p < 0.001$. Malaria and diarrhea were considered intermediate while diarrhea, nutrition and HIV services had low readiness. Details on the descriptive statistics are presented in Table A1, Appendix C. No statistically significant difference was observed in the comparison of diarrhea and malaria service readiness ($p = 1.000$) in health facilities from urban areas.

Figure A2, in Appendix B, presents the differences in the service readiness score according to the health facilities that provide or do not provide inpatient services. Among health facilities with inpatient services, the readiness percentage score was highest for malaria (median (IQ): 91.7 (83.3 to 91.7)), followed by diarrhea (median (IQ): 83.3 (77.8 to 94.4)), HIV (median (IQ): 77.8 (66.7 to 88.9)), and nutrition, which presented the lowest readiness score (median (IQ): 61.9 (57.1 to 66.7)) at $p < 0.001$. Only nutrition services had low readiness, while all other services were considered intermediate. There were no statistically significant differences between diarrhea and malaria service readiness ($p = 0.163$). Among health facilities without inpatient services, the service readiness percentage score was highest for malaria (median (IQ): 75.0 (66.7 to 83.3)), followed by diarrhea (median (IQ): 72.2 (66.7 to 83.3)), nutrition (median (IQ): 57.1 (52.4 to 66.7)), and HIV services, which presented the lowest readiness score (median (IQ): 55.6 (44.4 to 66.7)) at $p < 0.001$. Malaria services were considered intermediate, and other services presented low readiness; details on the descriptive statistics are presented in Table A1, Appendix C. No statistically significant difference was observed in the readiness scores of nutrition and HIV services ($p = 0.254$) within health facilities without inpatient services.

3.1.2. Quantile Regression Model Estimates for Readiness

Table 3 presents the median quantile regression model estimates for the readiness of diarrhea and nutrition services. Health facilities without inpatient services were less likely to score above the median quantile readiness for diarrhea compared to health facilities with inpatient services (adjusted odds ratio: aOR = 0.965, 95% CI: 0.951–0.980; $p < 0.001$). The readiness score for undernutrition, malaria, and HIV services had a positive effect on the median readiness score for diarrhea services, and the highest effect was seen in the undernutrition readiness score (aOR: 2.597, 95% CI: 2.447–2.758; $p < 0.001$), followed by the malaria readiness score (aOR: 1.199, 95% CI: 1.146–1.255; $p < 0.001$), and the lowest effect was seen on the HIV readiness score (aOR: 1.047, 95% CI: 1.001–1.094; $p = 0.045$).

Health facilities without inpatient services were more likely to score above the median quantile readiness score for undernutrition compared to health facilities with inpatient services (adjusted odds ratio: aOR = 1.029, 95% CI: 1.018–1.041; $p < 0.001$). The readiness score for diarrhea and HIV had a positive effect on the median readiness score for undernu-

trition ($p < 0.001$). The highest effect was seen on the diarrhea readiness score (aOR: 1.985, 95% CI: 1.911–2.062) and the lowest effect was seen on the HIV readiness score (aOR: 1.098, 95% CI: 1.054–1.126). The malaria readiness score had a negative effect on the median quantile readiness score for undernutrition (aOR: 0.892, 95% CI: 0.861–0.924).

Third quartile regression estimates for diarrhea and undernutrition are presented in Table A2, Appendix D.

Table 3. Median quantile regression model estimates for diarrhea and undernutrition readiness.

Variables	<i>p</i> -Value	cOR ¹ (CI ² 95%)	<i>p</i> -Value	aOR ³ (CI ² 95%)
Median quantile regression model estimates for diarrhea readiness				
Type of area	<0.001		0.495	
Urban		1		1
Rural		0.946 (0.919–0.974)		0.995 (0.981–1.010)
Type of health facility	<0.001		<0.001	
With inpatient services		1		1
Without inpatient services		0.895 (0.869–0.921)		0.965 (0.951–0.980)
Readiness for undernutrition	<0.001	3.211 (3.046–3.385)	<0.001	2.597 (2.447–2.758)
Readiness for malaria	<0.001	1.560 (1.446–1.683)	<0.001	1.199 (1.146–1.255)
Readiness for HIV	<0.001	1.649 (1.542–1.763)	0.045	1.047 (1.001–1.094)
Median quantile regression model estimates for undernutrition readiness				
Type of area	<0.001		0.087	
Urban		1		1
Rural		0.953 (0.930–0.977)		1.010 (0.999–1.021)
Type of health facility	<0.001		<0.001	
With inpatient services		1		1
Without inpatient services		0.953 (0.930–0.977)		1.029 (1.018–1.041)
Readiness for diarrhea	<0.001	1.902 (1.837–1.970)	<0.001	1.985 (1.911–2.062)
Readiness for malaria	<0.001	1.331 (1.247–1.420)	<0.001	0.892 (0.861–0.924)
Readiness for HIV	<0.001	1.535 (1.449–1.626)	<0.001	1.089 (1.054–1.126)

¹ Unadjusted odds ratio; ² 95% confidence intervals; ³ adjusted odds ratio.

3.2. Nutrition Service Assessment: NSA, 2021

From the five health facilities (HF) assessed, there were 67 health professionals, the majority of whom were from HF2 ($n = 24$) and HF5 ($n = 14$). Half of the included professionals were nurses (49.3%; 33/67). The median number of years of work ranged from 2.5 to 8.0 (Table 4).

All wards visited provided diagnostic/treatment services for undernutrition. The guidelines for the integrated management of childhood illness were observed in only one ward (12.5%; 1/8). Six out of eight wards provided growth monitoring services, although only three of the six had growth monitoring guidelines (Figure A3, Appendix E).

The percentage of health professionals who received at least one training on nutritional services in the last two years was 58.2% (39/67), with training on the feeding of babies and young children being the most reported (40.3%; 27/67), and training on the integrated management for childhood illness being the least reported (19.4%; 13/67), as shown in Figure A4a in Appendix F. Specific trainings on nutrition were reported by pediatricians (100%; 6/6), who represent a small fraction of the health professionals linked to nutrition management. Nutritionists were least likely to report with received nutritional training in the previous two years (33.3%; 4/12) (Figure A4b in Appendix F).

Supervision was reported by 53.7% (36/67) of health professionals, whereas 38.8% (26/67) did not receive any supervision related to nutrition services. Of the professionals who received supervision, 19.4% (7/36) received supervision every three months, 22.2% (8/36) received supervision every six months, and 41.7% (15/36) did not specify regularity,

as shown in Figure A5a in Appendix G. Most supervision involved nutritionists, at 75.0% (9/12) (Figure A5b in Appendix G).

The overall relative availability of services was 67.5%, with higher availability being observed for the human resources dimension (mean = 87.5%) (Figure A3). None of the health facilities presented all tracer items for nutrition services, as shown in Figure A3 in Appendix E.

Table 4. Distribution of health professionals by health facilities (HF), roles, and years of work (2021).

	<i>n</i> (%)
Number of health professionals by health facility (HF)	
HF2	24 (35.8)
HF5	14 (20.9)
HF1	12 (17.9)
HF4	9 (13.4)
HF3	8 (11.9)
Roles of the health professionals	
Nurse	33 (49.3)
Generalist medical doctor	15 (22.4)
Nutritionist	12 (17.9)
Pediatrician	6 (9.0)
Technician (preventive medicine)	1 (1.5)
Years of work by HF	
	Median (IQ), min–max
HF2	3.0 (1.75–7.25), 0–30
HF5	2.5 (2.0–6.5), 0–16
HF1	3.5 (1.0–6.75), 0–12
HF4	8.0 (3.0–15.0), 0–16
HF3	3.5 (1.5–5.25), 0–20

n: number of units in the subgroup.

The overall readiness score for nutritional services for children was 67.5%. The highest readiness score was at HF2 in the new-born ward, scoring 83.3%, and the lowest nutrition readiness score was observed in the diarrhea ward from HF2 with 53.3%, as depicted in Figure 2.

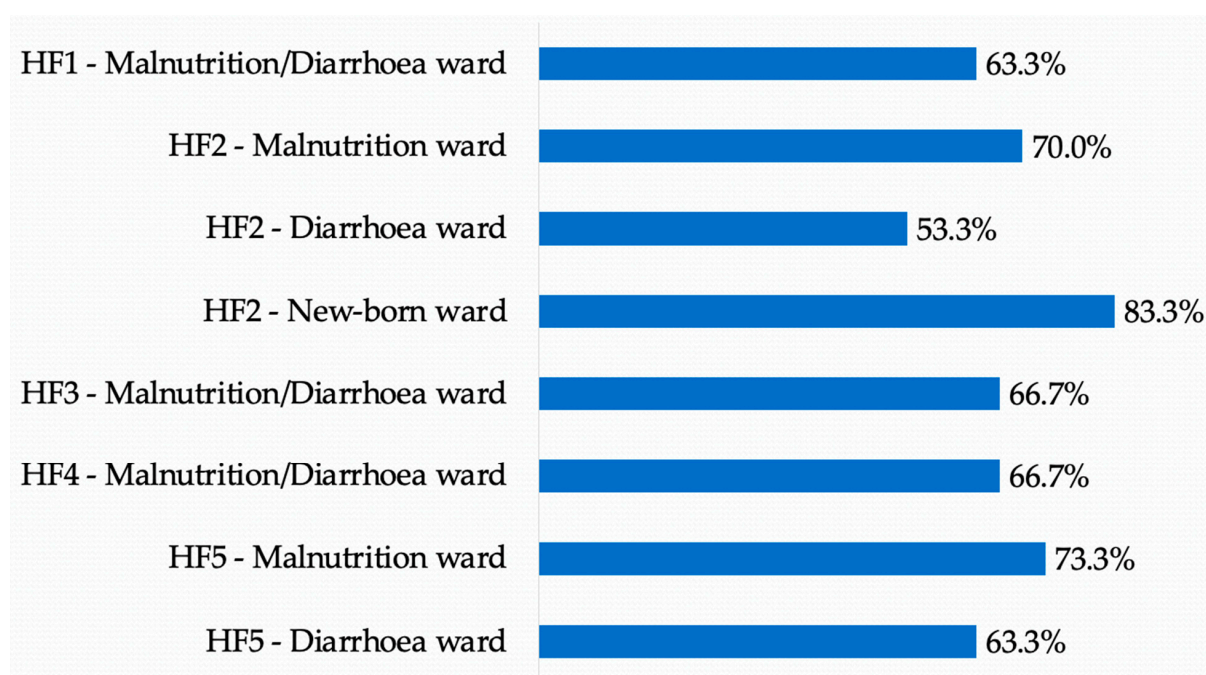


Figure 2. Readiness score for nutrition services, NSA (2021).

4. Discussion

Our results based on the Service Availability and Readiness Survey, SARA, largely cover the primary healthcare facilities, which represent the majority of national health service facilities, and the focus was on undernutrition, diarrhea, malaria, and HIV services. Nutrition health services were the least available compared to services for diarrhea; the HIV services had the lowest availability among all four assessed services, and diarrhea services had higher availability. Less than 5% of the health facilities had all service tracer items available. None of the health facilities had all of the nutrition service tracer items available. Only 1.2% and 0.6% of the health facilities had all tracer items for diarrhea and HIV services, respectively. The percentage of health facilities with all items is reported as low in other LMIC, where resources are scarce, and the health systems tend to unevenly direct resources to services [1,41–43]. Regarding the specific domains, human resources, their training, and guidelines presented lower availability; additionally, for HIV services, the medicine domain also presented lower availability. Our findings on HIV service availability are similar to the availability reported by a Nepalese facility survey conducted in 2015 and from a Tanzanian service provision assessment from 2014 to 2015 [44,45]. Poor human resources availability has been frequently reported in LMIC, where scarce resources and a low percentage of qualified human resources are common features [46]. The lower availability and readiness observed imply that a significant number of children under five are not well diagnosed and do not receive proper health assistance when they pursue these four services with special reference to nutrition and HIV services. A lack of resources in the health services can lead to unresponsiveness to population health needs [1,2,25].

Considering data from the nutrition service assessment conducted in 2021 (NSA, 2021), the overall nutrition services availability was relatively low at 67.5%, while the lowest availability was observed in the guideline domain. None of the included health facilities in the assessment had all tracer items available. The lower service availability that we noticed in 2021 is consistent with the 2018 findings from SARA and is also consistent with findings from other studies conducted in LMIC [29,47,48].

The overall nutrition and diarrhea service readiness scores were low, and for both services, fewer than 50% of the health facilities had a readiness equal to or higher than the entire sample mean readiness. The readiness score of diarrhea services was higher compared to nutrition services. The readiness of malaria services was intermediate; even so, malaria readiness was the highest among the four targeted services, whereas HIV service readiness was the lowest. The historically high burden of malaria and diarrhea in children under five is a possible reason for the malaria service readiness score being the highest and diarrhea services presenting higher readiness than nutrition services [4,49]. The high burden of malaria and diarrhea might therefore explain the high prioritization given to services dealing with high-burden diseases, as part of efforts to reduce child mortality [10,49]. Mozambique has been implementing strategies to reduce the malaria burden, through the Malaria National Control Program from the Ministry of Health, and through different non-governmental organizations [50–53]. The strategies include improved diagnosis, case management, and availability of medicines [51,52]. The lower service readiness observed for HIV can be explained by the well-documented, unsuccessful results observed in vertical disease programming that results in vertical funding, which is the type of funding observed in the Mozambican health system, especially for HIV [50,54–56].

Considering the nutrition service readiness assessment conducted in 2021 (NSA, 2021), the results pointed to hospitals' diarrhea wards scoring lowest on readiness for undernutrition services. Higher readiness for nutrition services was observed in nutrition-dedicated wards and in new-born wards. Based on the bidirectional relationship observed between nutrition and diarrhea in children under five, the ideal was for both services to be considered ready for nutrition services, or with readiness percentage scores that were approximately the same [18,19]. Better nutrition service readiness in diarrhea wards would allow every child with diarrhea to be assessed for undernutrition and avoid clinical complications and increased costs to the health system [23,24,57].

Nutrition refreshment trainings were frequently provided to pediatricians, of whom there were the fewest in number among those responsible for providing healthcare for undernutrition. However, the 2011–2020 multisectoral action plan for the reduction in chronic undernutrition in Mozambique highlights one of the interventions in the form of nutrition refreshment trainings to nurses [58]. Nutritionists were the health professionals who reported the lowest number of nutrition refreshment trainings. Training on the integrated management of childhood illness was the least frequently provided training to the health workers overall. Regular skills refreshments are well-known strategies for improving service delivery when targeting the technical quality of human resources [1]. Therefore, our result highlights a gap in nutrition service-specific training, and a limited coverage of health worker cadres benefiting from training programs. This scenario might underline the poor technical quality of the services provided [2,30,45,59,60].

The lower integrated management of childhood illness training provision to health workers highlights another key finding from our analysis and substantiates the low availability of guidelines on the integrated management of childhood illness at the point of care. Guidelines for the integrated management of childhood illness are critical resources for scaling up the impact of curative child services, and their implementation is highly recommended to be strengthened within health services [61–64]. Although supervision was not performed regularly, most supervision targeted nutritionists, which is a positive aspect identified in the study; other authors report that supervision is among the key interventions for improving the quality of services [44,59,61,63,65]. Kruk et al., 2018, highlighted that the combination of training and supervision has a great impact on the better quality of health services [1].

According to the 2018 SARA analysis outputs, diarrhea services had higher readiness than nutrition services, and malaria services had the highest readiness among all analyzed services. Services for HIV had the lowest readiness in rural areas whereas nutrition services had the lowest readiness in urban areas. Nutrition services had the lowest readiness in health facilities offering inpatient services, and HIV services had the lowest readiness in health facilities without inpatient services. Overall, higher service readiness was observed in urban areas and at health facilities with inpatient services. Tertiary and quaternary-level health facilities are mostly located in urban areas and offer inpatient services alongside their specialized services [51]. This could explain the results from this analysis, as specialized services are expected to present better readiness for the services provided.

We aimed to assess the comprehensiveness of readiness in services that are key for child health needs and whether the readiness of one service is associated with the readiness of others. Some services are expected to have better commodities and technical quality due to priority given through verticalized development aid funding toward specific services, which are often justified by the need to reduce the high burden of diseases dealt with by the same services. Services related to malaria and HIV, two health conditions with high prevalence, morbidity, and mortality rates in LMIC, receive priority attention and investments from verticalized global and local health initiatives [4,6,13,66]. In Mozambique, this funding is largely supported by the President's Emergency Plan for AIDS Relief (PEPFAR), the Global Fund to Fight AIDS, Malaria, and TB, the President's Malaria Initiative (PMI), and the World Bank [32,33,50]. Even so, some vertical investments may spill over and comprehensively impact child healthcare services since equipment, medicines, human resources, and commodities are shared within and across services. It is therefore expected that the strengthening of some vertical services, which are better funded, might influence the quality of other services targeting children under five. Diarrhea service readiness has a positive association with nutrition, malaria, and HIV service readiness. A higher readiness of diarrhea services is associated with a higher readiness of nutrition services. In turn, nutrition service readiness has a positive association with the provision of inpatient services and with the readiness of diarrhea and HIV services. Nutrition service readiness has the strongest association with diarrhea service readiness. However, at health facilities without inpatient services, which is characteristic of the primary healthcare facilities, when

nutrition service readiness increases, the readiness of diarrhea services reduces. These results need to be interpreted carefully, and further analysis is needed to better understand the determinants of these analytical findings. When the readiness of malaria services improves, the readiness of nutrition services decreases. These findings, on the association between the readiness of nutrition and diarrhea services and on the association between the readiness of malaria and nutrition services, suggest the uneven strengthening of services at primary healthcare services in Mozambique, and the lost opportunities for comprehensively supporting health programs' performance. The finding also suggests that strengthening and maintaining the services available are driven by a verticalized focus on specific diseases rather than system strengthening as a strategy.

None of the health services assessed using either the 2018 SARA or the 2021 NSA can be considered ready if the readiness reference score is set at 100%. Several authors [1,27,29,43,44,67] referred to similar gaps in service readiness and have highlighted unready services as being a widespread situation in LMIC, resulting in poor services provided to address population health needs in these countries [1,25].

The 2018 SARA was a cross-sectional survey. Thus, the assessment did not capture readiness across time, which can be variable depending on logistics, which determine the availability of medical commodities at health facilities. However, the SARA methodology is a reference for situational analyses and policy decisions beyond the timeframe of the cross-sectional study. SARA relied on the verification of tracer items, including medical commodities, medicines, and administrative documents. Data collection went beyond dimensions that are only determined by logistics, but rather are determined by overall health services management and resource availability and allocation. Although the employed verification of items is a cumbersome procedure, which may cause variability in data capturing, SARA surveys were standardized by training, the piloting of study procedures, and the supervision of real-time data collection. Moreover, a sample of the facilities was re-surveyed by a reference team for quality control within one to two weeks after primary data collection. In turn, the 2021 NSA survey was not only a cross-sectional study that was limited in its geographical scope, but it also relied largely on respondents with limited verification processes. Therefore, recall bias may be a limitation, especially for questions about training and supervision. For example, the survey faced a lack of systematic registration or reports on trainings to confirm the answers given by health professionals. Even so, considering that the 2021 evaluation targeted tertiary and quaternary health facilities, and despite the fact that several health facilities sampled do not allow generalization, we still found that specialized services were also unready, which can be indicative of lower readiness across entire health services.

5. Conclusions

The availability and readiness of nutrition and diarrhea services for children are low in Mozambique, both scoring below 75%. The unavailability of human resources and their refreshment trainings and guidelines drove these overall lower scores. Diarrhea services had higher readiness compared to nutrition services. A positive association was found between the readiness of nutrition and diarrhea services. HIV service readiness was positively associated with diarrhea and nutrition services. The readiness of malaria services was positively associated with the readiness of diarrhea services; however, it was negatively associated with the readiness of nutrition services. The readiness of nutrition services was lower in urban areas. These results highlight uneven readiness across services that are supposedly equally relevant for primary health care. As expected, the readiness of nutrition services was higher in dedicated nutrition wards and undesirably lower in dedicated diarrhea wards. The situations concerning the readiness of nutrition services in 2018 and 2021 were aligned; however, they scored low for both timepoints, below 75%. Our results also highlight the persisting need to invest comprehensively in service readiness, within and across child health services. In addition, specific trainings, supervision, and the implementation of point-of-care guidelines are critical for improving undernutrition and

diarrhea management in Mozambican children. These results can be used as a baseline for monitoring the improvement of the readiness of nutrition, diarrhea, malaria, and HIV services.

Author Contributions: J.S., A.F.L.B., N.d.D. and S.C. designed the study; J.S., A.F.L.B. and S.C. wrote the first draft; A.F.L.B. performed the data analysis; S.C. and J.S. reviewed the accuracy of the data analysis; S.B., A.J., A.P., L.G., N.d.D. and S.C. reviewed the writing of the manuscript; J.S., A.F.L.B., S.B., M.D., A.J. and S.C. performed the data collection and validation; J.S., N.d.D. and S.C. proceeded with funding acquisition. All authors have read and agreed to the published version of the manuscript.

Funding: The 2018 Service Availability and Readiness Assessment was funded by Canada's health cooperation with Mozambique, through the World Health's Organization representation in Mozambique. The 2021 nutrition service assessment in three provinces was supported by the Flanders government, through the BICMINS project phase III. Júlia Sambo has a PhD fellowship from the Calouste Gulbenkian Foundation—248036. The World Health Organization's representation in Mozambique (MOZ-19#79) supports the publication of the results through Instituto Nacional de Saúde.

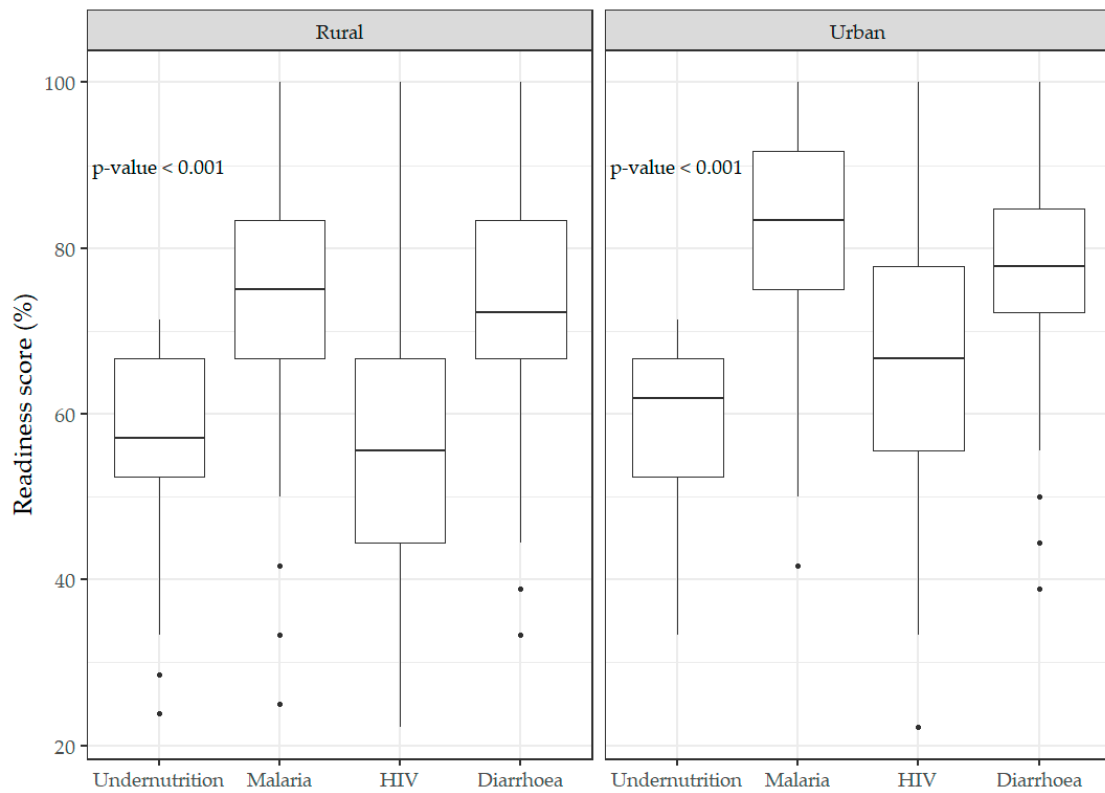
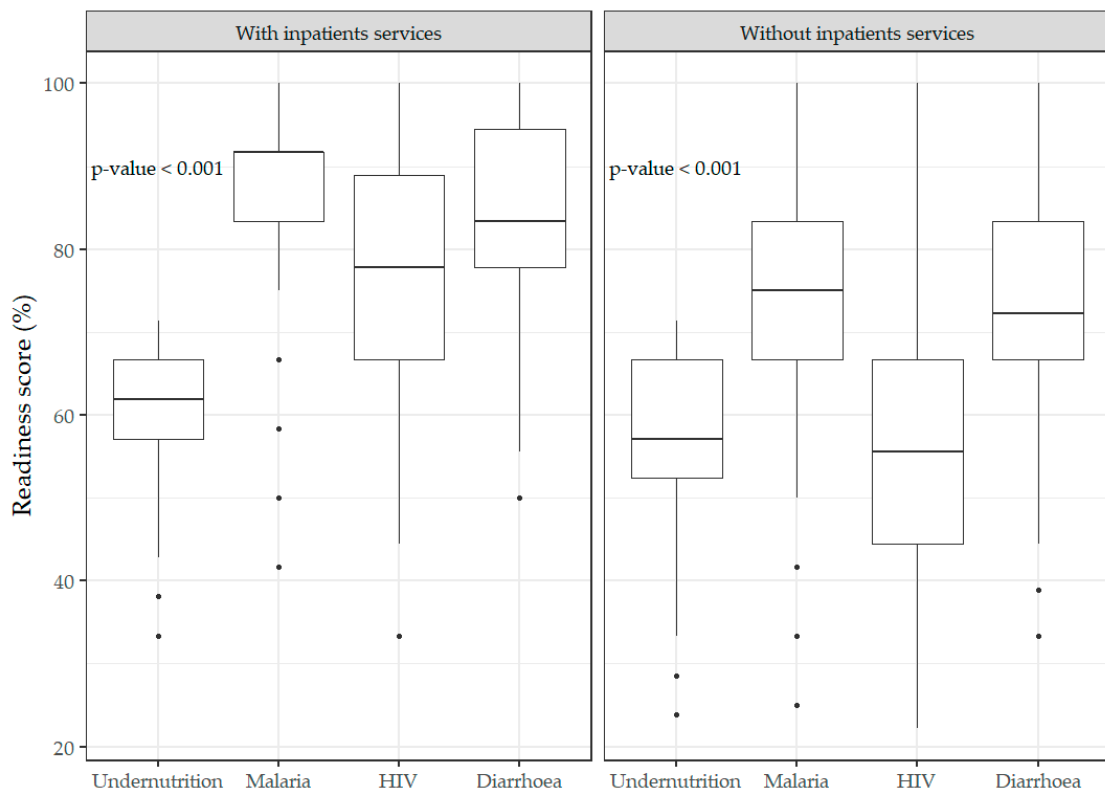
Institutional Review Board Statement: The 2018 Service Availability and Readiness Assessment was an inventory of infrastructure and commodities and was deemed not to include research and the participation of human subjects. The Service Availability and Readiness Assessment was granted approval by Mozambique's Ministry of Health. The 2021 nutrition service assessment in three provinces was granted ethical approval by the Instituto Nacional de Saúde's Bioethical Committee for Health (IRB00002657, reference N°: 39/CIBS/21). The study was conducted in accordance with the Declaration of Helsinki.

Informed Consent Statement: Written informed consent was obtained from all subjects among the health workers included in the 2021 nutrition service assessment in three provinces.

Data Availability Statement: The data from the 2018 Service Availability and Readiness Assessment are available upon reasonable request by e-mail to Instituto Nacional de Saúde from Mozambique or the World Health Organization's representation in Mozambique, or the Directorate of Planning and Cooperation at Mozambique's Ministry of Health. The data are subject to a data-sharing agreement. The 2021 nutrition service assessment data are not publicly available due to restrictions present in the consent forms. The data presented in this study are available from the corresponding author upon reasonable request subject to a data-sharing agreement.

Acknowledgments: We would like to thank the health workers and health facilities' leadership for their collaboration during data collection.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study, data collection, analyses, or interpretation, in the writing of the manuscript, or in the decision to publish the results.

Appendix A**Figure A1.** Service readiness according to the type of area.**Appendix B****Figure A2.** Service readiness according to the type of health facility.

Appendix C

Table A1. Descriptive statistics of readiness according to the type of area and type of inpatient services.

Readiness Type	N	Min	Q1	Median	Q3	Max
Overall readiness						
Undernutrition	1295	23.8	52.4	57.1	66.7	71.4
Malaria	1214	25.0	66.7	75.0	83.3	100.0
HIV	1301	22.2	44.4	55.6	66.7	100.0
Diarrhea	1295	33.3	66.7	72.2	83.3	100.0
Readiness for health facilities in rural areas						
Undernutrition	1123	23.8	52.4	57.1	66.7	71.4
Malaria	1057	25.0	66.7	75.0	83.3	100.0
HIV	1124	22.2	44.4	55.6	66.7	100.0
Diarrhea	1123	33.3	66.7	72.2	83.3	100.0
Readiness for health facilities in urban areas						
Undernutrition	172	33.3	52.4	61.9	66.7	71.4
Malaria	157	41.7	75.0	83.3	91.7	100.0
HIV	177	22.2	55.6	66.7	77.8	100.0
Diarrhea	172	38.9	72.2	77.8	84.7	100.0
Readiness for health facilities with inpatient services						
Undernutrition	174	33.3	57.1	61.9	66.7	71.4
Malaria	183	41.7	83.3	91.7	91.7	100.0
HIV	187	33.3	66.7	77.8	88.9	100.0
Diarrhea	174	50.0	77.8	83.3	94.4	100.0
Readiness for health facilities without inpatient services						
Undernutrition	1121	23.8	52.4	57.1	66.7	71.4
Malaria	1031	25.0	66.7	75.0	83.3	100.0
HIV	1114	22.2	44.4	55.6	66.7	100.0
Diarrhea	1121	33.3	66.7	72.2	83.3	100.0

Appendix D

Table A2. Third quantile regression model estimates for diarrhea and undernutrition readiness.

Variables	<i>p</i> -Value	cOR ¹ (IC ² 95%)	<i>p</i> -Value	aOR ³ (IC ² 95%)
<i>Third quantile regression model estimates for diarrhea readiness</i>				
Type of area	<0.001		0.337	
Urban		1		1
Rural		0.946 (0.910–0.983)		0.992 (0.976–1.008)
Type of health facility	<0.001		0.001	
With inpatient services		1		1
Without inpatient services		0.895 (0.878–0.912)		0.972 (0.955–0.988)
Readiness for undernutrition	<0.001	3.211 (3.211–3.211)	<0.001	2.559 (2.391–2.738)
Readiness for malaria	<0.001	1.560 (1.457–1.670)	<0.001	1.185 (1.126–1.248)
Readiness for HIV	<0.001	1.649 (1.576–1.725)	0.027	1.059 (1.007–1.113)
<i>Third quantile regression model estimates for undernutrition readiness</i>				
Type of area	1.000		0.001	
Urban		1		1
Rural		1.000 (0.983–1.017)		1.020 (1.008–1.032)
Type of health facility	1.000		<0.001	
With inpatient services		1		1
Without inpatient services		1.000 (0.984–1.017)		1.040 (1.027–1.053)
Readiness for diarrhea	<0.001	1.845 (1.772–1.920)	<0.001	1.831 (1.757–1.909)
Readiness for malaria	-	1.000 (1.000–1.000)	<0.001	0.874 (0.841–0.908)
Readiness for HIV	<0.001	1.331 (1.280–1.383)	<0.001	1.163 (1.123–1.205)

¹ Unadjusted odds ratio; ² 95% confidence intervals; ³ adjusted odds ratio. Bold: significant *p*-values.

Appendix E

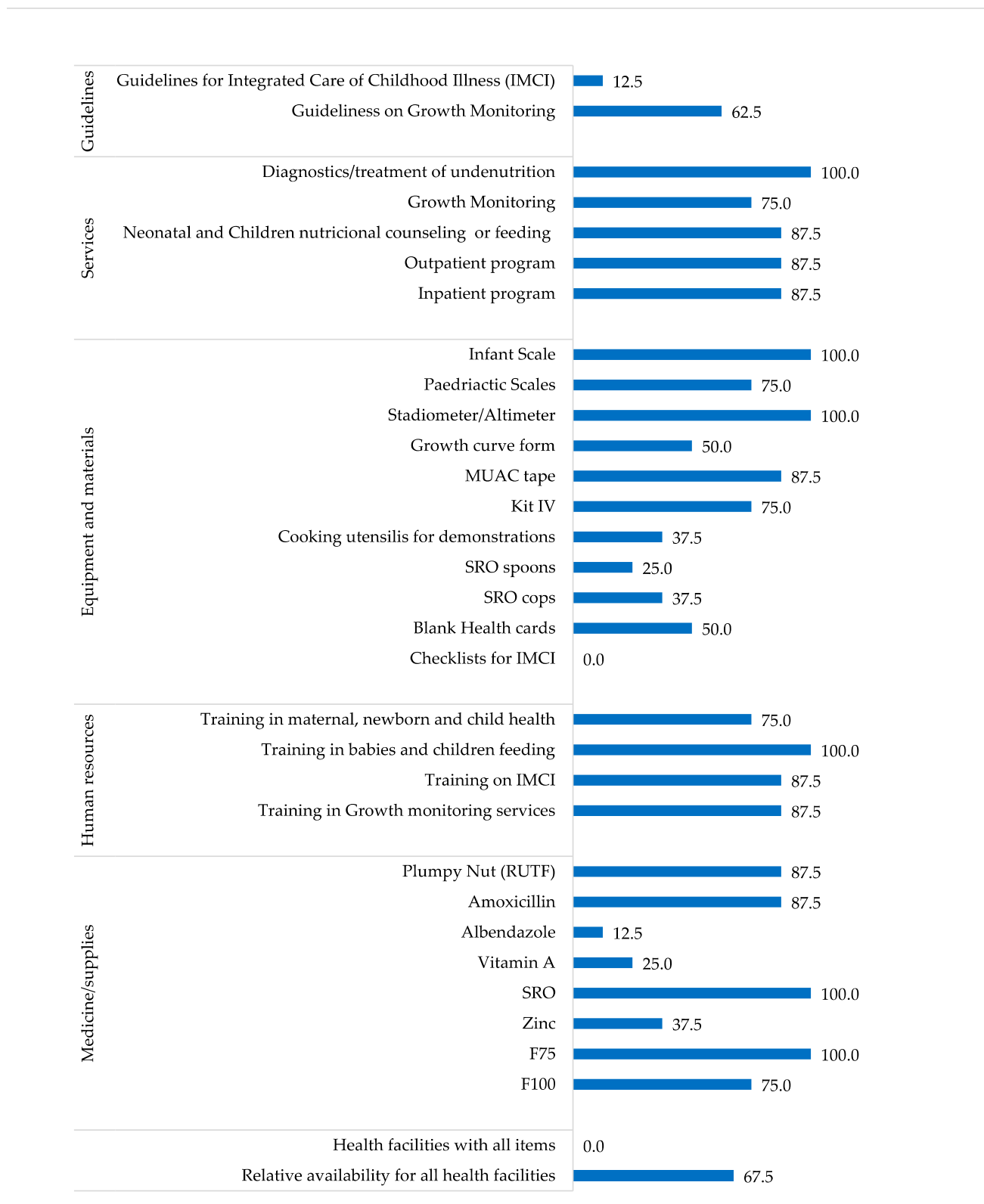


Figure A3. Availability of the items for nutrition services.

Appendix F

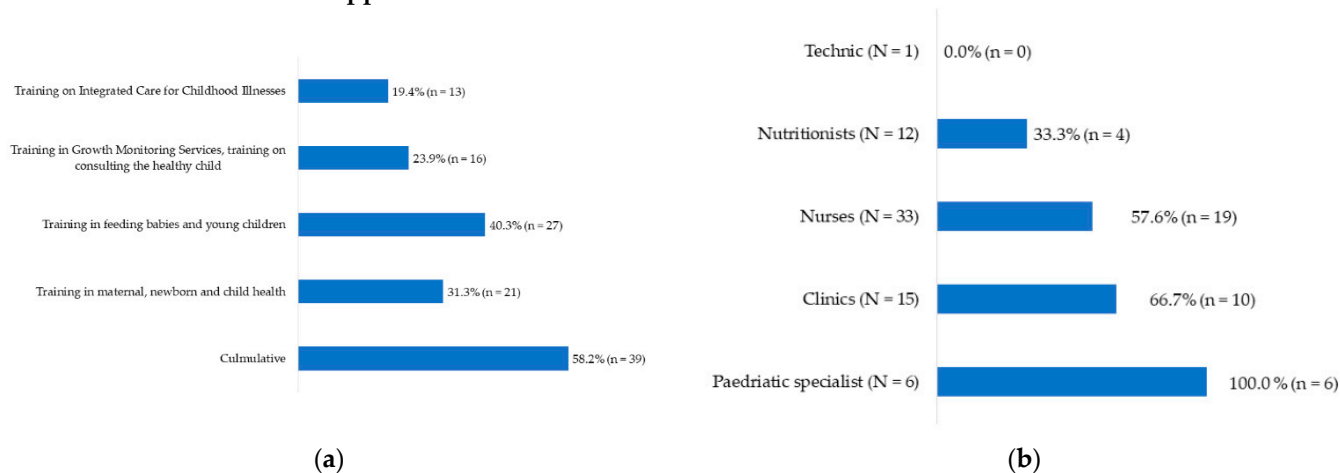


Figure A4. Trainings on nutrition in Mozambique (2021). (a) Trainings on nutrition received in the last two years ($n = 67$) in Mozambique (2021). (b) Trainings on nutrition received in the last two years by health professional roles ($n = 67$) in Mozambique (2021).

Appendix G

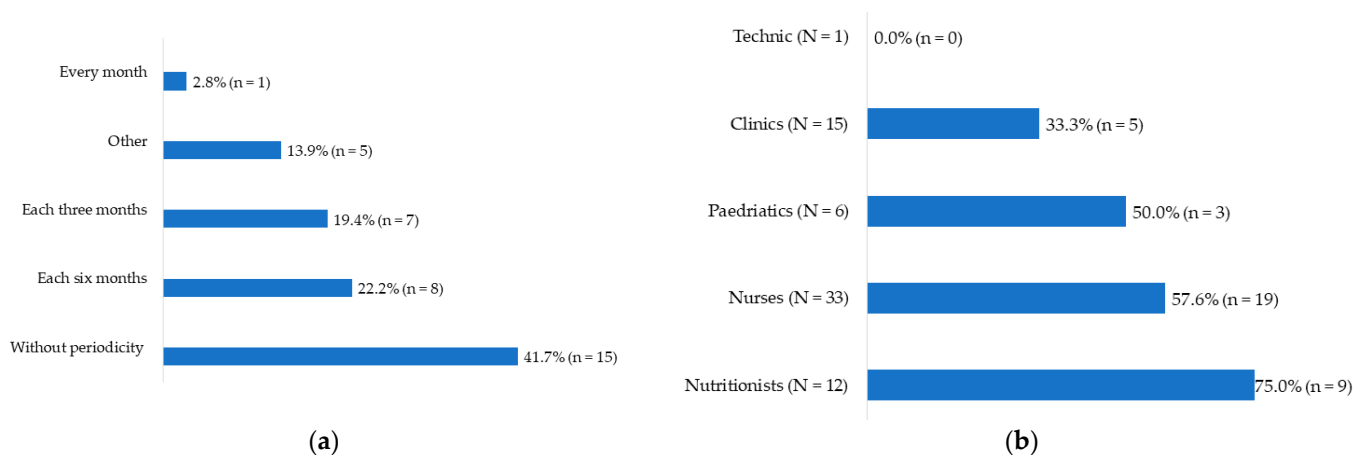


Figure A5. Supervision on nutrition in Mozambique (2021). (a) Supervision periodicity on nutrition received in the last two years by health facilities ($n = 36$) in Mozambique (2021). (b) Supervision according to the roles of health professionals ($n = 67$) in Mozambique (2021).

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RESULTS

2.3.Paper III. Quality of routine data for monitoring nutrition and diarrhoea indicators of children under 5 in Mozambique: an ecological study over a 5-year period.

Reference:

Sambo J, Chicumbe S, de Deus N, Gonçalves L. Quality of routine data for monitoring nutrition and diarrhoea indicators of children under 5 in Mozambique: an ecological study over a 5-year period. BMJ Open. 2023 Jul 21;13(7):e073239. Available from: <https://bmjopen.bmj.com/content/13/7/e073239.abstract>

BMJ Open Quality of routine data for monitoring nutrition and diarrhoea indicators of children under 5 in Mozambique: an ecological study over a 5-year period

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To cite: Sambo J, Chicumbe S, de Deus N, *et al.* Quality of routine data for monitoring nutrition and diarrhoea indicators of children under 5 in Mozambique: an ecological study over a 5-year period. *BMJ Open* 2023;**13**:e073239. doi:10.1136/bmjopen-2023-073239

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2023-073239>).

Received 01 March 2023
Accepted 12 July 2023



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ABSTRACT

Background Undernutrition and diarrhoea have a high burden in children under 5 in low/middle-income countries. Having data-driven quality health services for these two diseases is key in order to address the high burden of diseases; therefore, health systems must provide data to monitor, manage, plan and decide on policies at all levels of health services.

Objective We aimed to assess the quality of nutrition and diarrhoea routine data on children under 5 in Mozambique.

Design A longitudinal ecological study was implemented. Secondary data were used to assess the quality of moderate acute malnutrition (MAM), deworming and rotavirus vaccine indicators based on the data's completeness, presence of outliers and consistency, and seasonality analysis in the form of time series analysis was performed.

Setting We used monthly district-level count data from 2017 to 2021, from all health facilities, from the Mozambican health information system (*Sistema de Informação de Saúde para Monitoria e Avaliação*, or District Health Information System version 2).

Results The rotavirus vaccine indicators presented better completeness when compared with other indicators under analysis. Extreme outliers were observed for deworming and rotavirus vaccines, with a higher number of outliers in the Zambezia and Nampula Provinces. Better consistency over time was observed when analysing the period before the COVID-19 pandemic, for all of the indicators and across provinces. Indicators of MAM and MAM-recovered showed more consistency issues over time in both periods of 2017–2019 and 2018–2021. In terms of seasonality analysis, for the MAM and MAM-recovered indicators, lower variation was observed, and heterogeneous patterns were seen across provinces for the rotavirus vaccine, which had the most pronounced negative seasonality components in Maputo City.

Conclusion Major deficits regarding the analysed quality indicators were observed for Cabo Delgado, Nampula, Zambezia, Tete, Manica, and Maputo City and Province.

INTRODUCTION

Low/middle-income countries (LMICs) face a high burden of disease, especially among children under 5 years old, and infectious diseases and undernutrition remain big

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ Digital platforms improved the data collection, and routine data can help to improve health services especially in low/middle-income countries (LMICs) where infectious diseases have a high burden.
- ⇒ Many factors can affect the continuity of data collection using these platforms.
- ⇒ This study provides a specific evaluation of data quality regarding nutrition and diarrhoea indicators in an LMIC context, including seasonal component evaluation and the impact of the COVID-19 pandemic on the quality of these routine data.
- ⇒ The results highlight the need to improve the data monitoring and evaluation of these specific indicators, as well as the design of strategies that can help to maintain desirable qualities in a context similar to the one imposed by the COVID-19 pandemic.

concerns in this age group.¹ Diarrhoea and undernutrition morbidity and mortality in children under 5 are substantial and, in addition, the two diseases are frequently associated with one another in LMICs.^{2–5} In 2019, diarrhoea was responsible for 9.9% of deaths in children under 5, and in the same year, 21.9% of children were considered to be stunted worldwide.^{1 6 7} The most recent data from Mozambique are the 2015 estimates from the Survey of Immunization, Malaria, and HIV/AIDS Indicators in Mozambique and WHO statistics, pointing to a prevalence of 11.0% for diarrhoea and 41.7% for stunting.^{8 9}

Data-driven quality health services are key in order to address the high burden of diseases in LMICs, specifically where diarrhoea and malnutrition are affecting a large part of the population.^{10 11} Strategies to address child health and to improve respective services depend on quality information based on health indicators, which are used for monitoring and planning purposes as well as timely decision-making. The health

information system must thereby provide timely and complete data to monitor, manage, plan and decide on policies at all levels of health services.^{12 13}

In LMICs, the process of monitoring the health status of populations depends on data obtained through health information systems, surveys and rapid assessments. These comprise the data available and are used for decision-making concerning intervening in health needs and the quality of health services.^{14 15} Although being highly reliable, health surveys are not conducted yearly due to their high costs and workload; they are also time-consuming and highly demanding in terms of materials, equipment, human resources and logistics.^{14 16} In turn, routine data collected through a health management information system (HMIS) are an important information source for health service delivery monitoring, helping to set priorities and improve quality between waves of representative surveys.^{14 16–18} Rapid assessments are often used to inform prioritisation and needs assessments in response to specific situations such as natural disasters or conflict zones.¹⁹

Mozambique has a well-established national HMIS. In 2016, the HMIS transitioned to the operational District Health Information System, version 2 (DHIS-2), locally named *Sistema de Informação de Saúde para Monitoria e Avaliação* (SIS-MA).^{20 21} This system provides routine data deemed to be an important source of information for health service performance monitoring and its improvement.^{14 19} It is therefore critical that decision-makers rely on data that are continuously assessed in terms of their quality to not only guarantee the accuracy of the information that decision-makers receive, but also to set priorities for quality improvement to the HMIS.¹²

In spite of the concerns regarding routine data quality and therefore the use of these data, authors emphasise that routine data are key for health programme planning and prioritisation, while assessing the quality of the data.^{12 14 18} The WHO's guidelines on routine data quality review (DQR) are divided into three modules: (1) framework and metrics, (2) desk review of data quality, and (3) data verification and assessment system.^{12 13 22} Furthermore, the WHO's DQR process is based on four dimensions: (1) completeness and timeliness of data, (2) internal consistency of reported data, (3) external consistency and (4) external comparisons with population data.¹³ The WHO's DQR guidelines list is called the core indicators routine data quality assessment. These indicators are related to maternal health, immunisation, HIV/AIDS, tuberculosis and malaria. The guidelines also recommend assessing the data quality of specific health indicators.¹²

Studies have highlighted that health information system quality in LMICs is of major concern, not only related to the system's functioning but also the quality of data inputted into the system.^{14 16 23} Data incompleteness is reported as a concern of the Mozambican HMIS, SIS-MA.²⁰ Due to the high burden of illnesses in children under 5 years old, nutrition and diarrhoea indicators are critical in child

health in Mozambique. Thus, quality data for nutrition and diarrhoea are crucial for health managers' decision-making, health status and delivery monitoring, and overall service improvement. The quality of data must therefore be frequently assessed. Hence, this work aims to assess the quality of nutrition and diarrhoea routine data on children under 5 years old in Mozambique, covering a 5-year timespan. The results are important since they can inform ongoing efforts to improve the quality of data in the Mozambique health information system and possibly in similar LMIC settings; with the results, we might be able to assess whether the present routine data can generate statistics for decision-making.

MATERIALS AND METHODS

Data source and collection

Data were obtained from the Mozambican health information system, the designated SIS-MA, which is the DHIS-2 (HISP Centre, University of Oslo, Norway). Monthly district-level count data were obtained from January 2017 to December 2021. The SIS-MA is updated monthly with data collected from health facilities. The data flow diagram is presented in [figure 1](#).

Study design and population

This is a longitudinal ecological study based on secondary data analysis using routine children's nutrition and diarrhoea data collected from the Mozambique health information system over a 60-month period, from all health facilities in Mozambique. Data were collected from January 2017 to December 2021, which was the period after the migration to DHIS-2, when it was expected that better routine data would be available. Data were prospectively inputted monthly to the systems and represented the health condition of the Mozambican population under 5 years old who sought public health services. Data from all health facilities across the 11 Mozambican provinces were used, including 154 districts across the country and the additional 7 municipal districts from the capital city Maputo, totalling 161 districts.

Data quality assessment

We applied two of the four WHO DQR guideline dimensions, namely dimensions 1 and 2 for data quality review,^{13 24} and included a desk review component. Five health indicators were selected from SIS-MA for this analysis, which were related to nutrition and diarrhoea indicators for children under 5 years old in Mozambique, as shown in [table 1](#). The selected indicators had enough available data to be analysed based on the following dimensions.

Dimension 1: completeness of data

This refers to at least 90% presence of data in the system for all five selected indicators over a 60-month period, from January 2017 to December 2021. Data for completeness analysis were gathered from all of the 154

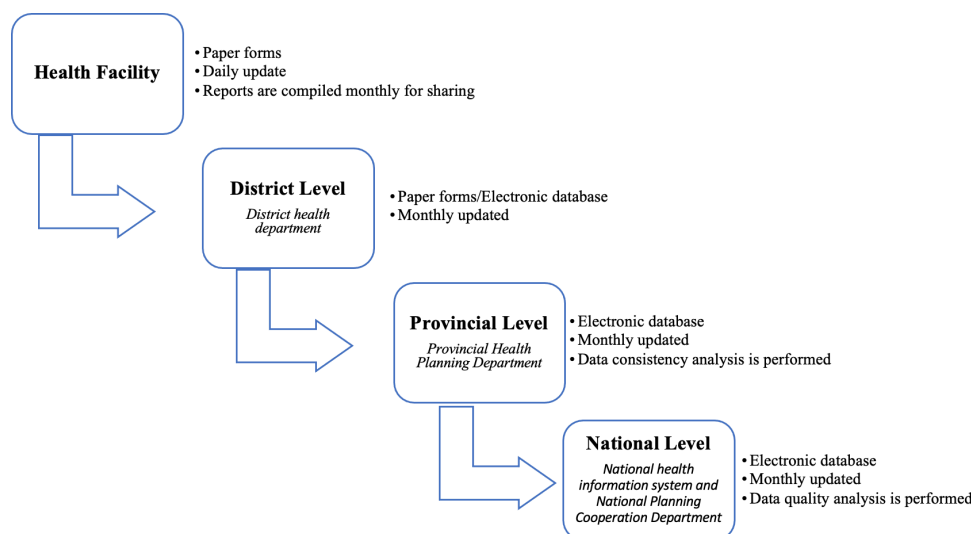


Figure 1 SIS-MA data flow diagram (adapted from Gimbel *et al*⁴⁰ and Mavimbe *et al*⁴¹). SIS-MA, *Sistema de Informação de Saúde para Monitoria e Avaliação*.

Mozambican districts, plus 7 municipality districts from the capital city Maputo¹³ (p2).

Dimension 2: internal consistency

Presence of outliers

Outliers refer to count data which deviated from the yearly mean of the indicator in both directions ($\pm$) and were defined as follows: (1) moderate outlier: 2–3 SD, and (2) extreme outliers: >3 SD¹³ (p2).

Consistency between related indicators

The first and second doses of rotavirus vaccine are inherently related and this allowed us to analyse consistency between these indicators via the computation of divergence scores using a threshold of $\pm 10\%$ to evaluate inconsistencies.¹³

Consistency over time

The year 2021 was the reference year to assess consistency over time. Data from 2021 were compared with the mean

of the previous 3 years, 2018, 2019 and 2020, following the WHO guidelines¹³ (p2). Regarding the quality of this indicator, a threshold of $\pm 33\%$ was used as the reference. For the period prior to the COVID-19 pandemic, an additional analysis of consistency over time was performed, also considering the reference year of 2019 and making a comparison with the means of the years 2017 and 2018, to assess whether the COVID-19 pandemic had any impact on data quality regarding consistency over time.¹³

Data analysis

The analysis was performed using Microsoft Excel (V.16).¹³ The district-level data were used to perform provincial-level and district-level analyses. Provincial-level analysis was performed for the whole country. To showcase a detailed district-level analysis, the focus was on the Nampula Province districts, since this province has high rates of undernutrition and diarrhoea in children under 5 years old.^{5 8 25} Simple linear regression was performed to

Table 1 Definition of selected indicators of nutrition and diarrhoea and dimensions assessed

Indicator	Numerator	Dimensions assessed
Moderate acute malnutrition (MAM)	Total number of MAM cases in children	Completeness, presence of outliers, consistency over time, seasonality
MAM-recovered	Total number of recovered cases of MAM in children	Completeness, presence of outliers, consistency over time, seasonality
Deworming*	Number of dewormed children aged 12–59 months	Completeness, presence of outliers, seasonality
Rotavirus vaccine—1st dose	Total number of children who received the first dose of the rotavirus vaccine	Completeness, presence of outliers, consistency over time, consistency across indicators, seasonality
Rotavirus vaccine—2nd dose	Total number of children who received the second dose of the rotavirus vaccine	Completeness, presence of outliers, consistency over time, consistency across indicators, seasonality

*Deworming had no data entered in 2017 and 2018, therefore not allowing for the analysis of consistency over time. During the transition to the operational system DHIS-2, named *Sistema de Informação de Saúde para Monitoria e Avaliação*, in 2016, interruptions to data/report input were observed for some indicators, but data have been consistently introduced in the system from 2019 onwards. DHIS-2, District Health Information System, version 2.

assess the seasonality component and projection of cases for the year 2020. Time series analyses were performed to identify the seasonal component and to also determine the impact of the COVID-19 pandemic on cases at the provincial level, using a population-adjusted average model.²⁶ Data were organised into quarters and per 100 000 individuals, and series were smoothed out and analysed to identify the seasonal and trend components. The trend component was obtained through the use of the deseasonalised data and the time in quarters; it was used to forecast the data of the year 2020 to compare them with the real data collected in this year.^{27–29}

Additionally, the percentage of average seasonality per quarter was obtained, which was converted into an average of people in excess or deficit in relation to the baseline (time series line without the seasonality component). Excess/deficit was described by mean and range in graph form.²⁹

Patient and public involvement

For the present research, there was no patient or public involvement in the design, conduct or dissemination of the research.

RESULTS

Completeness

Across the 5 years of analysis, from January 2017 to December 2021, higher completeness was observed for the first and second doses of the rotavirus vaccine, with all of the districts presenting completeness equal to or above 90%, except for Cabo Delgado which had 70.6% (12 of 17) of districts with completeness equal to or above 90% for both indicators (table 2). Deworming had no data entered for the years 2017 and 2018. Moderate acute

malnutrition (MAM)-recovered had lower completeness when compared with MAM cases and first and second doses of rotavirus vaccine.

For the indicator MAM, Maputo City with 14.3% (1 of 7), Gaza with 28.6% (4 of 14) and Niassa with 43.8% (7 of 16) had fewer than 50% of districts recording completeness equal to or above 90%. For the indicator MAM-recovered, Gaza with 7.1% (1 of 14), Maputo City with 14.3% (1 of 7), Inhambane with 14.3% (2 of 14), Cabo Delgado with 23.5% (4 of 17), Niassa with 31.2% (5 of 16) and Maputo Province with 37.5% (3 of 8) had fewer than 50% of districts with completeness equal to or above 90%.

For the deworming indicator, due to the lack of data in the years 2017 and 2018, all of the provinces had fewer than 50% of districts with completeness equal to or above 90%. When analysing the years of 2019, 2020 and 2021, the completeness of the deworming indicator had improved in all of the provinces, with all of the districts having completeness equal to or above 90% (data not shown).

Considering an analysis across the 60 months, for all of the indicators, the Nampula Province districts had a completeness equal to or above 90%, except for deworming (online supplemental table 1).

Consistency

Outliers

Across the 5 years of analysis in the districts of each province, moderate outliers were more frequent than extreme outliers. Most of the outliers, both moderate and extreme, across the 5 years and across all of the indicators, were observed in Zambezia, followed by Nampula Province. A higher number of moderate outliers was observed

Table 2 Percentages of districts with completeness of data equal to or above 90% per province according to selected indicator, from January 2017 to December 2021

Provinces (no of districts)	MAM % (n/N)	MAM-recovered % (n/N)	Deworming* % (n/N)	Rotavirus 1st dose % (n/N)	Rotavirus 2nd dose % (n/N)
Niassa N=16	43.8 (7/16)	31.2 (5/16)	0.0 (0/16)	100.0 (16/16)	100.0 (16/16)
Cabo Delgado N=17	52.9 (9/17)	23.5 (4/17)	0.0 (0/17)	70.6 (12/17)	70.6 (12/17)
Nampula N=23	100.0 (23/23)	95.6 (22/23)	0.0 (0/23)	100.0 (23/23)	100.0 (23/23)
Zambezia N=22	81.8 (18/22)	59.1 (13/22)	0.0 (0/22)	100.0 (22/22)	100.0 (22/22)
Tete N=15	100.0 (15/15)	73.3 (11/15)	0.0 (0/15)	100.0 (15/15)	100.0 (15/15)
Sofala N=13	84.6 (11/13)	84.6 (11/13)	0.0 (0/13)	100.0 (13/13)	100.0 (13/13)
Manica N=12	83.3 (10/12)	83.3 (10/12)	0.0 (0/12)	100.0 (12/12)	100.0 (12/12)
Inhambane N=14	50.0 (7/14)	14.3 (2/14)	0.0 (0/14)	100.0 (14/14)	100.0 (14/14)
Gaza N=14	28.6 (4/14)	7.1 (1/14)	0.0 (0/14)	100.0 (14/14)	100.0 (14/14)
Maputo City N=7	14.3 (1/7)	14.3 (1/7)	0.0 (0/7)	100.0 (7/7)	100.0 (7/7)
Maputo Province N=8	50.0 (4/8)	37.5 (3/8)	0.0 (0/8)	100.0 (8/8)	100.0 (8/8)
National mean	67.7 (109/161)	51.6 (83/161)	0.0 (0/161)	96.9 (156/161)	96.9 (156/161)

n=number of districts in the province without data per month across the 60 months evaluated; N=total number of districts per province.
 *For 2017 and 2018, almost no data were entered for deworming.
 MAM, moderate acute malnutrition.

Table 3 Percentages of districts where first and second doses of rotavirus vaccine were outside of the $\pm 10\%$ threshold, aggregated per province per year (percentages of inconsistency)

Province	2017 % (n/N)	2018 % (n/N)	2019 % (n/N)	2020 % (n/N)	2021 % (n/N)
Niassa N=16	12.5 (2/16)	100.0 (16/16)	25 (4/16)	31.2 (5/16)	62.5 (10/16)
Cabo Delgado N=17	82.4 (14/17)	100.0 (17/17)	82.4 (14/17)	100.0 (17/17)	86.7 (13/15)
Nampula N=23	65.2 (15/23)	100.0 (23/23)	69.5 (16/23)	86.9 (20/23)	91.3 (21/23)
Zambezia N=22	72.7 (16/22)	100.0 (22/22)	77.3 (17/22)	86.4 (19/22)	68.2 (15/21)
Tete N=15	33.3 (5/15)	100.0 (15/15)	26.75 (4/15)	13.3 (2/15)	53.3 (8/15)
Sofala N=13	46.1 (6/13)	100.0 (13/13)	30.8 (4/13)	23.1 (3/13)	61.5 (8/13)
Manica N=12	16.7 (2/12)	100.0 (12/12)	0.0 (0/12)	0.0 (0/12)	50.0 (6/12)
Inhambane N=14	0.0 (0/14)	100.0 (14/14)	14.3 (2/14)	0.0 (0/14)	0.0 (0/14)
Gaza N=14	0.0 (0/14)	100.0 (14/14)	0.0 (0/14)	0.0 (0/14)	0.0 (0/14)
Maputo City N=7	0.0 (0/7)	100.0 (7/7)	0.0 (0/7)	0.0 (0/7)	0.0 (0/7)
Maputo Province N=8	0.0 (0/8)	100.0 (8/8)	0.0 (0/8)	0.0 (0/8)	0.0 (0/8)

n=number of districts that had consistency between first and second doses of rotavirus vaccine equal to or below -10% and equal to or above $+10\%$; N=total number of districts per province with data for the analyses.

in Nampula Province for deworming in 2021 and for the first dose of rotavirus vaccine in 2017, with both having 16 moderate outliers observed (online supplemental table 2). In 2021, a higher number of extreme outliers (11) was observed in Zambezia for the second dose of rotavirus vaccine. The first and second doses of rotavirus vaccine were the indicators with more moderate outliers, with 377 and 349 moderate outliers observed in all of the districts, respectively. Deworming and the second dose of rotavirus vaccine were the indicators with more extreme outliers, with 56 and 19 observed in all of the districts, respectively.

Regarding the number of deworming cases in 2021, in Nampula Province, 1 extreme outlier (in August) and 16 moderate outliers were observed particularly in December, as presented in online supplemental table 3.

Consistency between related indicators

All of the 161 analysed districts had data to analyse the consistency between the first and second doses of rotavirus vaccine across the study period, except for 2021, when two districts, Mocímboa da Praia and Quissanga in Cabo Delgado Province, had no data entered for these indicators. Most of the inconsistency was observed in Cabo Delgado Province, with 82.4% (14 of 17), 100.0% (17 of 17), 82.4% (14 of 17), 82.4% (14 of 17), and 86.7% (13 of 15) in 2017, 2018, 2019, 2020, and 2021, respectively, followed by the Nampula and Zambezia Provinces (table 3). Nampula Province had 65.2% (15 of 23), 100.0% (23 of 23), 69.5% (16 of 23), 86.9% (20 of 23), and 91.3% (21 of 23) inconsistency in 2017, 2018, 2019, 2020, and 2021, respectively. In Zambezia Province, the consistency percentages were 72.7% (16 of 22), 100.0% (22 of 22), 77.3% (17 of 22), 86.4% (19 of 22), and 68.2% (15 of 21) in 2017, 2018, 2019, 2020, and 2021, respectively. In 2018, inconsistencies were observed in all of the districts. Across

the years, better consistency was observed in Maputo City and Province, followed by Gaza and Inhambane Province.

The inconsistencies observed were in most of the cases due to higher numbers registered for the first dose of rotavirus vaccine compared with the registered number for the second dose, for example, for the Cabo Delgado, Nampula and Zambezia Provinces. Only in 2018 were there more children registered as being vaccinated with the second dose compared with the first dose. In the remaining 4 years, the pattern changed toward more children registered as being vaccinated with the first dose compared with the second dose (data not shown).

Consistency over time

Overall, better consistency was observed when analysing the period before the COVID-19 pandemic, from the years 2017 to 2019, either across the provinces or across the indicators (online supplemental table 4). The indicators MAM and MAM-recovered showed more consistency issues over time in both periods of 2017–2019 and 2018–2021. Maputo, Tete and Nampula were the three provinces with more inconsistencies for the MAM and MAM-recovered indicators when analysing the period of 2018–2021, and Tete and Maputo Provinces had more inconsistencies when analysing the period prior to the pandemic, from 2017 to 2019.

Analysing Nampula in more detail, better consistency was also observed in the period before the pandemic (online supplemental table 4 and online supplemental figure 1).

When projecting the counts to 2020 based on data from 2017 to 2019, we observed a high percentage of loss between the observed and expected cases per 100 000 inhabitants in the provinces of Maputo, Tete and Cabo Delgado for all of the indicators. Nampula reported

more cases than expected for all of the indicators (online supplemental table 5).

Seasonality decomposition

Overall, according to the population-adjusted average model, an excess or deficit of records was relatively low for the indicators MAM and MAM-recovered compared with the smoothed baseline (zero line) across the study period, respectively, at -14 (minimum -203 , maximum 255) and -7 (-122 , 176) persons/100 000 inhabitants. Conversely, the population-adjusted average seasonality component against the baseline, across the study period, for the records of the first and second doses of rotavirus vaccine, was relatively pronounced at -673 (-8056 , 1193) and -628 (-8160 , 1408) persons/100 000 inhabitants, respectively (online supplemental table 6).

The seasonality decomposition also shows variations across the quarters, with the records of the first and second doses of rotavirus vaccine being the most pronounced across the quarters using population-adjusted average seasonality components against the baseline. For these two indicators, the seasonal variation in the records reached thousands of persons/100 000 inhabitants above and below the baseline. In quarter 4, the variation magnitude from the baseline in the first and second doses of rotavirus vaccine records was lessened in comparison with the magnitudes in quarters 1–3; however, it is still pronounced when compared with the averaged seasonality components of the MAM and MAM-recovered indicators.

The seasonality component per indicator across provinces was heterogeneous for all of the indicators. The results show that the MAM and MAM-recovered indicators had the most pronounced positive and negative seasonality components in Maputo City (figure 2).

Cabo Delgado, Nampula, Zambezia, Tete and Manica follow, with high magnitude of seasonality components for the indicator MAM, with minimum -99 persons/100

000 inhabitants in Nampula and maximum 67 persons/100 000 inhabitants in Zambezia; the indicator MAM-recovered had both positive and negative highest extremes in Nampula, with minimum -113 persons/100 000 inhabitants and maximum 176 persons/100 000 inhabitants, respectively.

Heterogeneous patterns were also seen across provinces for indicators regarding the first and second doses of rotavirus vaccine, which had the most pronounced negative seasonality components in Maputo City. In Maputo City, the seasonal variation in the first dose of rotavirus vaccine recorded was on average -6080 (minimum -8056 , maximum -319) persons/100 000 inhabitants, and that of the second dose of rotavirus vaccine was on average -5985 (-8160 , -816) persons/100 000 inhabitants (figure 2).

Cabo Delgado, Nampula, Zambezia and Tete follow with relatively high magnitude of seasonality components regarding records on the first and second doses of rotavirus vaccine. Among the latter provinces with the largest seasonality components regarding the first dose of rotavirus vaccine, the most pronounced negative average seasonality was recorded in Tete with -1409 (-2298 , -587) persons/100 000 inhabitants, and the positive extreme average seasonality was recorded in Cabo Delgado with 188 (-840 , 1193) persons/100 000 inhabitants.

A similar pattern was verified for the records on the second dose of the rotavirus vaccine, since the largest average positive seasonality was recorded in Cabo Delgado Province with 146 (-820 , 1319) persons/100 000 inhabitants, and the largest average negative seasonality component was -169 (-1544 , 1408) persons/100 000 inhabitants in Tete Province.

The same seasonality component across the provinces showed a relatively homogeneous pattern, either for the indicators MAM and MAM-recovered or for those of the first and second doses of rotavirus vaccine (online supplemental figure 2).

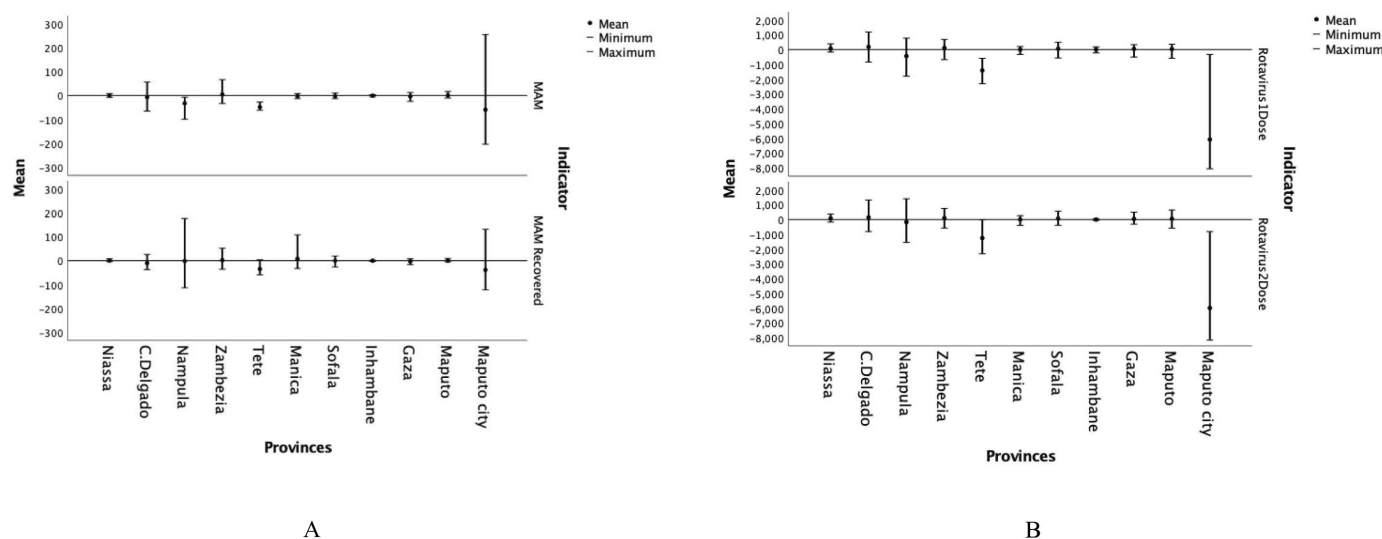


Figure 2 Mean, minimum and maximum (person/100 000 inhabitants) to (A) MAM and MAM-recovered, and (B) rotavirus first and second doses seasonality component per province. MAM, moderate acute malnutrition.

DISCUSSION

In this study, we aimed to assess the routine health system data quality of the years 2017–2021 in Mozambique, using selected WHO DQR parameters, namely completeness, outliers, consistency and seasonality, on selected indicators relevant for child health, specifically nutrition and diarrhoea. The selected indicators included those for MAM, deworming and rotavirus vaccination. The indicators of the first and second doses of rotavirus vaccine presented better completeness when compared with other indicators under analysis. This indicator presented 100% of completeness in all of the provinces, except for Cabo Delgado, which had 70.6% completeness, with missing data mostly observed in 2020 and 2021. Terrorism began in 2017 in Cabo Delgado Province, with intensification observed at times since 2020, which has created disruption to health service provision and use.³⁰ Most of the missing data in the present analysis were observed specifically in the districts that have been more affected by conflict: Palma, Mocímboa da Praia, Quissanga and Macomia. Conflicts can limit the delivery of healthcare and use of health services, and it has been reported that Mocímboa da Praia, Quissanga and Macomia are among the districts left without access to basic healthcare in Cabo Delgado.^{30–32}

We found very good completeness regarding the vaccination and deworming indicators for the years of 2019–2021, which might be associated with specific vaccination and deworming health strategies to increase adherence to vaccination by the population, to ensure good coverage. The number of cases that recovered from MAM had lower completeness, especially in the southern region of the country, which might indicate a problem with the information system's functioning or follow-up of confirmed cases of MAM.³³

Although the first and second doses of rotavirus vaccine indicators presented higher completeness, there were months in which a small number of vaccinated records were inputted into the system, and in some cases, the numbers did not reach 10 children, which might also indicate problems with data quality. The data that showed higher completeness deserve further external comparison with survey results and an analysis to confirm whether the reported numbers are indicative of what was expected.¹³

Extreme outliers were observed for deworming and first and second doses of rotavirus vaccine, which could also be associated with an improved health strategy for rotavirus vaccination and deworming, since in all of the scenarios, there were more cases reported compared with the mean observed in the particular year. A study conducted in Ethiopia that aimed to assess the routine data quality also found that deworming presented outliers.²⁴ A higher number of outliers was observed in the Zambezia and Nampula Provinces, which could be associated with specific strategies implemented in these provinces to increase vaccination coverage, since these provinces not only are the most populous but also have the highest prevalence of undernutrition and diarrhoea.^{8 25}

This study also looked at indicator consistency by considering the first dose of rotavirus vaccine compared with the second dose, which highlights problems in coverage for the second dose and/or drop-outs of vaccination follow-up, with Nampula, Zambezia and Cabo Delgado being the provinces where the inconsistency was higher. For Cabo Delgado Province, one of the explanations could be the use of health facilities outside of the province due to terrorism. Similar studies conducted in Ethiopia showed that, in general, the child nutrition indicator presents less consistency.^{16 24}

Considering 2021 as the reference for examining consistency over time, all of the indicators presented inconsistency. However, the first and second doses of rotavirus vaccine, overall, had better consistency in the period prior to the COVID-19 pandemic (2020). This finding emphasises the disruption to health services reported worldwide, especially in low-income and lower middle-income countries, due to the COVID-19 pandemic.^{28 34} Similar problems regarding maternal and child health service indicators have previously been experienced and reported during Ebola outbreaks.^{35 36} In all cases of health service disruption, the reduction in the numbers of reported cases should be analysed in detail in terms of the impact to public health, as it represents a missed opportunity to observe the data in real time and guide decision-making.

This study analysed selected indicators, exploring the expected cases for the period after year 2020. This allowed us to compare the expected and observed count data and draw comparisons on gains or losses. Maputo, Tete and Cabo Delgado were the provinces with a higher percentage of loss between what was reported and what was expected in terms of cases for 2020, while Nampula Province reported a higher number of cases in 2020 than expected.

For the MAM and MAM-recovered indicators, lower variation was observed, although some authors have reported that malnutrition can be more frequent in some seasons.^{37 38} A hospital-based study conducted in Mozambique showed that the wet season was associated with higher odds of wasting⁵; the absence of the seasonal component in the present data could be indicative of a lack of data quality. It has been reported that the colder and drier months of the year are associated with the highest numbers of rotavirus infection³⁹; these could justify the intensification of strategies to ensure a good coverage of rotavirus vaccination right before and during these months of the year, which in Mozambique are in the second and third quarters, justifying the variation observed for the first and second doses of rotavirus vaccine in the present analysis. The findings related to the seasonality decomposition for the first and second doses of rotavirus vaccine might be an indicator of good data quality.

Diarrhoea and acute malnutrition are diseases prone to seasonal patterns in Mozambique, thus reflecting seasonal decomposition with regard to selected and presented

indicators. Indeed, limited access to safe drinking water, a key determinant of diarrhoea outbreaks, is a constant, but it also varies since it is impacted by rainy seasons in Mozambique and other ecological and weather events. It is also known that public health services prepare response plans for the 'diarrhoeal season' almost as a routine, in advance of the rainy season, every year. Acute malnutrition may also have seasonality, also due to population variation in access to food over a period of a year. Interestingly, the rotavirus vaccine had more pronounced seasonality than the previous indicators. The most probable reasons may be the fact the vaccine is relatively new in the Expanded Program of Immunization in Mozambique; thus, its rollout may have faced challenges in terms of distribution across the vast country in the early years after the introduction of the vaccine.

For the present analysis, we only considered indicators with enough available data to be analysed based on the dimensions evaluated here; some key indicators for nutrition and diarrhoea monitoring were not included, although not including these indicators in the analysis due to missing data is itself indicative of poor data quality. Additionally, not all WHO-recommended dimensions for data quality assessment were analysed due to a lack of some external data, limited resources to conduct site visits to compare the data from the books with those introduced in the system and to interview health workers. Additionally, the system itself does not allow us to track patients and transfers among health facilities, as these data are not routinely collected. This limits our analysis of data quality to certain dimensions and did not allow us to obtain a complete picture of the quality of Mozambican routine data for nutrition and diarrhoea indicators; nevertheless, the present analysis is important, as this is the first routine data quality analysis for the selected indicators. The present results cannot be generalised to other countries, as the health indicators for routine data may sometimes vary and country-specific settings have an important role in the matter.

CONCLUSIONS

As per the selected indicators, routine health information data concerning malnutrition and diarrhoea are available and substantively complete in Mozambique, although outliers and inconsistencies are heterogeneously shown in records. Major deficits in terms of the analysed quality indicators were observed for Cabo Delgado, Nampula, Zambezia, Tete, Manica, and Maputo City and Province.

Additional and continuous analyses of data quality are recommended to inform reliance on the data. Specifically for Cabo Delgado and neighbouring provinces, it may be important to implement surveys at the population level, considering the developing emergency context, adapting specific methodologies to the context to obtain more precise population health data to inform decision-making, as the routine data in these provinces might be highly influenced by the conflict in Cabo Delgado,

resulting in poor data quality. Studies to identify the problems behind poor data quality should be conducted in order to assess whether they are infrastructure and system related or due to a lack of technical knowledge of the health professionals.

Contributors JS, SC, NdD and LG designed the study. JS is the guarantor. JS wrote the manuscript's first draft. JS and SC performed data analysis. SC, LG and NdD reviewed the manuscript writing. All authors have read and agreed to the published version of the manuscript.

Funding The project was funded by the Calouste Gulbenkian Foundation where JS has a PhD fellowship—248036. LG was supported by FCT—Portugal (UID/04413/2020, UIDB/00006/2020, UIDP/00006/2020).

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

Ethics approval Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. The data from the Mozambican information system (SIS-MA) are available upon reasonable request via email to the Directorate of Planning and Cooperation at Mozambique's Ministry of Health.

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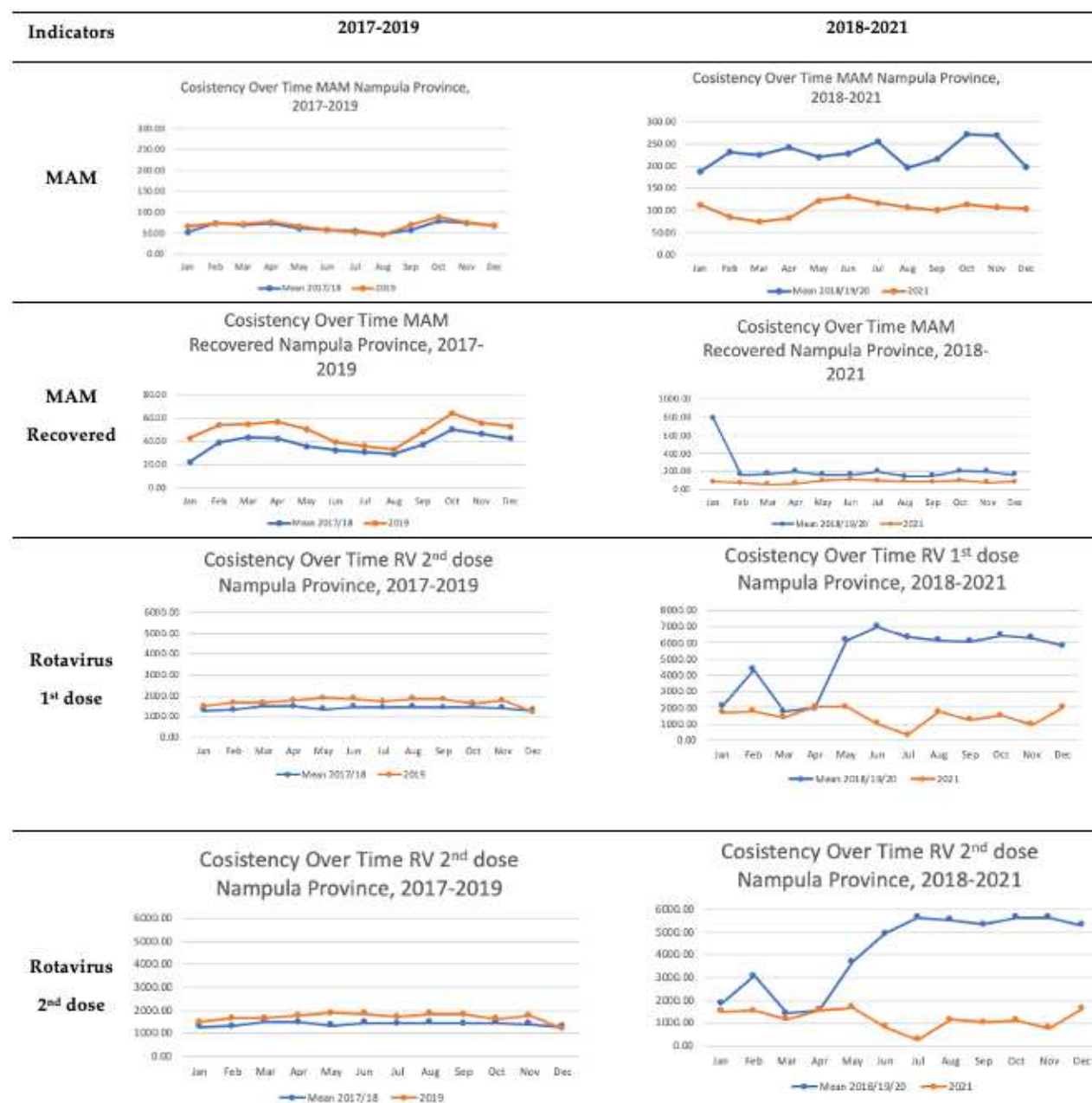
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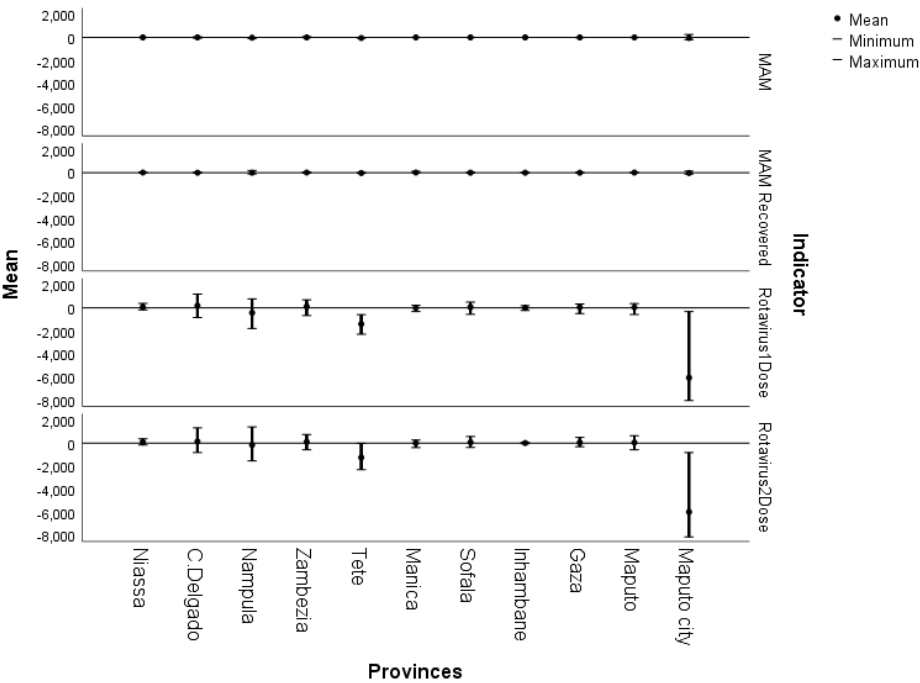
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Supplementary Figure 1: Consistency over time for MAM, MAM recovered, first and second dose rotavirus vaccine during the period before the COVID-19 pandemic (2017 to 2019) and in the pandemic period (2018 to 2021) in Nampula province



Supplementary Figure 2: Seasonality component per indicators across provinces

Supplementary Table 1: Percent of months with completeness of data equal or above 90% for selected indicators, from January 2017 to December 2021, Nampula Districts.

Province	District	MAM	MAM Recovered	Deworming*	Rotavirus 1 st Dose	Rotavirus 2 nd Dose
		Completeness % (n/N)	Completeness % (n/N)	Completeness % (n/N)	Completeness % (n/N)	Completeness % (n/N)
Nampula	ANGOCHE	100.0 (60/60)	98.3 (59/60)	60.0 (36/60)	100.0 (60/60)	100.0 (60/60)
Nampula	DISTRITO DE NAMPULA	100.0 (60/60)	100.0 (60/60)	61.7 (37/60)	100.0 (60/60)	100.0 (60/60)
Nampula	ERATI	98.3 (59/60)	98.3 (59/60)	60.0 (36/60)	95.0 (57/60)	95.0 (57/60)
Nampula	ILHA DE MOÇAMBIQUE	96.7 (58/60)	93.3 (56/60)	60.0 (36/60)	95.0 (57/60)	95.0 (57/60)
Nampula	LALAUÁ	100.0 (60/60)	83.3 (50/60)	60.0 (36/60)	98.3 (59/60)	96.7 (58/60)
Nampula	LARDE	100.0 (60/60)	96.7 (58/60)	60.0 (36/60)	96.7 (58/60)	96.7 (58/60)
Nampula	LIUPO	96.7 (58/60)	95.0 (57/60)	60.0 (36/60)	95.0 (57/60)	95.0 (57/60)
Nampula	MALEMA	98.3 (59/60)	95.0 (57/60)	58.3 (35/60)	100.0 (60/60)	100.0 (60/60)
Nampula	MECONTA	100.0 (60/60)	100.0 (60/60)	60.0 (36/60)	95.0 (57/60)	95.0 (57/60)
Nampula	MECUBURI	98.3 (59/60)	100.0 (60/60)	60.0 (36/60)	98.3 (59/60)	98.3 (59/60)
Nampula	MEMBA	100.0 (60/60)	96.7 (58/60)	60.0 (36/60)	98.3 (59/60)	98.3 (59/60)
Nampula	MOGINCUAL	96.7 (58/60)	96.7 (58/60)	60.0 (36/60)	91.7 (55/60)	91.7 (55/60)
Nampula	MOGOVOLAS	98.3 (59/60)	98.3 (59/60)	60.0 (36/60)	95.0 (57/60)	95.0 (57/60)
Nampula	MOMA	100.0 (60/60)	100.0 (60/60)	60.0 (36/60)	95.0 (57/60)	95.0 (57/60)
Nampula	MONAPO	100.0 (60/60)	100.0 (60/60)	60.0 (36/60)	100.0 (60/60)	100.0 (60/60)
Nampula	MOSSURIL	100.0 (60/60)	98.3 (59/60)	58.3 (35/60)	93.3 (56/60)	93.3 (56/60)
Nampula	MUECATE	100.0 (60/60)	98.3 (59/60)	60.0 (36/60)	93.3 (56/60)	93.3 (56/60)
Nampula	MURRUPULA	98.3 (59/60)	91.7 (55/60)	58.3 (35/60)	96.7 (58/60)	98.3 (59/60)
Nampula	NACALA-A-VELHA	100.0 (60/60)	100.0 (60/60)	55.0 (33/60)	100.0 (60/60)	100.0 (60/60)
Nampula	NACALA-PORTO	100.0 (60/60)	100.0 (60/60)	60.0 (36/60)	96.7 (58/60)	96.7 (58/60)
Nampula	NACAROA	100.0 (60/60)	98.3 (59/60)	58.3 (35/60)	98.3 (59/60)	98.3 (59/60)
Nampula	RAPALE	100.0 (60/60)	98.3 (59/60)	60.0 (36/60)	96.7 (58/60)	96.7 (58/60)
Nampula	RIBAUE	100.0 (60/60)	98.3 (59/60)	60.0 (36/60)	98.3 (59/60)	98.3 (59/60)

n: number of months in Nampula province without data across the 60 months evaluated.

N: total number of months for the entire period in analysis.

*: For 2017 and 2018 there is almost no data was entered for deworming.

Supplementary table 2: Number of moderate (M) and extreme (E) outliers observed in the districts of each province, per month from January 2017 to December 2021.

Province	MAM					MAM Recovered					Deworming					Rotavirus 1 st Dose					Rotavirus 2 nd Dose				
	2017 (M;E)	2018 (M;E)	2019 (M;E)	2020 (M;E)	2021 (M;E)	2017 (M;E)	2018 (M;E)	2019 (M;E)	2020 (M;E)	2021 (M;E)	2017 (M;E)	2018 (M;E)	2019 (M;E)	2020 (M;E)	2021 (M;E)	2017 (M;E)	2018 (M;E)	2019 (M;E)	2020 (M;E)	2021 (M;E)	2017 (M;E)	2018 (M;E)	2019 (M;E)	2020 (M;E)	2021 (M;E)
Niassa	2;2	4;0	4;0	4;0	3;0	4;0	1;0	4;0	4;0	5;0	-	-	4;0	9;0	6;1	7;0	6;0	5;0	10;0	6;0	6;0	4;0	7;0	11;0	5;0
Cabo Delgado	7;0	6;1	8;0	8;0	5;0	4;0	4;1	6;0	6;0	6;1	-	-	12;0	7;0	3;6	4;0	8;0	8;0	2;0	4;1	5;0	5;0	10;0	0;0	4;0
Nampula	9;0	10;0	12;0	11;0	10;0	9;0	8;0	10;0	12;1	9;0	-	-	10;0	10;2	16;1	16;0	7;1	11;0	5;0	3;0	9;0	8;1	10;0	5;0	3;0
Zambézia	9;0	10;0	10;0	8;0	10;0	9;0	11;0	8;0	9;0	11;0	-	-	10;2	8;9	11;7	12;1	11;0	11;0	13;0	12;0	12;2	7;0	11;0	10;0	10;11
Tete	5;1	7;0	8;0	7;0	5;0	6;0	8;0	11;0	10;0	5;0	-	-	10;1	7;1	8;2	9;0	10;0	5;1	7;0	8;0	9;0	8;0	6;0	6;0	9;0
Sofala	5;0	5;0	8;0	4;1	4;0	4;0	5;1	3;0	7;0	6;0	-	-	6;3	10;1	6;0	9;0	5;1	8;1	5;0	8;0	8;1	6;0	8;1	6;0	7;0
Manica	8;0	4;0	3;0	6;0	3;0	2;0	4;1	4;0	3;0	6;0	-	-	3;5	7;1	7;0	12;1	13;0	4;0	8;0	7;0	9;1	12;0	3;0	8;0	8;0
Inhambane	4;0	3;1	4;0	4;0	5;1	0;0	4;0	2;0	2;0	5;0	-	-	4;1	6;1	7;0	7;0	6;0	6;1	4;0	9;1	10;0	6;0	7;0	5;0	7;1
Gaza	2;0	4;0	4;0	4;0	8;0	1;0	2;0	3;0	5;0	4;0	-	-	4;0	5;0	4;2	5;0	4;0	14;0	7;0	8;0	9;0	6;0	6;0	3;0	7;0
Maputo City	1;0	2;0	4;0	1;0	4;0	2;0	2;0	0;1	1;0	2;0	-	-	7;0	6;1	5;2	4;0	0;0	2;0	1;0	3;0	2;0	1;0	4;0	2;0	4;0
Maputo Province	1;0	2;0	5;0	1;0	4;0	0;0	3;0	6;0	3;0	2;0	-	-	4;2	5;2	5;3	5;0	3;0	2;1	3;0	5;0	4;0	2;0	2;1	3;0	4;0

M: number of moderate outliers observed in that year
E: number of extreme outliers observed in that year

Supplementary Table 3: Deworming counts per month, highlighting moderate and extreme outliers per month in the districts of the Nampula province in 2021

Nampula Districts	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Angoche	974	966	736	889	564	1130	595	911	491	387	756	1627
Distrito De Nampula	5390	5167	6763	3617	3686	4837	3756	3933	5529	7588	8959	6230
Erati	1299	3624	3665	2322	1996	2565	2357	2394	1970	1770	1892	1585
Ilha De Moçambique	158	179	173	274	166	132	185	231	230	144	141	129
Lalaua	138	898	299	421	398	482	207	182	168	232	213	747
Larde	134	109	188	153	50	278	124	365	121	111	90	828
Liupo	91	534	469	459	367	96	259	176	225	245	197	146
Malema	231	700	1001	597	885	920	805	252	289	299		299
Meconta	738	574	1289	1380	1335	2961	1141	14835	860	742	472	1851
Mecuburi	414	373	552	582	602	624	604	535	512	674	714	1278
Memba	2938	2223	1661	2255	1713	1868	2298	2361	2536	2662	1836	5894
Mogincual	1011	1446	1357	1547	1736	1352	1615	2133	1724	1530	993	1376
Mogovolas	4042	4016	3257	5244	3857	7437	3487	4517	3798	3942	1665	3963
Moma	3483	2575	2821	2452	2170	2242	2297	2699	2500	3267	2582	1963
Monapo	380	456	724	608	352	589	407	499	681	532	382	366
Mossuril	502	840	638	1976	1772	2545	2571	1548	1464	1840	542	917
Muecate	283	538	572	340	448	423	532	402	226	477	457	235
Murupula	1324	815	941	956	694	963	842	951	674	899	468	2212
Nacala-a-Velha	505	766	716	832	1471	1042	812	269	391	555	247	492
Nacala-Porto	559	735	1036	1192	1493	2872	1171	1878	1070	731	852	783
Nacaroa	1078	1229	1511	2858	1249	1253	811	762	792	1096	1460	789
Rapale	1107	2084	1875	2256	2407	3168	2283	2808	1894	2404	2529	6236
Ribaue	995	1447	882	995	1467	1066	1188	999	1215	1021	522	973

Data: moderate (2-3 standard deviations) outliers identified.

Data: extreme (> 3 standard deviations) outliers identified.

Supplementary Table 4: Number of months with inconsistency per period of analysis for each indicator and province

Province	MAM		MAM Recovered		Rotavirus 1 st Dose		Rotavirus 2 nd Dose	
	2017-2019 (n/N)	2018-2021 (n/N)	2017-2019 (n/N)	2018-2021 (n/N)	2017-2019 (n/N)	2018-2021 (n/N)	2017-2019 (n/N)	2018-2021 (n/N)
Niassa	3/12	9/12	5/12	10/12	1/12	3/12	1/12	5/12
Cabo Delgado	12/12	8/12	12/12	11/12	3/12	6/12	2/12	6/12
Nampula	0/12	12/12	4/12	12/12	1/12	9/12	1/12	9/12
Zambézia	1/12	6/12	5/12	8/12	0/12	7/12	0/12	6/12
Tete	12/12	11/12	12/12	7/12	12/12	12/12	2/12	12/12
Sofala	2/12	2/12	3/12	9/12	0/12	1/12	0/12	1/12
Manica	6/12	11/12	5/12	11/12	1/12	1/12	0/12	0/12
Inhambane	5/12	4/12	7/12	6/12	0/12	0/12	0/12	0/12
Gaza	8/12	5/12	8/12	5/12	0/12	0/12	0/12	0/12
Maputo City	5/12	7/12	6/12	8/12	0/12	0/12	0/12	0/12
Maputo Province	12/12	12/12	12/12	12/12	12/12	12/12	1/12	12/12

n: number of months with inconsistency

N: number of months analyzed per year

Supplementary Table 5: Difference between the observed number of cases and expected number of cases of MAM, MAM Recovered, Rotavirus 1st dose, Rotavirus 2nd dose in 2020 per 100 000 habitants

Province	QI ₂₀₂₀		QII ₂₀₂₀		QIII ₂₀₂₀		QIV ₂₀₂₀		Total ₂₀₂₀		
	E	D	E	D	E	D	E	D	E	D	% of loss
	Moderate Acute Malnutrition										
Niassa	145.30	-12.78	140.51	23.94	141.86	-0.09	166.44	4.58	594.11	15.66	2.64
Cabo Delgado	480.74	-107.96	476.47	-83.87	394.77	-94.41	384.22	-109.53	1736.21	-395.76	-22.79
Nampula	643.77	809.48	682.16	920.55	595.22	1038.29	775.12	935.74	2696	3704.06	137.39
Zambézia	271.20	-17.10	231.52	-47.49	183.60	-4.00	181.80	10.05	868.13	-58.54	-6.74
Tete	572.12	-240.85	535.35	-206.55	518.89	-31.26	516.33	-112.02	2142.69	-590.68	-27.57
Sofala	351.28	45.75	350.45	28.43	372.28	211.80	403.64	62.21	1477.66	348.18	23.56
Manica	243.14	21.27	250.10	32.22	243.42	81.79	262.66	55.77	999.31	191.05	19.12
Inhambane	94.46	-12.48	107.46	-24.93	104.90	4.58	108.91	1.67	415.73	-31.15	-7.49
Gaza	134.09	31.39	111.20	35.17	103.28	33.26	157.37	-27.39	505.94	72.44	14.32
Maputo City	64.23	21.07	56.78	-13.70	66.10	-4.54	78.97	8.09	266.07	10.91	4.10
Maputo Province	519.52	-392.81	431.91	-321.50	330.51	-217.14	501.64	-357.14	1783.58	-1288.58	-72.25
	Moderate Acute Malnutrition Recovered										
Niassa	108.56	-6.48	104.29	12.71	111.42	-1.89	131.72	7.07	455.99	11.41	2.50
Cabo Delgado	295.15	-60.86	357.00	-91.96	300.44	-67.92	305.15	-85.60	1257.74	-306.34	-24.36
Nampula	763.30	2295.67	595.56	675.94	488.35	741.09	701.85	631.99	2549.07	4344.70	170.44
Zambézia	212.77	-36.44	180.63	-43.45	122.52	16.35	154.29	7.59	670.21	-55.95	-8.35
Tete	419.16	-165.41	383.79	-123.78	392.82	-11.29	422.60	-83.07	1618.37	-383.55	-23.70

Sofala	271.17	10.16	274.94	17.99	252.40	8.76	324.62	33.09	1123.13	69.99	6.23
Manica	193.13	31.64	205.97	30.21	349.09	-59.71	213.63	65.16	961.82	67.29	7.00
Inhambane	59.65	-4.08	68.41	-8.44	71.47	-0.49	75.01	3.11	274.54	-9.90	-3.61
Gaza	106.26	-0.85	84.72	27.24	85.05	23.09	120.41	-24.29	396.44	25.19	6.36
Maputo City	55.90	17.08	53.00	-13.43	59.95	-7.19	66.20	6.78	235.06	3.24	1.38
Maputo Province	283.71	-185.89	274.43	-182.17	232.40	-140.88	331.19	-217.44	1121.72	-726.39	-64.76
Rotavirus 1st Dose											
Niassa	6395.24	-275.82	6030.73	-428.85	5839.69	673.70	6049.04	1035.02	24314.70	1004.06	4.13
Cabo Delgado	3950.81	-2096.56	5358.59	-809.99	5699.85	1230.04	4401.85	349.79	19411.11	-1326.71	-6.83
Nampula	9864.64	4162.47	13279.57	21039.81	15867.23	28465.72	15699.48	29630.85	54710.91	83298.85	152.25
Zambézia	4428.29	-1161.43	5229.91	-584.48	5658.28	1068.33	5288.03	767.85	20604.51	90.27	0.44
Tete	13796.44	-6967.87	13742.44	-6852.00	12835.03	-5432.83	10691.47	-3852.62	51065.37	-23105.32	-45.25
Sofala	5564.99	268.48	6069.25	-122.85	6606.83	611.58	6499.36	-74.51	24740.42	682.70	2.76
Manica	5909.63	665.44	6158.57	-135.65	6346.08	-318.27	6350.18	-370.42	24764.46	-158.89	-0.64
Inhambane	8248.82	812.78	8549.64	-1.92	8478.35	112.29	8697.42	210.67	33974.23	1133.83	3.34
Gaza	7835.17	400.26	8619.37	110.88	8746.41	-122.12	8572.12	358.02	33773.08	747.04	2.21
Maputo City	5626.74	432.67	6484.44	185.22	6381.90	140.03	6015.99	102.33	24509.06	860.25	3.51
Maputo Province	32744.65	-27859.86	29410.54	-23740.27	24415.43	-18605.11	23441.47	-17309.92	110012.09	-87515.15	-79.55
Rotavirus 2nd dose											

Niassa	5467.67	-122.76	5738.48	-457.44	5453.09	963.60	5171.82	1060.72	21831.06	1444.11	6.61
Cabo Delgado	2995.78	-2091.40	3943.39	-1365.42	4711.79	1258.82	3533.75	237.78	15184.72	-1960.21	-12.91
Nampula	7731.75	2107.59	9685.28	11288.17	13428.90	25546.15	13170.29	27027.45	44016.22	65969.36	149.88
Zambézia	3800.17	-1275.90	4270.29	-949.19	4939.69	737.57	4579.76	815.43	17589.91	-672.09	-3.82
Tete	12351.48	-6023.49	12275.88	-5886.91	12011.69	-5088.19	9791.11	-3208.25	46430.15	-20206.84	-43.52
Sofala	5186.23	342.46	5341.74	48.81	6090.59	593.15	5869.80	176.43	22488.36	1160.85	5.16
Manica	5375.87	865.85	5801.10	-80.05	5977.58	-261.69	5800.35	-402.60	22954.90	121.52	0.53
Inhambane	7942.42	770.36	8013.26	-96.05	8042.57	56.20	8113.65	295.43	32111.90	1025.93	3.19
Gaza	7832.42	392.10	8341.68	110.03	8685.52	-127.86	8053.10	321.61	32912.72	695.87	2.11
Maputo City	5508.67	602.62	6057.81	97.44	6531.82	35.83	6036.45	260.37	24134.76	996.26	4.13
Maputo Province	31783.83	-27085.78	28347.29	-22973.05	24781.95	-19086.48	22748.02	-17011.06	107661.08	-86156.37	-80.03

E: number of cases expected per 100 000 habitants

D: difference between the number of cases observed and the number cases expected in 2020

Supplementary Table 6: Adjust-coverage seasonality component against the baseline per quarter per province.

Province	Quarter	MAM	MAM Recovered	Rotavirus 1 st Dose	Rotavirus 2 nd Dose
Niassa	1	4.83	3.28	395.32	47.73
	2	-4.02	-4.62	6.42	375.86
	3	-7.81	-3.85	-167.04	84.58
	4	8.15	7.85	41.51	-167.18
Cabo Delgado	1	56.63	1.27	-839.60	-819.73
	2	31.28	25.61	648.75	167.28
	3	-49.68	-31.54	1192.67	1319.31
	4	-65.08	-37.28	-251.73	-81.54
Nampula	1	-7.15	176.36	-1796.05	-1544.29
	2	-12.72	-38.37	-716.37	-1161.96
	3	-98.66	-113.26	783.81	1407.71
	4	-11.41	-30.06	-6.89	620.96
Zambézia	1	66.51	52.04	-673.66	-581.66
	2	15.01	10.15	131.35	-99.12
	3	-29.82	-35.52	695.41	743.68
	4	-32.81	-19.58	298.78	347.92
Tete	1	-48.97	-37.75	-2297.84	-2317.48
	2	-61.11	-59.15	-1102.64	-1283.74
	3	-56.17	-45.89	-587.49	-18.48
	4	-27.36	3.55	-1647.84	-1385.04
Sofala	1	-1.44	7.56	-558.96	-385.61
	2	-12.80	-0.56	-91.75	-234.06
	3	-5.71	-26.27	500.05	566.00
	4	10.48	18.69	397.62	327.18
Manica	1	8.28	-22.88	-322.76	-397.95
	2	2.98	-22.12	-53.06	40.56
	3	-12.66	107.59	174.70	262.27
	4	-8.26	-33.12	211.87	102.54
Inhambane	1	-5.40	-4.07	-220.87	-56.86
	2	3.87	0.67	59.56	-3.93
	3	-0.69	0.92	-24.22	8.20
	4	0.70	1.65	184.82	62.23
Gaza	1	9.08	8.02	-500.35	-307.02
	2	-11.79	-10.28	224.40	158.97
	3	-24.05	-16.72	338.73	493.94
	4	12.83	5.41	143.63	-176.41
Maputo City	1	-4.53	-3.21	-576.10	-586.25
	2	-9.86	-5.33	371.99	12.59
	3	-0.80	1.00	339.71	639.67
	4	17.33	9.01	22.70	149.30
Maputo Province	1	-133.10	-81.66	-8055.91	-8160.39
	2	-154.81	-81.46	-7892.42	-8159.62
	3	-203.10	-122.01	-8054.81	-6803.70
	4	254.87	131.14	-318.66	-816.29

3. DISCUSSION & CONCLUSIONS

DISCUSSION & CONCLUSIONS

3.1. Discussion

Mozambique is a country with a high prevalence of undernutrition, diarrhoea, and other infectious diseases in children under-five (1–4). The high prevalence is frequently observed in low and lower-middle-income countries worldwide and highlights the need for the capacity to prevent, monitor, and provide early diagnosis and adequate treatment of these diseases (5–8). This is particularly critical in cases where there is a co-occurrence of these diseases in the same child, especially in regions where they are highly prevalent.

The present thesis aimed to assess undernutrition among children under-five years old with diarrhoea in Mozambique, evaluate the readiness of health services, and analyse the quality of routine data used to monitor nutrition and diarrhoea indicators, through three studies. These studies aim to provide evidence on the burden of undernutrition in children with diarrhoea, and highlight the strengths, weakness, and opportunities to improve the quality of health services in managing these reported cases.

Our results can help to define actions to contribute to achieving the Sustainable Development Goals in Mozambique, with a focus on SDG 2 - Zero hunger, on improve nutrition; SDG 3 - Good health and well-being, on ensuring health lives and promoting well-being; SDG 6 - Clean water and sanitation, on improving access to clean water; SDG 10 - Reduced inequalities, on reducing inequalities on health resources and services (9).

Initiatives such as the Multisectoral Action Plan for the Reduction of Chronic Undernutrition, known in Portuguese as PAMRDC; the Nutrition Rehabilitation Program, which begins with action at community level; and IMCI, which aims to improve child health in general with a focus on undernutrition for the first two initiatives mentioned (10–12). All initiatives present actions that also have an impact on diarrhoea, demonstrating the association between these two diseases in children.

In the first study, our results show a higher frequency of undernutrition in children with diarrhoea compared to the results of studies conducted in children without diarrhoea, with an overall frequency of 54.1%, being 24.7% for underweight, 26.6% for wasting and 32.5% for stunting. When we look to our results of the second study, regarding the readiness of services for diagnosis and treatment, we can see that there are significant gaps in providing high-quality health services. These results highlight a high dual burden of undernutrition and diarrhoea, and low readiness of health services, emphasising the need to strengthen health services by

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monitoring the implementation of the IMCI strategy, and ensuring the availability of essential supplies for the management of undernutrition and diarrhoea in children.

A high prevalence of undernutrition in children with diarrhoea was observed in Nampula and Zambézia provinces with 47.4% and 49.0% for stunting, respectively. Both provinces rank among those in the country with highest prevalence of undernutrition and diarrhoea in children under-five (1–4). Over the past 20 years, Mozambique has been afflicted by droughts, cyclones and floods that consistently lead to food insecurity, which is one of the main factors for undernutrition in LMIC (13). The high frequency of undernutrition in children with diarrhoea might be associated with poverty, high population density, food insecurity, poor health indicators and natural disasters that exacerbate the precarious situation of the country especially when it comes to health issues in certain provinces, such as Nampula and Zambézia (14,15). These two provinces are among the poorest in the country, with high population density, and are among those that suffer the most from cyclones, droughts, floods, and impact of armed conflicts (13,15).

Although Nampula is not the epicentre of the terrorism, it is a province that is under pressure due to the displacement of the population from the province of Cabo Delgado, where the terrorism is taking place since 2017. The influx of people to Nampula alters the health, hygiene, water, and sanitation needs of the population, increasing pressure in the province and reducing the availability of services and care. The increase in pressure to provide services and care can influence the readiness of health services, making it crucial to have mechanisms for monitoring the health situation of populations in real time.

Our results from the third study show that the quality of data is low in the provinces of Cabo Delgado and Nampula. In Cabo Delgado, a vicious cycle has taken root, in the sense that terrorism increased the need for care, but it has also led to interruption of services similar to what has been reported in other humanitarian crisis (16,17). As a result, access to quality routine data, that is critical for decision-making to address health problems and needs created by the same terrorism, is severely limited. In Nampula, the poor quality of routine data makes it even more difficult to monitor the rapid changes occurring mainly in the districts neighbouring Cabo Delgado. For example, as wasting indicates the urgent moment for action, it is imperative that the indicators be easily monitored for rapid intervention. It would be particularly beneficial nutrition indicators such as moderate acute malnutrition (MAM) and cases recovered from it to be of high quality to guide the development of actions aimed at

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mitigating the impact of undernutrition. However, our results show that in SIS-MA, these two indicators are of poor quality, with notably low completeness across the country. There is a need to enhance the capacity and quality of service delivery in districts near the conflict areas, which are likely destinations for population fleeing conflict. Additionally, the COVID-19 pandemic has exacerbated issues concerning the quality of services provided and the quality of routine data as observed in another study analysis performed using routine data for tuberculosis indicators from SIS-MA (18). Our analysis of data quality during the pandemic period, suggests that the already low quality might have been further impacted by disruption in the reporting process, rendering this data even less usable for decision-making.

Moreover, when we assess the service availability and readiness, it is evident that none of the health facilities had all nutrition service tracer items available. The overall nutrition and diarrhoea service readiness scores were low, fewer than 50% of the health facilities had a readiness equal to or higher than the mean readiness. This highlights the poor quality of services available for diagnosing and treating undernutrition and diarrhoea in children under-five.

In examining other sociodemographic factors associated with undernutrition in children with diarrhoea, unsafe water was one of the factors. The WASH indicators are among the main causes of undernutrition and diarrhoea. Our results show that the frequency of undernutrition in children with diarrhoea was higher among those with no access to piped water. Although no statistical association was observed in our analysis, the higher frequency observed can be attributed to the quality of the water from non-piped sources, which tend to be contaminated with pathogens that can cause diarrhoea. The increased risk of undernutrition due to consumption of unsafe water is associated with waterborne diseases. Even though the relationship between water quality and undernutrition is indirect, it has been reported that poor quality of water is associated with stunting and thinness (19). This might be directly related to the overall high frequency of undernutrition in children with diarrhoea, particularly in Nampula, where 61.9% of the population consumes water from unsafe sources and approximately 50% of the population takes 30 to 60 min to access basic services, such as water source, public transportation, and food markets (15).

The results of the present study indicate that, like many LMICs, Mozambique's health system faces structural challenges that hinder readiness. These challenges may include inadequate financing, poor infrastructure, and a lack of a systematic approach to healthcare delivery, exacerbating the challenges in providing quality care (20,21). It is vital to prioritize and allocate

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resources for essential supplies and human resources, as well as to develop robust supply chains to ensure consistent availability of drugs. Investment in human resources through training, supervision and capacity-building programs focusing on the effective management of childhood undernutrition and diarrhoea is also crucial for improving the quality of care and child health. Moreover, improving health infrastructure to ensure that facilities have the basic amenities necessary for service delivery is imperative (21). Developing integrated service delivery models that address both undernutrition and diarrhoea, for instance, ensuring that for example that children who visit a health facility for diarrhoea are also screened and treated for undernutrition and vice versa, could help improve the efficiency and effectiveness of interventions.

A significative difference was observed for wasting between the wet and dry season on the first study. Higher odds of being wasted were observed in the wet season in children aged under-five with diarrhoea. During the wet season, diarrhoeal disease is more frequent, which is already known as a risk factor for undernutrition due to food insecurity, and challenges with food access and availability (22,23). While some authors have reported that undernutrition can be more frequent in certain seasons (24,25), as also showed in our first study, the absence of the seasonal component in the present data for MAM and MAM-recovered indicators from the third study on routine data quality could be an additional indicator of data quality issues.

It has been reported that the colder and drier months of the year are associated with the highest number of rotavirus infections, which could justify the intensification of strategies to ensure good coverage on Rotavirus vaccination, especially before and during these months of the year (26). In Mozambique, these are in the second and third quarters. The findings on the seasonality decomposition for rotavirus 1st and 2nd doses might be an indicator of good data quality for this specific indicator.

We also analysed the consistency of indicators, considering the first dose of rotavirus vaccine compared to the second dose, under the data quality assessment. Problems regarding coverage for the vaccine second dose and drop-outs in vaccination follow-up were identified, with Nampula, Zambézia, and Cabo Delgado being the provinces with higher inconsistencies.

This finding might be related to the disruption of health services reported worldwide especially in LMICs due to the COVID-19 pandemic. Similar problems on maternal and child health services indicators were reported during Ebola outbreaks (27). In all cases of health services disruption, the reduction in the numbers of reported cases should be analysed in detail in terms

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of its impact for public health, as it represents a missed opportunity to observe the data in real time and guiding decision-making.

Emergencies situations that have an impact on health service disruption are of major concern. This study explored the expected cases for the period after year 2020, which allowed a comparison between expected and observed count data and drawing comparisons on gains or losses due to the COVID-19 pandemic. Maputo province, Tete and Cabo Delgado were the provinces with higher percentage of loss between what was reported and what was expected in terms of cases for 2020, whilst Nampula province reported a higher number of cases in 2020 than expected. The higher number of cases observed in Nampula might be directly associated with the loss observed in Cabo Delgado, as part of Cabo Delgado population might have moved to Nampula due to the terrorism in that province.

When we look at other factors associated with undernutrition in children under-five years of age with diarrhoea, we perceive, among the socio-demographic factors, the academic level of the child's caregiver. Having an illiterate caregiver is associated with higher odds of a child being underweight compared to those with caregivers having secondary or higher education levels. Same results were observed in studies conducted in Bangladesh, Nigeria, Kenya, Tanzania, Ethiopia, and Mozambique, although those studies were conducted in children without diarrhoea (28–34). The education level influences the ability to understand and follow instructions given by health professionals. During formal education, women can gain knowledge on health subjects, including nutrition, which could help them better address health issues within their family and community (28,34). Additionally, refresher training for health professionals is important, especially when targeting the technical quality of human resources, knowledge of norms and other elements are essential for the readiness of services (21). However, this point is of the with low availability and readiness, especially in relation to health professionals responsible for providing care to children under-five years of age in Mozambique.

In summary, our results point out that, in one side an illiterate caregiver can struggle to fulfil their role in preventing and treating undernutrition in children with diarrhoea. On the other side, we have a health professional that might not be sharing key and correct guidelines for the prevention and treatment of undernutrition in children with diarrhoea. Moreover, nutrition refresher trainings were frequently provided to paediatricians, despite them being the least numerous among healthcare providers for undernutrition. The 2011–2020 Mozambican

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multisectoral action plan for the reduction in chronic undernutrition highlights nutrition refresher trainings to nurses as one of the key interventions, although our study showed that nutritionists were the healthcare professionals who reported the fewest number of such trainings (11).

Of all the nutrition-related training assessed during the study implementation, the integrated management of childhood illness was the least frequently provided training to the health workers overall. Thus, our result highlights a gap in nutrition service-specific training for health workers, which in turn implies a poor technical quality of the services provided (20,35–38).

The low provision of integrated management of childhood illness training to health workers highlights another key finding from our analysis and substantiates the low availability of guidelines on the IMCI at the point of care. Guidelines for the IMCI are vital resources for scaling up the impact of curative child services, and their implementation should be strengthened within health services (39–42).

Another aspect associated with the technical quality of human resources is supervision, as Kruk et al., 2018, pointed that a combination of training and supervision significantly enhances the quality of health services (21). However, without regular supervision, it is difficult to assess the health professional's capacity and propose specific training to improve the care provided. Supervision was not performed regularly, but most targeted nutritionists, authors report that supervision is among the key interventions for improving the quality of services (37,39,41,43,44).

Regarding the clinical factors analysed, there was a positive association between all type of undernutrition and low birthweight in children with diarrhoea. A child born with a low weight has a higher risk of developing wasting, underweight and stunting than a child born with a normal weight (45,46).

The quality of health services has a significant role in reducing the incidence of low birthweight and consequently all associated health problems. Main health services quality indicators associated with low birthweight are management of maternal health conditions, access to prenatal care, nutrition education and counselling, and access to appropriate interventions. Nutrition education and counselling, and access to appropriate interventions are the two indicators related to the quality indicators assessed in the present study.

Nutrition education and counselling is particularly important for pregnant and breastfeeding women as it can provide information about the importance of a balanced and nutrient-rich diet

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for both the mother and the baby. Access to appropriate interventions is associated with providing suitable interventions for infection treatment and feeding support, which can help improve maternal and child health. To secure access to appropriate interventions, low-income countries, such as Mozambique, can employ strategies such as, community health programs which include task shifting, and mobile clinics and outreach services that leverage technology. Additionally, they can engage in public-private partnership, subsidize healthcare costs, improve supply chains, enact law and policies that support maternal and child health, implement nutritional programs, and establish robust monitoring and evaluation systems (47–50).

The two main indicators related to low birthweight are associated with caregiver education level that most of the time is the mother, and her capability to understand and follow health guidelines and recommendations. It's also related to health professional training, including supervision, that can improve their capacity to address nutrition and infections. Additionally, the access to appropriate interventions is linked with all trace items for availability and readiness of child health services assessed in the present study. This suggests that the poor health services quality observed in this study might have a negative impact on child low birthweight and its association with increased high risk of undernutrition in children with diarrhoea.

Another clinical factor known to be associated with all three types of undernutrition is HIV (51). HIV positive children have a higher risk of developing undernutrition, especially underweight and stunting (52–54). Due to the high burden diseases, several initiatives have been implemented worldwide with specific fund to reduce morbidity and mortality associated with infections, a trend also observed with malaria, a disease with particularly high morbidity and mortality (2,3,55,56). As both diseases are highly prevalent in children under-five and receive specific funding, we assessed the readiness of HIV and malaria services for children and examined their impact on nutrition and diarrhoea service readiness. Malaria readiness was the highest among the four targeted services, whereas HIV service readiness was the lowest.

The prioritization given to malaria might explain its higher readiness compared to other services, but even then, the service was below 100%. Through the Malaria National Control Program from the Ministry of Health, and through different non-governmental organizations Mozambique has been implementing strategies to reduce the malaria burden. Beyond the overall lower readiness observed for HIV services, these services had the lowest readiness in rural areas whereas and also in health facilities without inpatient services.

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The lower service readiness observed for HIV services, along with the non-optimal service readiness for malaria services, could be attributed to the limited success of vertical funding, which results from disease-specific programming. Certain health services may receive enhanced resources and technical quality due to the prioritization of vertical development AID funding. Such prioritization is often justified by the high disease burden associated with these conditions. Malaria and HIV, which have high prevalence, morbidity, and mortality rates in LMIC are prime examples of health conditions that receive priority attention and investment from both global and local health initiatives (2,3,55,56).

In Mozambique, such funding is primarily supported by the President's Emergency Plan for AIDS Relief PEPFAR, the Global Fund to Fight AIDS, Malaria, and TB, the President's Malaria Initiative (PMI), and the World Bank (57–59). Despite this, some vertical investments may have spillover effect, positively impacting child healthcare services more broadly, since equipment, medicines, human resources, and commodities are often shared with and across services. As a result, the enhancement of certain vertical funded services may indirectly influence the quality of other services targeting children under-five.

For instance, a higher readiness in diarrhoea services is positively associated with the readiness of nutrition, malaria, and HIV services. In addition, nutrition service readiness positively correlates with the provision of inpatient services and the readiness of diarrhoea and HIV services. The association between HIV and higher odds of undernutrition in children with diarrhoea, coupled with the positive relationship between nutrition service readiness and HIV service readiness for children under-five, suggests that the benefits gained from vertical funding for HIV may also positively impact nutrition in this age group.

In the country, less than 5% of the health facilities had all service tracer items available. A mere 1.2% and 0.6% of health facilities had all tracer items for diarrhoea and HIV services, respectively. Generally, higher service readiness was observed in urban areas and health facilities offering inpatients services. Tertiary and quaternary-level health facilities, mostly located in urban areas, provide inpatient services along with specialized care. This could account for the findings of the analysis, as specialized services are expected to demonstrate better readiness for the services they offer.

In urban areas nutrition services exhibited the lowest readiness particularly in health facilities providing inpatient services, while diarrhoea services displayed lower readiness overall. Given the high prevalence of undernutrition and diarrhoea in Mozambique, it was anticipated that these disease services would be prepared to ensure the delivery of quality care. Additionally, considering the link between diarrhoea and undernutrition in children under-five, it was

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expected that both services would demonstrate the optimal readiness. However, this was not the case, posing a potential barrier to prompt diagnosis and treatment, especially when these conditions are comorbid.

Based on the 2021 nutrition service assessment (NSA,2021), diarrhoea-specific wards in hospitals scored the lowest in terms of readiness for undernutrition services. Higher nutrition service readiness was observed in wards dedicated to nutrition and in new-borns wards. For improved diagnosis and treatment, both services should be fully prepared, with a 100% capacity for handling either condition in dedicated or mixed wards.

Although a strong association exists between diarrhoea and undernutrition service readiness, in health facilities without inpatients services which are typical of primary health facilities, an increase on nutrition service readiness corresponds to a decrease in diarrhoea service readiness. Improving nutrition service readiness in diarrhoea wards would enable every child with diarrhoea to be evaluated for undernutrition, thereby preventing clinical complications, and reducing the financial burden on the health care system.

Our findings indicate a general lack of readiness for these services, though nutrition specific wards presented better readiness compared to mixed or diarrhoea-specific wards. While these results are as anticipated, the service readiness in mixed or diarrhoea-specific wards for the diagnose and treatment of undernutrition is considerably low. This clearly illustrates the difficulty in providing timely and appropriate diagnosis and treatment for cases involving both undernutrition and diarrhoea, meaning that in diarrhoea-specific or mixed wards, children with diarrhoea are unlikely to be diagnosed and treated for undernutrition. Although our results should be interpreted cautiously, and additional analysis is required to better comprehend the factors influencing these findings, the relationship between the readiness on nutrition services and the readiness of diarrhoea and malaria services, highlight the uneven strengthening of services in Mozambique's primary healthcare system and the missed opportunities for holistically supporting health program performance.

3.1.1. Study Limitations

Apart from the selection bias that characterizes most hospital-based surveillance studies, there were two main limitations: missing data, which reduced the sample size, and its cross-sectional nature, which hindered establishing a cause-and-effect relationship between variables and

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undernutrition in children with diarrhoeal disease. Nevertheless, the analysis offers valuable insights, informing future research, prevention strategies, and improved childcare.

The 2018 SARA survey, a cross-sectional study, served as a reference for situational analyses and policy decisions, focusing on verifying tracer items and examining factors beyond logistics. Despite potential data variability, the survey was standardized and included quality control measures. The 2021 NSA survey, also cross-sectional but with limited geographical scope, relied on respondents with minimal verification, potentially introducing recall bias. Despite limited generalizability, it revealed unpreparedness in specialized services, suggesting lower readiness across health services.

The analysis on routine health data quality considered only indicators with adequate data, excluding some crucial nutrition and diarrhoea monitoring indicators due to insufficient data, which itself indicates poor data quality. Additionally, the unavailability of some external data limited the analysis to specific WHO-recommended dimensions for data quality assessment.

3.2. Conclusion

Mozambican health system faces substantial challenges in healthcare infrastructure, worker shortages, financing, and access, particularly in rural areas. To improve the healthcare system, investments in infrastructure, worker training and education programs, financing mechanisms, and access improvements are needed. The Mozambican government, private sector, and international partners all have a role to play in supporting these efforts. Addressing these challenges will require continued investment in infrastructure, equipment and supplies, staffing, and management capacity to ensure quality health services are provided to the population. The conflict in Cabo Delgado has significantly impacted health services, creating barriers to essential care for many people in the region. To address this challenges, sustained efforts are needed to improve access to health services, tackle healthcare worker shortages, and provide assistance to those displaced by the conflict.

A comprehensive approach addressing factors such as access to clean water, sanitation, adequate nutrition, and healthcare is crucial for preventing undernutrition in under-five children with diarrhoea. Additionally, improving the quality of services is key to reduce the morbimortality related to undernutrition in children with diarrhoea.

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Striking a balance between vertical and horizontal approaches in healthcare delivery is crucial for optimizing health outcomes. It is essential to integrate vertical interventions into existing services, promote collaboration among programs, and ensure funding supports health system strengthening. Ultimately, a balanced approach that incorporates targeted interventions within a comprehensive and resilient health system is needed to achieve optimal results.

The integrated management of childhood illness should be integrated into a broader healthcare system. Investments in infrastructure, worker training, and financing mechanisms are essential for enhancing the strategy implementation and ultimately improve child health outcomes. As high-quality routine health data is crucial for informed decision-making and improved health outcomes, it plays an important role in preventing and reducing the morbi-mortality of undernutrition in children with diarrhoea. Implementation of targeting intervention to improve the quality of routine health data is needed to lead to better health outcomes and more efficient healthcare delivery. Recognizing and leveraging the interdependence between health service quality and routine health data can help systems achieve better health outcomes for their population.

Undernutrition and diarrhoea are two diseases that should be monitored in an integrated way, although the country has adopted on paper the issue of integrated management of diseases in early childhood, according to what was observed in this study, it is not being implemented at least not for diarrhoea and malnutrition, where, on the one hand, there is complete ignorance of the strategy by the health professionals who participated in the study and, on the other hand, in terms of availability and readiness of services, the scenario is inadequate for integrated management, with no conditions to exist. We have the quality of services to implement the strategy.

Mozambique has poor quality of services to manage undernutrition in children under-five with diarrhoea. The country has high frequency of undernutrition in under-five children with diarrhoea and lower service readiness to diagnose and treat the association. To worsen the scenario, the routine data collected that could help monitoring health indicators related to undernutrition and diarrhoea, and that could help decision making are of poor quality.

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