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Coverage and effectiveness of severe acute malnutrition treatment by community health workers in West Africa

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CERTIFY:

That the doctoral thesis entitled " **Coverage and effectiveness of severe acute malnutrition treatment by community health workers in West Africa** ", has been carried out under their direction by Mrs. Pilar Charle Cuéllar and meets all the scientific and formal requirements to be presented and defended before the corresponding tribunal.

And for the record for all purposes, this certificate is signed in Madrid on the 1st day of January 2022.

Dr. André Briend   Dra. Ruth Gil Prieto

A. Briend

Ruth Gil

To my mother, my father, my 2 sisters and brother, always with me, when I started to grow up.

To the father of my daughters, with whom I have been growing up for many years now.

To my 3 daughters, who will continue to grow when I stop.

For all the mothers, for all the community health workers, most of them women, from more than 40 countries in Africa. This work with them and for them.

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ABBREVIATIONS

CHWs	Community health workers
CMAM	Community management of acute malnutrition
COMPAS	Combined Protocol for acute malnutrition
CORTASAM	Council for Research and Technical Advice on Acute Malnutrition
FAO	Food and agricultural organization
GAM	Global acute malnutrition
HAZ	height-for-age z-score
HF	Health facility
iCCM	integrated community case management
IYCF	Infant and Young child feeding
LMICs	Low-income and middle-income countries
MAM	Moderate acute malnutrition
MoH	Ministry of health
MUAC	Mid-upper arm circumference
NGOs	Nongovernment organizations
PHC	Primary Health care
RUTF	Ready to use therapeutic food
SAM	Severe acute malnutrition
SDG	Sustainable development goals
UHC	Universal Health Coverage

UN	United Nations
UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations International Children's Emergency Fund
USAID	U.S Agency for International Development
WAZ	Weight-for-age z-score
WHZ	Weight-for-height z-score
WFP	World Food Program
WHO	World Health Organization

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SUMMARY

SUMMARY

Introducción y justificación

La malnutrición es un estado nutricional que se caracteriza por un déficit de energía, proteínas y otros nutrientes que produce efectos adversos en la composición y el tejido de diferentes órganos, y por tanto en las funciones vitales que el organismo debe desarrollar.

La malnutrición en sus diferentes formas es un grave problema de salud pública. Los diferentes tipos de malnutrición afecta al crecimiento, al desarrollo físico, mental y social, a la educación y a la felicidad de más de 180 millones de niños y niñas menores de 5 años, año tras año. Esta alteración en su desarrollo repercute directamente en los adultos que llegarán a ser, y en sus familias, en el desarrollo social y económico de sus comunidades y pueblos, condenando a estos países al círculo vicioso de la malnutrición y la pobreza.

La desnutrición aguda severa, es la forma de malnutrición con un mayor impacto en la morbi-mortalidad de niños y niñas menores de 5 años. A pesar de existir un tratamiento eficaz para luchar contra esta enfermedad, la cobertura de tratamiento sigue siendo baja en la mayoría de los países de baja y media renta.

El tratamiento de la desnutrición aguda severa ha evolucionado durante los últimos 30 años. Al inicio de los años 90, era necesario el tratamiento a nivel hospitalario de todos los niños, con las fórmulas de leche terapéutica F-75 y F-100. Años más tarde con el descubrimiento de los Alimentos terapéuticos listos para ser utilizados (RUTF, Ready-to-use therapeutic food, en inglés) y los protocolos del manejo de casos, permitieron el tratamiento ambulatorio de los niños y niñas que sufrían desnutrición aguda severa sin complicaciones. A

pesar del gran avance que supuso este tratamiento y el elevado número de niños y niñas tratados, el aumento de la cobertura no fue suficiente.

A nivel internacional existen diferentes iniciativas y enfoques apoyados por la OMS y UNICEF, que apoyan el trabajo de los/as agentes de salud comunitarios en la malnutrición aguda severa, como la forma de contribuir a la cobertura universal en salud y los objetivos de desarrollo sostenible.

Hipótesis y objetivos

La hipótesis del presente trabajo se basa en que la integración del tratamiento de la desnutrición aguda severa con los/as agentes de salud comunitarios permite la identificación precoz de los niños y niñas, y mejora el acceso al tratamiento. Identificando más casos de desnutrición en un estado menos grave, permite acortar el tiempo de tratamiento y reducir los costes asociados. La disponibilidad del tratamiento de la desnutrición cerca de las familias conduce a un aumento de la cobertura de tratamiento.

El objetivo principal es la reducción de la morbilidad y mortalidad asociada a la desnutrición aguda severa de las familias vulnerables en Africa del Oeste, a través del tratamiento con los/as agentes de salud comunitarios.

Los objetivos específicos: 1) Revisión de experiencias operacionales sobre el empoderamiento de los/as agentes de salud en el tratamiento de la desnutrición aguda severa; 2) evaluar si añadir el tratamiento de la desnutrición aguda severa al paquete de actividades de los/as agentes de salud comunitarios, tiene un efecto en la identificación precoz de esta enfermedad; 3) comparar la eficacia y cobertura de los/as agentes de salud comunitarios, con el personal de los centros de salud, en un nuevo contexto; 4) evaluar el efecto de diferentes niveles de supervisión en la eficacia tratamiento con los/as agentes de salud comunitarios a nivel regional .

Material y métodos

Previa a la realización de los dos estudios de campo se llevó a cabo una revisión de los trabajos publicados sobre el nuevo modelo de prestación de servicios. Este trabajo nos permitió sintetizar la evidencia científica disponible a través de los estudios primarios de los/as agentes de salud comunitarios en la identificación y el tratamiento de la desnutrición aguda severa.

Para responder a la hipótesis de nuestro trabajo, se realizaron dos estudios de investigación operativa en la región de Guidimakha de Mauritania y en la región de Kayes de Malí. El primero fue un estudio piloto que nos permitió evaluar la eficacia y la cobertura del tratamiento de la desnutrición aguda severa con los/as agentes de salud comunitarios en una nueva zona geográfica; y el segundo evaluó el efecto de diferentes niveles de supervisión en la eficacia de tratamiento, cuando la intervención es puesta en escala a nivel regional.

Se realizaron análisis secundarios con los datos del estudio piloto en Malí, ya publicado en una revista de revisión por pares, para evaluar las condiciones antropométricas e identificación temprana de la desnutrición aguda severa a través de los/as agentes de salud comunitarios.

Resultados

La revisión de experiencias operacionales mostró que, los/as agentes de salud comunitarios pueden identificar y tratar los casos no complicados de desnutrición aguda severa, logrando proporción de curación por encima de los estándares mínimos y reduciendo la proporción de abandonos a menos del 8%. Aunque los estudios son limitados, estos resultados sugieren que la detección y el tratamiento tempranos en la comunidad pueden aumentar la cobertura de tratamiento de la desnutrición aguda severa y que este modelo con los/as agentes de salud es costo-efectivo. La formación adecuada y la supervisión de los/as agentes de salud resultaron esenciales para garantizar un tratamiento de calidad. La motivación a través de la compensación económica y otros incentivos, que mejoran su reconocimiento social, también resultó ser un factor importante que contribuye en la calidad de tratamiento. La falta de medicamentos y alimentos terapéuticos afecta negativamente al modelo de tratamiento con los/as agentes es salud.

En Mali, los resultados mostraron un menor número de niños y niñas con edema a la admisión en el grupo de los/as agentes de salud que en el de los centros de salud (0,4% frente al 3,7%; OR = 10,585 [2,222-50,416], p = 0,003). Las medidas antropométricas en el momento de la admisión fueron más altas en el grupo de los/las agentes de salud, con menos niños y niñas as que se encontraban en los cuartiles más bajos de las puntuaciones z de peso para la altura (20,2% frente a 31,5%; p = 0,002) y la media de perímetro braquial (18,0% frente a 32,4%; p<0,001), que en el grupo del centro de salud. No hubo diferencias en la duración de la estancia media. La proporción de niños y niñas curados fue mayor con los/as agentes de salud comunitarios (95,9% frente a 88,7%; RR = 3,311 [1,772-6,185]; p<0,001), y hubo menos abandonos (3,7% vs. 9,8%; RR = 3,345 [1,702-6,577]; p<0,001) que en el grupo del centro de salud. Los análisis de regresión demostraron que unas medidas antropométricas menos severas en el momento de la admisión daban lugar a una mayor probabilidad de curación. Los/as agentes de salud proporcionaron una atención más integrada, diagnosticaron y trataron. significativamente más casos de enfermedades infecciosas que el modelo de los centros de salud (diarrea: 36,0% frente a 18,3%, p<0,001; malaria: 41,7% frente a 19,8%, p<0,001). 19,8%, p<0,001; infección respiratoria aguda: 34,8% vs. 25,2%, p = 0,007).

El estudio piloto en Mauritania mostró una proporción de niños y niñas curados del 82,3% en el grupo de intervención con los/as agentes de salud comunitarios y del 76,4% en el grupo de control, sin diferencias significativas entre los grupos. La cobertura en la zona de intervención aumentó del 53,6% al 71,7%. Por el contrario, la cobertura se mantuvo en aproximadamente 44% en la zona de control desde la línea de base hasta la línea final.

En el segundo estudio de Mali se incluyeron 6112 niños y niñas de entre 6 y 59 meses con desnutrición aguda severa sin complicaciones. La proporción de niños y niñas curados fue del 81,4% en los tratados por los/as agentes de salud en el grupo de alta supervisión, el 86,2% en el grupo de supervisión ligera y el 66,9% en el grupo de control. Los niños y niñas tratados por los/as agentes de salud que recibieron algún tipo de supervisión, tuvieron mejores resultados que los niños y niñas tratados por agentes de salud sin supervisión (p<0.001). No hubo diferencias entre los 2 grupos con supervisión.

Conclusiones

El modelo de tratamiento descentralizado de la desnutrición aguda severa a través de los/as agentes de salud comunitarios permite: alcanzar una proporción de niños y niñas curados, mayor o igual que los enfermeros de los centros de salud; aumentar la cobertura de tratamiento de esta enfermedad; identificación precoz de los niños y niñas que sufren desnutrición aguda severa. El efecto en la eficacia se ha visto tanto en nuevos contextos específicos como cuando la intervención es puesta en escala a nivel regional.

La supervisión formativa de los/as agentes de salud ha tenido un efecto sobre la calidad de tratamiento en los dos grupos intervención, el grupo control no alcanzó los estándares internacionales de calidad. Sin embargo, no hemos podido evidenciar con el presente trabajo que los diferentes niveles de supervisión tengan un efecto sobre la calidad del tratamiento de la desnutrición aguda severa por los/as agentes de salud.

Los elementos clave identificados para la generalización del nuevo modelo de tratamiento de la desnutrición aguda severa, son asegurar el salario y/o motivación de los/as agentes de salud comunitarios, y, la identificación de un modelo eficaz que permita el aprovisionamiento del tratamiento con alimentos terapéuticos listos para ser utilizados, a nivel de la comunidad.

1.INTRODUCTION

1 INTRODUCTION

1.1 What is malnutrition

"Malnutrition is a state of nutrition in which a deficiency of energy, protein, and other nutrients causes measurable adverse effects on tissue/body form (body shape, size, and composition) and function, and clinical outcome" (1). Malnutrition has four general forms: 1) wasting, defined by a low weight-for-height z-score (WHZ), which usually indicates recent and severe weight loss, and is often described as acute malnutrition. However, this is not always correct as this type of malnutrition may also persist during months or years; 2) stunting, defined by a low height-for-age z-score (HAZ), usually associated with poverty, poor maternal health and nutrition, frequent illness and/or inadequate nutrition in the early years of life; 3) underweight, defined by a low weight-for-age z-score (WAZ). An underweight child can suffer stunting, wasting, or both; 4) micronutrient deficiencies, defined as the lack of vitamins and minerals essential for body functions, such as the production of enzymes, hormones, and other substances necessary for development and growth (2).

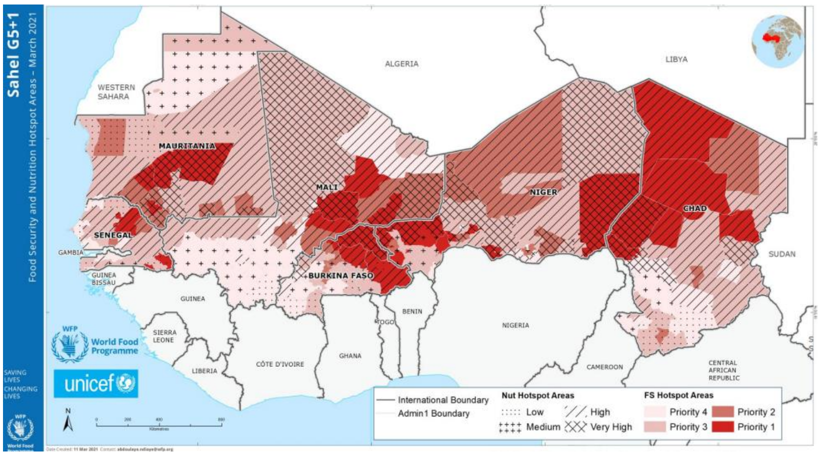
Malnutrition is one of the major public health problems in most parts of the world. In all its different forms it affects the growth, physical, mental, social development, education, and happiness of more than 180 million children under 5 years of age, year after year. This disruption in their development has a direct impact on the adults they will become and their families, and on the social and economic development of their communities and villages, in a lasting way. This condemns the countries where they grow to the vicious circle of malnutrition and poverty (3), (4).

Severe acute malnutrition (SAM) is defined by World Health Organization (WHO) and United Nations International Children's Emergency Fund (UNICEF) by a mid-upper arm circumference (MUAC) less than 115 mm WHZ less than -3 or bilateral pitting oedema (+, ++). According to prevalence surveys, there are 13.6 million under-five children affected by SAM globally (3). The number of children affected each year (yearly incidence) is several times higher (5). SAM is associated with a high risk of death comparing with well-nourished children (6). Estimates suggest that SAM contributes to 500,000 deaths per year (7).

Over the last two years, this situation has been affected by the COVID-19 pandemic. Several factors contributed to the nutritional deterioration of the most vulnerable families. The containment measures put in place have made it possible to reduce mortality caused by the pandemic, but at the same time have increased the already existing vulnerabilities of most communities living in many West African countries. These includes the worsening food insecurity of families and the decrease of available foods due to the closure of borders, restriction of movement, and access to local markets. The fragility of health systems that existed before the pandemic has been overwhelmed by the urgent need to cope with COVID-19, which has meant a decline in the provision of other essential health services. Finally, the weakening of social protection systems in countries where acute malnutrition prevails is higher than in others. As a result, it is estimated that 1.7 more children will suffer from SAM in the next year, and 10,000 deaths per month will be caused by the disease in low-income and middle-income countries (LMICs) (8), (9).

In west and central Africa, more than 5 million children under five were expected to suffer from acute malnutrition in 2020. Armed conflict and violence have caused massive population displacement, limiting access to primary health and social care, which has led to an unprecedented increase in child malnutrition. Other factors including land and crop degradation, periodic droughts and weather-related shocks, poverty, and COVID-19, have contributed to these emergency levels of malnutrition in the region (10). Figure 1 shows the expected proportion of children under five at high risk of acute malnutrition (11).

Figure 1. Nutrition and food security hotspot areas in the Sahel countries (Mali, Mauritania, Senegal, Niger, Chad, Burkina Faso)



1.2 Evolution of acute malnutrition treatment

Over the last 50 years, the treatment of malnutrition has undergone major changes and adaptations. Initially, these were aimed at reducing mortality from malnutrition, which is currently associated with more than 50% of children under 5 years of age. Later, these treatments were focused on improving efficacy and increasing coverage (12), (13), (6).

1.2.1 The beginning of acute malnutrition treatment

The development of the current treatment protocol for SAM began with the work of John Conrad Waterlow's group in the Tropical Metabolism Research Unit in Jamaica starting from the 1950s. His long experience in research on children suffering acute malnutrition at the hospital were the first steps for a more appropriate treatment protocol. In the second half of the twentieth century, several humanitarian crises led to famines, which highlighted the importance of having a specific treatment protocol for this disease. Since then, the management of acute malnutrition has gone through several changes.

The first treatment manual was produced by the WHO in 1981. "A guide for severe protein-energy malnutrition (PEM)" (14). The objective was to reduce the high in-patient hospital mortality of children suffering from this type of severe malnutrition. The treatment was focused on treating the most frequent complications that these children presented: moderate and/or severe dehydration, infections, eye damage due to vitamin A deficiency, hypoglycemia, hypothermia, skin lesions, diarrhea, and anorexia. Most of the malnourished children had several of these complications at the same time. Children were kept on a low protein low energy maintenance diet during this period. Children who had recovered from initial treatment were switched to a high protein and energy diet for the catch-up phase of the treatment. This consisted of different amounts of high energy milk, 125mg/kg/day to 150mg/kg/day, administered every 2 hours for the first few days. Intake during this period was progressively increased according to the evolution of the child. Depending on the tolerance, these amounts of feeds could be diluted to avoid possible complications During the catch-up growth phase, intakes went up to 175-200 kcal/kg/day (15).

1.2.2 In-patient treatment with F-75 and F-100 formulas

The first specific service delivery model for malnutrition took place in the early 1990s with the introduction of the F-75 and F-100 formulas for the initial phase and recovery phase of treatment respectively. Knowledge of nutrient physiology led to improved dietary management of this disease. Both formulas contained enough protein, carbohydrates as well as minerals, which the child needs to recover from malnutrition. The great success of this in-patient model was to reduce mortality from the disease.

The F-75 and F-100 formulas development was based on the work of the Jamaica group, in particular of Michael Golden, and tested in the field by Action against Hunger.

Initially, these formulas were prepared by health workers mixing dried skimmed milk, oil, and sugar and giving mineral and vitamin supplements in therapeutic feeding centers. The company Nutriset initiated their industrial production in 1993, which greatly facilitated their use. In 1999, the WHO published the guideline of “Management of severe acute malnutrition treatment: a manual for physicians and other senior health workers” with recommendations for the new treatment of acute malnutrition. This treatment had to be administered at the level of health structures and hospitals, with an average length of stay of 4-6 weeks for the treated children. It was in this same period when malnutrition started to be recognized not only as a public health problem but also as a social factor that highlighted the lack or reduction of care that these children suffered at home, due to the poverty of their families. This led to the need to complement nutritional treatment with physical and psychological stimulation of the children to avoid the short, medium, and long-term consequences of malnutrition. The treatment consisted of several phases: 1) initial treatment: identification and treatment at a hospital of life-threatening problems, where correction of specific deficiencies, reversal of metabolic abnormalities, and feeding begun. This first phase used F-75, a low-protein, low-energy milk-based as a therapeutic food until the child regained his appetite. This recovery of appetite was due a control of infections, liver capacity to metabolize, and improvement of metabolic alterations of malnutrition; 2) rehabilitation: In order to recover most of the lost weight, intensive feeding was given, and emotional and physical stimulation were increased, and the mother or caregiver was trained to continue the care at home. In this phase, the formula used was F-100, with a higher protein concentration (100 Kcal and 2.9 gr of protein /100ml) than F-75 (75 Kcal and 0.9 gr of protein /100ml). This allowed rapid weight gain and nutritional improvement of the child; 3) Follow-up: after discharge, the child and the child's family were followed to prevent relapse and assure the continued physical, mental, and emotional development of the child (16).

The great success of the formulas-based treatments used with a standard protocol was the reduction of mortality by half in SAM children (17). Other literature reviews evidenced the effectiveness and clinical outcomes of this new protocol (18). The WHO insisted on the need for training of nurses and senior health workers so that the implementation of its treatment protocol guidelines could achieve the goal of improving the performance of acute malnutrition treatment (19), (20).

Despite the achievements made, the inpatient service delivery model faced major challenges. Clinical outcomes were good enough and the model was considered efficacious, but the lack of access to a hospital resulted that in the best situations, often less than 10% of children suffering SAM could receive the needed treatment. The need to remain in hospital with a caregiver, usually the mother who left the rest of her children at home for weeks, meant that many children did not complete their treatment and left the hospital before they had fully recovered. The need to mix powdered milk formulas with water exposed to the risk of bacterial proliferation in case of accidental contamination leading to infection. In practice, these diets had to be prepared in specialized therapeutic feeding centers, which limited access to the treatment. In addition, remaining in hospital for a prolonged period increased the likelihood that these children could contract nosocomial diseases, which their immunity, weakened by the disease itself, could not cope with.

1.2.3 Out-patient treatment with ready to use therapeutic food

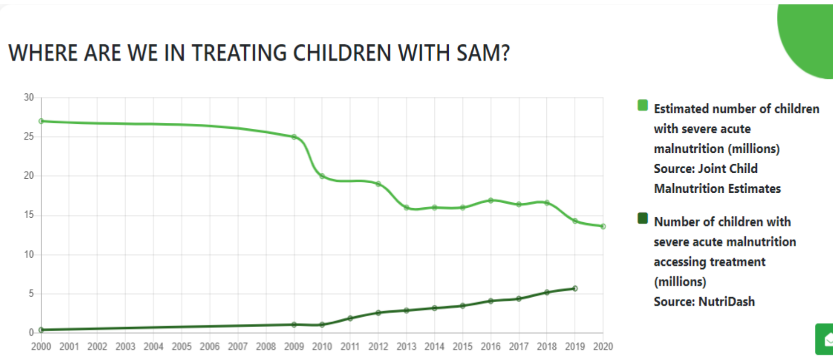
At the end of 1996, André Briend in collaboration with Michel Lescanne, then director of Nutriset, developed a ready-to-use therapeutic food (RUTF). This nutritional product had a nutritional composition similar to that of F-100 but could be consumed without the addition of water. This eliminated the need to mix the food with water and the risk of bacterial proliferation in case of accidental contamination. This made possible the refeeding of malnourished children at the community level, eliminating the need to treat most of these children in hospital. In-patient treatment was only needed for those with serious complications until they were under control. The development of this food led two pioneers, Steve Collins and Mark Manary, followed by others to develop a community-based approach in the early 2000s (21), (22).

In 2007, WHO, the World Food Program (WFP), and UNICEF issued a joint statement “Community management of acute malnutrition (CMAM)”, which recommended to treat with F-75 and F-100 formulas as inpatients only SAM children with complications while treating uncomplicated SAM cases with RUTF at the community level (23).

The efficacy of the new formulas was first evaluated in terms of weight gain and recovery in comparison with WHO-standard F-100 in in-patient settings (24). Then, in the community, it was evaluated in terms of infant recovery, defaulters, and mortality, but also in terms of weight gain and relapse after 6 months. The new treatments resulted in a higher cured proportion and weight gain, as well as increased SAM treatment coverage (25), (26), (27).

Despite the efforts made during the last years in the fights against SAM, figure 2 shows the huge difference that exists between the estimation of children who are suffering from SAM, with those children that have access to an efficacious treatment with RUTF (28).

Figure 2. Estimated number of children with SAM, and number of children with SAM with access to treatment



1.3 Community management of childhood illness

The integrated management of childhood illness (IMCI) is an initiative that was supported in 1995 by WHO and UNICEF, whose objective was to reduce morbidity and mortality in children under 5 years of age due to prevalent childhood illnesses (29). The initiative foresaw the case management of malaria, diarrhea, and respiratory infections at the first level of health facility's (HFs). However, due to the lack of access to HFs of large parts of the population in developing countries, most deaths still occurred in the community (30). Years later, was launched a new initiative called "integrated community case management" (iCCM) (31).

1.3.1 Integrated community case management

iCCM "is a proven equity-focused intervention for extending affordable care to hard-to-reach populations to reduce deaths among children under 5 years" (32). This initiative was led in 2012 by WHO and UNICEF and is based on training, supervision, and ensuring the supply chain of community health workers (CHWs) for prompt and effective community management of pneumonia, malaria, and diarrhea. This intervention has been found to reduce mortality by 70%, 60%, and 70%-90% respectively of these 3 important diseases (33), (34).

There is scientific evidence of the effectiveness and coverage of this initiative in development contexts and sub-Saharan African countries (35), (36), (37), as well as in contexts of emergencies, displaced and refugee communities, violence, and insecurity (38), (39), (40), (41). Friedman and Wolfheim, in a review of operational experiences, suggested that iCCM might be a logical platform, and a missed opportunity, for increasing the reach and coverage of treating malnourished children, and potentially for preventing malnutrition (42).

Evidence regarding the integration of SAM treatment into the iCCM intervention and its effect on treatment coverage and effectiveness is emerging and is documented by several small-pilot studies (43), (44). More studies are needed to evaluate what is necessary to scale up the intervention to district and/or regional level, and to assess whether the results could be the same in different realities and contexts.

Table 1, a summary of the ongoing initiatives that contribute to tackling acute malnutrition.

Table 1 Health and nutrition initiatives launched in the late 20th century

	IMCI (Integrated management of childhood illness)	**iCCM (integrated Community Case Management)**	**CMAM (Community-based Management of Acute malnutrition)**
Launched	1995 WHO, UNICEF	2012 WHO	2007, WHO, WFP, UNICEF
Focus	Prevention and treatment the leading causes of childhood illness (malaria, diarrhoea, and pneumonia)	Prevention and treatment the leading causes of childhood illness (malaria, diarrhoea, and pneumonia)	Identify and treatment of acute malnutrition
Level of implementation	Implemented at the health facility level	Implemented at community	Detection and initiation of treatment at the health facility level Continuation of treatment at the community level
Main goal	Decrease mortality	Increase coverage of illness treatment and decreased mortality	Increase coverage of acute malnutrition treatment

1.3.2 Community health workers

Interventions with CHWs have been identified as one of the most effective methods for improving quality and extending primary health care (PHC) at the community level. There is not a common understanding of who are these CHWs. The profile, role, and responsibilities of these human resources have varied over the last decade. Even the terminology can be different depending on the context in which they work: lady health workers in Pakistan, health extension workers in Ethiopia, frontline health workers, or lay- health workers in most of the countries (45), (46), (47).

Initially, they were usually unpaid volunteers recognized and elected by the community, who provided services such as prevention of common diseases and/or community awareness. Over the time, CHWs have been integrated into the health system.

“A health system consists of all the organizations, institutions, resources, and people whose primary purpose is to improve health. This includes actions to influence causes of health as well as more direct health-improvement activities. The health system delivers preventive, promotive, curative, and rehabilitative interventions through a combination of public health actions. It also includes the pyramid of health care facilities that deliver personal health care by the State and nongovernment organizations (NGOs)” (48). The WHO Health System’s framework consists of six building blocks: 1) service delivery; 2) health workforce; 3) health information systems; 4) access to essential medicines, chain supply; 5) financing, and 6) leadership/governance

There is a wide range of services delivered by CHWs. Their activities are linked to the HFs who oversee data collection, monitoring, supervision, and the referral system. Like other human resources in the system, they need funding to ensure their salary and/ or motivation and drugs and equipment supply at the community level. There is a remarkable difference between them, regarding the content and duration of their training. Some of them might receive a training of 21 days focused on health promotion and prevention, while others can have a health training of 2 years, including curatives action of common diseases. The training can be formal or informal and be led by Ministries of Health (MoH) or/and NGOs. Supervision is another key component to maintaining the effectiveness of CHWs programs and varies from one setting to another. Supervision focusing on supportive approaches, quality assurance, and problem-solving may be most effective at improving the performance of CHWs. The type and quality of supervision can have more impact on the CHWs than its frequency (49), (50). There is evidence of the impact of the recognition by the authorities on the motivation and performance of CHW on the level of their health care. Further analysis is needed to determine the volume of work and number of tasks, that CHWs can develop without having a negative impact on the quality of care (51), (37).

1.4 INTERNATIONAL STRATEGIES AND GUIDELINES

1.4.1 Sustainable development goals

The Sustainable Development Goals (SDGs) agenda was developed by the United Nations (UN) in 2015. This initiative followed the Millennium Development Goals (MDGs), which were signed by the UN in 2000, and included eight targets to be achieved by 2015 (52). The SDGs agenda was “a global action plan for people, the planet, where eradicating poverty was recognized as the greatest global challenge and an indispensable requirement for the achievement of the rest of the SDGs” (53). The UN was determined to end poverty and hunger in all their forms and dimensions, within a healthy environment, to ensure that all human beings can fulfil their potential in dignity and equality. This agenda includes 16 SDGs with 169 targets to be achieved during the next 15 years.

The work we are presenting with CHWs, and the treatment of SAM can contribute to the following SDGs: goal 1, end poverty in all its forms; goal 2: end hunger, achieve food security, improve nutrition, and promote sustainable agriculture; and goal 3, ensure healthy lives and promote wellbeing for all ages.

In 2020 the WHO, in collaboration with the Food and Agricultural Organization (FAO), the United Nations High Commissioner for Refugees (UNHCR), UNICEF, and the WFP, published the Global Action Plan 2020 to Accelerate Progress in Preventing and Managing Child Wasting and achieve the SDGs targets for acute malnutrition. They encouraged strengthening the integration of early detection and treatment of wasting as part of routine PHC services. In this same document, some research gaps related to how service delivery coverage can be increased through the CHWs approach in a sustainable manner have been identified (54).

1.4.2 Simplified approaches for the treatment of acute malnutrition

The expression ‘simplified approaches’ refers to “several simplifications to the existing national and global protocols for the treatment of child wasting. These approaches aimed to improve effectiveness, quality, coverage, and reduce the costs of treating for children who are suffering from SAM without complications” (55). There are 7 different aspects that can be implemented together: 1) family MUAC, engaging family members to detect children with SAM by regular measure of MUAC and referring these children for treatment; 2) CHW-led management of wasting by CHWs, including SAM management; 3) reduced Frequency of Follow-up visits throughout treatment; 4) MUAC and oedema only; Admission, treatment, discharge based on MUAC and/or oedema only; 5) expanded admissions criteria, systematic expansions of MUAC to include all children <125mm; 6) use of a single treatment product, RUTF for the treatment of all wasted SAM and moderate acute malnutrition (MAM) children; 7) reduced dosage, reducing the quantity of RUTF throughout treatment one the child passed the most critical phase

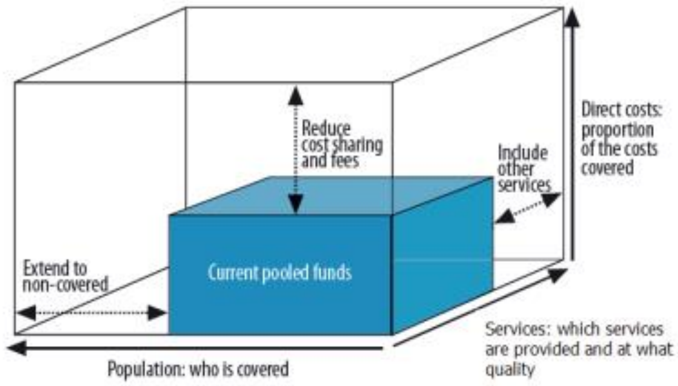
During the COVID-19 pandemic, the UN and other international and national actors agreed on the need to act more quickly to reduce the negative impact of this crisis on children suffering from wasting. A joint statement of UNICEF and the Global Nutrition Cluster assumed that children with SAM were at a higher risk of COVID-19 and complications due to their compromised immune systems (56). For this reason, UNICEF suggested that country implementers start a discussion with the MoH, nutrition cluster and national coordination groups, on context-specific adaptations of treatment protocols for SAM management, including the decentralized model for treatment of acute malnutrition by CHWs (57).

1.4.3 Universal health coverage

The WHO is supporting Universal Health Coverage (UHC) since 2017. “This means that all individuals and communities should receive the health services they need without suffering financial hardship, and double health coverage by 2030 while ensuring the quality of services and cost-effective interventions” (58). The UHC is closely related to the SDGs and represents a commitment to the right to health as a human right. The monitoring of UHC is done through two indicators: the coverage of essential health services, and the proportion of a country’s population with catastrophic spending on health. The monitoring report, carried out in 2017, provided evidence of the economical barrier to essential health services. 800 million people spent more than 10 per cent of their household budget on health care, and almost 100 million people were pushed into extreme poverty each year because of out-of-pocket health expenses (59).

The three dimensions that need to be taken into consideration in order, to reach UHC are shown in figure 3: To extent to non-covered population, to reduced cost-sharing, and to include other new services (60).

Figure 3. The three dimensions of universal health coverage



Aligning with these WHO axes, with the CHWs approach, we are proposing to reach the population who live more than 5 km away from the HFs. By including SAM treatment to the tasks that CHWs must develop, we are adding a new care health service, as well as sharing the cost with the existing system that ensures training, supervision, monitoring and data collection at the community level.

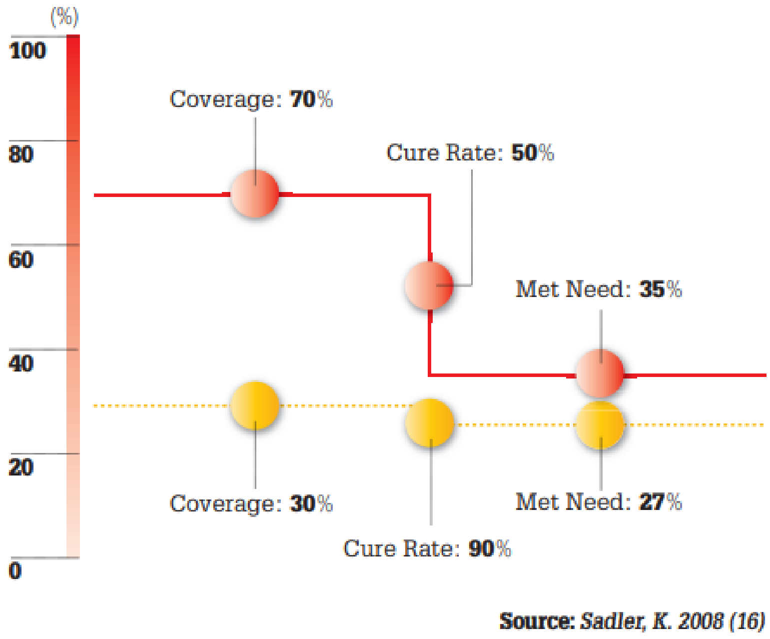
1.5 Impact of acute malnutrition treatment

Treatment coverage is defined as “the proportion of people eligible for service in comparison with the number of people who receive that service” (61). Coverage is key in determining the impact of SAM treatment. It has been included in the international Sphere standards, as one of the indicators to follow up in humanitarian context. In rural areas, CMAM coverage should be >50%. Different analyses identified some common barriers to SAM treatment, which led to low coverage of CMAM protocol. We can mention those that have been found repeatedly in several contexts: lack of knowledge of malnutrition and /or lack of knowledge of the program, high opportunity costs for families and communities, distance to HFs, and previous rejection. Some of these barriers are linked to the health service delivery model itself. Even if CMAM protocol is available and integrated into the health system, HFs are still located at a distance from communities. This can mean that mothers and caregivers may decide not to attend the SAM treatment because of the direct and indirect costs of doing so (payment of transport, loss of income, insecurity (62), (63), (64).

The effectiveness of the CMAM treatment protocol can be defined by the cured proportion of children observed in an entire beneficiary cohort under the program's conditions. According to the international Sphere standards, the quality of care in a CMAM program is measured by a proportion of cured children > 75% of the total of children discharged of the program (61). Effectiveness depends on three main factors: severity of cases at admission, defaulters of children who left the program before being discharged, and treatment adherence. Programs in which the beneficiary and the provider adhere strictly to the CMAM treatment protocol have a better cured proportion and outcomes (65), (66).

For CMAM programs, effectiveness and treatment coverage are strongly linked. Even if a program is achieving good clinical outcomes, high cured proportion, and low proportion of deaths, the ultimate impact is low if it only achieves low levels of coverage. When it combines effectiveness and coverage, a CMAM program is meeting the needs of the target population. Maximizing coverage is likely to improve effectiveness and meet needs. Figure 4 shows that if we have a program with a low cure proportion of children but with high coverage, we can reach the needs of a higher population with our intervention (63).

Figure 4. The relationship between coverage, cure proportion, and met need (impact) in the treatment of SAM



In consequence, investigating coverage (and the factors which influence it) is essential for improving the overall performance of the program and to understanding how CMAM is perceived by the population. The CHW approach that we are presenting with this work can contribute to improve the effectiveness and coverage of current programs by using the CMAM protocol. CHWs living close to the household can result in early treatment-seeking, timely case-finding, and solving of uncomplicated cases. These human resources are part of the community who know, share, and understand the needs of families. The confidence between each other can improve adherence to treatment and result in a decrease of defaulter's children.

2. JUSTIFICATION

2 JUSTIFICATION

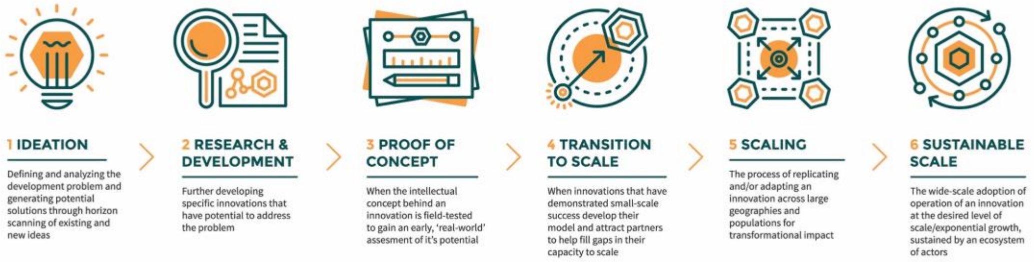
The context of vulnerability in West Africa makes it one of the geographical areas with the highest number of children suffering from SAM and lower coverage of acute malnutrition treatment. Between the 80-84% of children suffering SAM who received treatment with RUTF, are cured of the disease, but only a third of children in need have access to it (67). Stock-out of RUTF, together with geographical and economic barriers to access to HFs, have been identified as the causes of low treatment coverage (64).

In most of West and Central Africa countries, between 2008 and 2011, management of acute malnutrition policies changed to allow outpatient treatment with RUTF of children with uncomplicated SAM. Despite great efforts made to tackle wasting, the estimated burden of SAM during 2021 in Mali and Mauritania, was 192,005 children, and the number of cases admitted into the CMAM program was 103,041 children under five, which means a coverage of 53.6% of children SAM in need (UNICEF West and Central Office Dakar, wasting working group). Recent evidence suggests that incidence correction factors needed to estimate yearly incidence from prevalence vary widely within and between countries and that using the currently recommended single incidence correction factor of 1.6 will underestimate the burden of severe wasting in many settings where the burden of SAM is high (68).If we take into account the correction factor of 3.6 to estimate the SAM caseload, instead of the 1.6 used for these estimates, the number of children in need would be almost double of the figures cited above, and therefore the treatment coverage in the two countries would be considerably lower.

The Council for Research and Technical Advice on Acute Malnutrition (CORTASAM) was assembled under No Wasted Lives to encourage the use of evidence for action in order to ultimately reach more children for prevention programs and provide more children with an effective treatment. CORTASAM published a global Research Agenda for Acute Malnutrition, outlining seven priorities research areas to drive the use of evidence to scale-up interventions for children with wasting. The priority area was the need for "strengthening the evidence on integration of community-based approaches to the management of wasting beyond HFs, with another level of health systems" (69). The need to support the scale-up of the CHWs approach in the management of severe wasting by implementation research and improvement of best practices across contexts was also highlighted.

There is not a widely agreed definition of what is meant by scaling up. There are several definitions related to scaling or implementing: "To support the widespread replication and/or adaptation of an innovation across large geographies and populations for transformational impact" (70) or "Building on demonstrated successes to ensure that solutions reach their maximum potential, have the greatest possible impact, and lead to widespread change" (71). According to UNICEF, the scaling up of intervention goes through different stages: 1) ideation: defining the development problem and potential solutions through scanning of existing and new ideas; 2) research and development: further developing specific innovation that has the potential to address the problem; 3) proof of concept: when the intellectual concept behind the innovation is field-tested to gain an early real-world assessment of its potential; 4) transition to scale: when the innovation that have demonstrated small scale success develop their model and attract partners to help fill gaps in their capacity of scale; 5) scaling: the process of replicating and/or adopting and innovation across large geographies and populations for transformational impact; 6) sustainable scale: the wide-scale adoption of operation of innovation in the desired level of scale sustained by an ecosystem of actors (72).

Figure 5. Stages of scaling adopted by International Development Innovation Alliance



The work proposed in this thesis aimed at assessing the current situation of this intervention and available proof of concept, its usefulness in different contexts, as well as the possibility of transition to scale. The results will contribute to the revision and development of new WHO guidelines, with the possible addition of SAM management into the health package delivered by CHWs, making them the lead-actors of SAM management.

3. HYPOTHESIS

3 HYPOTHESIS

The hypothesis of the present work is that integration of SAM treatment as part of the iCCM package with CHWs will provide early identification of cases and better access to treatment services. By identifying more cases when they are uncomplicated, clinical outcomes will improve, treatment duration will be shortened and treatment costs lower. Providing health services closer to people's homes will also lead to better treatment coverage.

3.1 Main objective

To reduce morbidity and mortality associated with SAM among vulnerable families in West Africa through delivery treatment by CHWs.

3.2 Specifics objectives

- Review of operational experience to assess the impact of empowerment CHWs in the diagnosis and treatment of wasting
- To evaluate if adding SAM treatment to the iCCM package of CHWs results in early admission for treatment and less complicated cases
- To compare effectiveness and coverage of CHWs treating SAM with nurses at HFs level in a pilot study
- To evaluate the impact of the level of supervision in the effectiveness, when scaling SAM treatment with CHWs at a regional level

4. MATERIAL AND METHODS

4 MATERIALS AND METHODS

A review of operational experiences on the new service delivery model with CHWs was conducted before the implementation of the two field studies. This work allowed us to synthesize the scientific evidence available through the primary studies of CHWs in the identification and treatment of SAM.

To answer our working hypothesis, two operational research studies were conducted, one in the Guidimakha district of Mauritania and the other in the Kayes region of Mali. The former was a pilot study that allowed us to assess the effectiveness of SAM treatment with CHWs in a new geographical area. The latter assessed the level of supervision needed to scale up the program at the regional level in a geographical context, within a pilot project where the effectiveness and coverage of the intervention had previously been demonstrated.

Secondary analyses were done with the data from a pilot study in Mali, already published in a peer-review journal, to evaluate the effect of SAM treatment by CHWs on the level of early admissions.

4.1 Indicators

4.1.1 Treatment outcomes

The performance of the nutritional program is assessed by different outcomes, including the proportion of children discharged as cured or recovered, which means not more malnourished, free from medical complications, and having regained their appetite.

Treatment outcomes are compared to the humanitarian Sphere standards (61). Humanitarian standards are developed by humanitarian practitioners with specific areas of expertise and are formulated based on evidence, experience, and learning. The Sphere standards are a set of principles and minimum humanitarian standards in four technical areas of humanitarian response: 1) water supply, sanitation, and hygiene promotion (WASH); 2) food security and nutrition; 3) shelter and settlement; 4) health. According to these international standards, a CMAM program should reach outcomes in table 2 (61):

Table 2. Performance indicators CMAM program

Cured proportion	Defaulted proportion	Died proportion
> 75%	< 15%	< 10%

Cured proportion

- Proportion of children discharged as cured
- Cured is defined as a child who achieves a WHZ < -1.5 or/and a MUAC> 125 mm during two consecutive visits and no nutritional oedema.
- % Of cured children= number of children cured /total number of children discharged (cured, defaulters, died) x 100

Defaulted proportion

- Proportion children discharged as a defaulter
- Defaulter is defined as a child who did not attend follow-up visits for 2 consecutive visits and left the program before reaching cured criteria.
- % Of defaulted children= number of children defaulted /total number of children discharged (cured, defaulters, died) x 100

Died proportion

- Proportion children discharged as died.
- Died is defined as a child who died during acute malnutrition treatment.

- % Of died children= number of children died /a total number of children discharged (cured, defaulters, died) x 100.

4.1.2 SAM treatment coverage

Program coverage is one of the most useful and reliable indicators for measuring the performance of CMAM programs. Mark Myatt was the first to develop the current coverage methodologies (74).

According to international Sphere standards, coverage (% of SAM cases with access to treatment services) in a CMAM program should reach values in table 3, (61)

Table 3. Coverage indicators, % of SAM cases with Access to treatment services

Rural area	Urban area	Camp
> 50%	>70%	> 90%

Coverage assessment methods set out to measure the "treatment" coverage of CMAM programs. Coverage is defined as the percentage of SAM in a defined area who are successfully enrolled in the program. There are five principal coverage assessment methodologies including, the Semi-Quantitative Evaluation of Access and Coverage (SQUEAC), Simplified Lot Quality Assurance Sampling Evaluation of Access and Coverage (SLEAC), Simple spatial survey method (S3M), Bottleneck Analysis (BNA), and Community Assessment. The present study used the SQUEAC method.

The **Semi-Quantitative Evaluation of Access and Coverage (SQUEAC)** is a survey that provides investigation of barriers and boosters of coverage, which results in the estimated treatment coverage. The methodology facilitates implementers to develop activities and interventions to improve access and coverage to CMAM programs. It is primarily used for the estimation of coverage in smaller zones at health district level. The analysis is made up of three stages: Stage 1: to identify areas of low and high coverage and the reasons for coverage failure using routine program quantitative data and qualitative data collected before the survey; Stage 2: to confirm the location of areas of high and low coverage and the reasons for coverage failure identified in Stage 1 using small studies and small surveys; Stage 3: to provide an estimate of overall program coverage using Bayesian techniques (73).

Single coverage: The SQUEAC methodology suggests the use of the single coverage measure. It considers recovering cases both within and outside of the program.

— Single Coverage = (Cin+ Rin)/ (Cin+Rin+Cout+Rout)

Cin = Current SAM cases in the program

Cout = Current SAM cases, not in the program

Rin = Recovering SAM cases in the program

Rout = Recovering SAM cases not in the program

4.2 Can community health workers manage uncomplicated severe acute malnutrition? A review of operational experiences in delivering severe acute malnutrition treatment through community health platforms

This part of the thesis is published here:

López-Ejeda N, Charle Cuellar P, Vargas A, Guerrero S. Can community health workers manage uncomplicated severe acute malnutrition? A review of operational experiences in delivering severe acute malnutrition treatment through community health platforms. Maternal & Child Nutrition. 2019;15(2): e12719.

4.2.1 Study design

A search for peer-reviewed articles and grey literature was conducted to identify all relevant studies published between January 2005 and February 2018. The search strategy was developed using the Population–Intervention–Comparison–Outcome framework. This search strategy focused on the following: (a) population: children from 6 to 59 months diagnosed with SAM, without medical complications; (b) intervention: therapeutic food treatment provided by CHWs; (c) comparison: outpatient treatment at HFs provided by medical staff; and (d)outcome: clinical outcomes (cure, default, and death proportion), treatment coverage, quality of care, and/or cost-effectiveness (74).

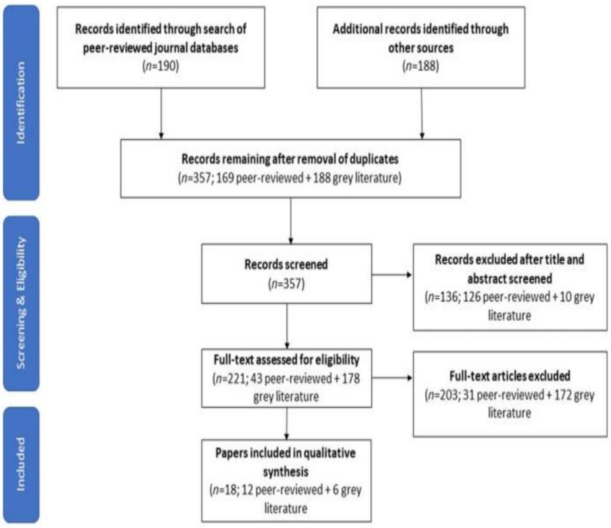
4.2.2 Data collection

The search relied on PubMed, Cochrane Library, ClinicalTrials.gov, LILACS, African Index Medical, and Google Scholar databases. Additional grey literature was reviewed using OpenGrey and the Emergency Nutrition Network sites. The following keywords were used during the search: “Severe Acute Malnutrition”; “Marasmus”; “Kwashiorkor”; “Community Health Worker”; “Community Nutrition Worker”; “Community Health Agent”; “Health Extension Worker”; “Lady Health Worker”; “Health Promoters”; “Health Aids”; “Health Volunteers”; “Treatment”; “Ready-to-Use Therapeutic Food”; “RUTF”; “local level”; “home-based”; and “household level.”

4.2.3 Studies selected

The initial search resulted in 190 peer-reviewed articles and 188 technical reports from grey literature. Most of the peer- review articles were excluded as they focused on facility-based interventions without CHWs in the treatment of uncomplicated SAM. Regarding grey literature, only articles that provided outcome figures were ultimately included. A total of 18 articles on implementation experiences providing outcomes were included in the review.

Figure 6. PRISMA flow diagram of literature revised and accepted for the review



4.2.4 Ethical considerations

All the manuscripts used here were public peer review or/and grey literature. Approval from the ethical committees was the responsibility of the authors of the original articles.

4.3 Bringing severe acute malnutrition treatment close to households through community health workers can lead to early admissions and improved discharge outcomes

This part of the thesis is published here:

López-Ejeda N, Charle-Cuéllar P, G B Alé F, Álvarez JL, Vargas A, Guerrero S. Bringing severe acute malnutrition treatment close to households through community health workers can lead to early admissions and improved discharge outcomes. PLoS One. 2020;15(2): e0227939.

4.3.1 Study design

The present work is based on secondary data analysis of previous study data consisting of the disaggregation of children by their treatment provider independent of the health area (HFs vs. CHWs), to assess whether providing treatment close to households through CHWs allows children to be admitted into treatment earlier and in a relatively less severe condition, with a positive impact on the treatment outcomes compared to standard care at the HFs. Accordingly, the intervention group consisted of all the children assessed and treated by the 17 CHWs in their communities, and the comparison control group consisted of all the children assessed and treated in the seven HFs.

Both treatment providers used the same tools and followed the same protocols and criteria for initial assessment, admission, follow-up, and discharge of the children according to the National requirements; thus, the main difference between the two treatment models was the convenience of accessing CHWs (CHWs typically assess and treat children closer to the households compared to HFs) and the education degree of the providers (nonmedical CHWs compared to doctors or nurses at HFs).

The sample consisted of 930 children aged 6 to 59 months suffering from SAM in seven communes of the Kita district of the Kayes Region in southwest Mali. All the children were enrolled in the multicenter and prospective study, to explore the potential of including SAM treatment as part of the services delivered by CHWs to improve affected family access and coverage.

4.3.2 Data collection

The intervention was carried out for twelve months between February 2015 and February 2016. Anthropometric assessments were performed to evaluate weight (kg), height (cm), and the MUAC (mm). The inclusion criteria in both groups were those recommended by the WHO (12): the presence of mild bilateral oedema or a MUAC under 115 mm or WHZ less than -3 according to the WHO growth reference. All children meeting those criteria received weekly rations of RUTF according to their weight (170 Kcal/kg/day). Recovery was defined as the absence of oedema and two consecutive weekly WHZ measurements above -1.5 or MUAC readings above 125 mm. Other reasons for exclusion included death, nonresponse (failure to gain weight within 14 days or weight loss during the first seven days after admission or during two consecutive follow-up visits or a total loss of 5% at any time during treatment), and default (absence at two consecutive weekly visits). The length of stay was calculated as the days elapsed between the admission and discharge dates.

4.3.3 Statistical analyses

Statistical analyses were performed with SPSS v.25 software. The normal distribution of quantitative variables was assessed with the Kolmogorov-Smirnoff test with Lilliefors correction. All variables showed a nonnormal distribution, so the Mann-Whitney test was applied to compare their central tendency and dispersion parameters. For proportion comparisons, a chi-square test was used, and Yates’s correction or the Monte Carlo exact test was applied when the minimum expected count for a category was fewer than 5 cases. For variables related to the admission moment, a logistic regression analysis was carried out to assess crude and adjusted odds ratios (ORs), and for those related to stay and discharge, the

ORs were estimated applying the Cochran-Mantel-Haenszel method to adjust for confounders.

4.3.4 Ethical considerations

The study was approved by the Comité d'Ethique de l'Institut National de Recherche en Santé Publique from Mali (décision n° 03/2015/CE-INRSP). Written informed consent was obtained from all the caretakers whose children were part of the study.

4.4 Effectiveness and coverage of treatment for severe acute malnutrition delivered by community health workers in the Guidimakha region, Mauritania

This part of the thesis is published here:

Charle-Cuéllar P, Lopez-Ejeda N, Toukou Souleymane H, Yacouba D, Diagana M, Dougnon AO, Vargas A and Briend A. Effectiveness and Coverage of Treatment for Severe Acute Malnutrition Delivered by Community Health Workers in the Guidimakha Region, Mauritania. Children (Basel). 2021 Dec;8(12):1132.

4.4.1 Study design

This study was a nonrandomized controlled trial conducted in an agro-pastoral region of Guidimakha. The control zone involved the communes of Ould Yengé and Dafor in the Department of Ould Yengé and the commune of Baydiam of the Khabou Department with a total population of 35,562 habitants. The intervention zone included the communes of Sélibabi and Hassi Cheggar in the Department of Sélibabi with a total population of 44,885 inhabitants. Children in the control zone received outpatient treatment for uncomplicated SAM from HFs, while in the intervention group zone they received outpatient treatment for uncomplicated SAM from HFs or CHWs. The intervention area had 10 HFs and 12 CHWs, and the control area included 6 HFs.

To assess the comparability of both zones, a two-stage cross-sectional cluster survey was conducted before implementing the intervention. The first level of sampling consisted of villages covered by HFs in each zone, and the second level consisted of households in selected villages. Data collection took place from June 7 to June 25, 2018. NutriSurvey.ena delta software was used to calculate the needed sample size based on the prevalence of SAM as measured by MUAC, which was estimated to be 4.9%, desired level of accuracy 3%, design effect of 1.5 with an average household size of 5.5, 16% of children under five years and 6% of non-response household. The total number of households to be surveyed was 218 in each zone (30 clusters with seven households each). When a household was selected, all children aged 6 to 59 months were included for MUAC measurements and oedema testing, and demographic and socio-economic variables were collected (75), (76).

To assess the possible impact of treatment by CHWs on the treatment coverage, two surveys were conducted in each zone at the baseline (June 2018) and end-line (June 2019) of the study applying the SQUEAC standardized methodology (73).

4.4.2 Data collection

The study took place between November 2018 and May 2019. The inclusion and exclusion criteria defined in the national protocol for the management of acute malnutrition were applied (77). All children aged 6 to 59 months presented to an HFs or a CHW's site, and/or detected by community volunteers (Relais Commaunitaires in French) or mobile clinics with mild or moderate oedema (+, ++), a MUAC less than 115 mm, and/or a WHZ less than -3 were included in the analysis. All severe oedema cases (+++), children with other severe medical conditions, or those who failed the appetite test were referred for inpatient treatment (78). Noncomplicated cases were treated at home. These children received 170 kcal/kg/day of RUTF to be consumed at home. The children were rechecked once a week until they reached one of the program's exit criteria, MUAC > 125 mm, and/or WHZ > 1.5. They also received amoxicillin (50–100 mg/kg/day divided twice a day for five days) and one single dose of 500 mg of mebendazole at the first visit for deworming.

4.4.3 Statistical analyses

The statistical analysis was performed with SPSS v.26. The normality of the continuous variables was tested with the Shapiro–Wilk test. Depending on the result, the central parameters were compared with Student’s t-test for normal and the Mann–Whitney test for non-normal parameters. The comparison of percentages was made through crossed tables applying the chi-square statistic with Yates' correction when the expected cases were less than 5 in more than 20% of the cells. The Mantel-Haenszel chi-square test was applied to compare the final treatment coverage adjusted to the baseline coverage data. For the analysis of the treatment outcomes, a Cox regression analysis was performed to obtain the time-adjusted probability (hazard ratio) until the outcome occurred. A 95% confidence level was applied in all analyses, considering significant p values below 0.05.

4.4.4 Ethical considerations

Informed consent was sought from all participants, both from the socioeconomic and coverage surveys and parents or guardians of children included in the study. The study received approval from the Ethical Committee of the Ministry of Health in Nouakchott, October 25th, 2018.

4.5 Impact of Different Levels of Supervision on the Recovery of Severely Malnourished Children Treated by Community Health Workers in Mali

This part of the thesis is published here:

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4.5.1 Study design

This was a prospective non-randomized community intervention trial with two intervention groups and one control group that compared the outcomes obtained with community treatment of SAM children under different levels of supervision (79).

A **socio-economic cross-sectional survey** was implemented before the intervention in September–October 2017 in all 3 areas to check their comparability. The survey was administered to 1350 randomly selected households with a two-stage cluster sampling design: In the first stage, 30 villages were randomly selected in each of the 3 intervention groups, and in the second stage, 15 households were randomly selected within each village. Empty households, households without children, or households with children absent were not replaced. The head of the household or mother of the children was interviewed after their informed consent was obtained.

SAM management. All children who were 6–59 months old, presented to an HFs or a CHW's site and were diagnosed as having uncomplicated SAM were eligible for the study. Children identified at the community level as having SAM received treatment directly from the CHWs without being referred to an HFs. The treatment of children with SAM by CHWs was progressively introduced during the first 3 months of the study, as CHWs were participating in the internship training at the HFs level at the beginning of the study in November and December 2017.

Admission criteria to the program followed Mali's National CMAM protocol: MUAC < 115 mm and/or WHZ < 3 based on the WHO growth standard and/or bilateral oedema were used at HFs, but only MUAC and bilateral oedema were used at the CHW level (80). In all 3 groups, clinical outcomes were evaluated. Cured was defined as a child with a WHZ 1.5 or MUAC 125 mm and absence of nutritional oedema during two consecutive visits. A defaulter case was defined as a child who missed two consecutive follow-up visits (14 days); a referred case was a case transferred to an inpatient care facility for treatment due to complications, and death referred to children who died during treatment.

Children with SAM received a weekly ratio of RUTF of 170 kcal/kg/day until recovery. They also received systemic treatment with amoxicillin (50–100 mg/kg/day twice a day for five days) and one single dose of 500 mg of mebendazole at the first visit.

Supportive supervision (SS). In the 3 study groups, the country's CMAM and iCCM protocol was applied with different levels of SS. The control group was the district of Bafoulabé, where SAM treatment was delivered at the HFs and CHWs levels with the expected supervision recommended by the MoH but without any support from the Action Against Hunger. In the Kayes district, light supervision was applied for which the Action Against Hunger supervised the iCCM component of the program more closely. In the Kita district, high supervision was applied for which in addition to the close supervision of the iCCM activities, the CHWs also received monthly nutrition-specific supervision, and both were supported by the Action against Hunger.

The supervision period was from February 2017 to October 2018. SS was planned to occur monthly and focused on identifying and solving problems and strengthening the health system from the community and included all the packages of the iCCM activities. As part of the supervision, the center's technical director (DTC) had to complete a checklist and follow a booklet to assess the implementation of the recommendations made at each visit (81). The checklist used in the iCCM activity supervision applied to the Kita and Kayes districts had 5 sets of questions:1) clinical examination of the sick child with 13 different items collected;2) newborn monitoring with 12 items;3) family planning with 4 items;4) Infant and Young child feeding (IYCF) with 3 items, and 5) hygiene and sanitation with 7 items.

In the Kita district, extra nutrition-specific supervision was implemented to assess the quality of care and performance provided by the CHWs, to identify training needs, to check the maintenance of equipment, to assess input and storage management, to check the quality of statistics, to assess the care of beneficiaries, and to identify implementation problems of SAM management. The checklist used during the nutrition-specific supervision applied in the Kita district was the same as the list included in the national CMAM protocol normally applied at HFs. This checklist has 8 sets of questions:1) anthropometric and medical equipment;2) identification of danger signs;3) systematic screening;4) admission and discharge criteria application;5) appetite test performance;6) nutritional treatment;7) systematic medical treatment, and 8) IYCF promotion. For each question, the performance of the CHW was classified as "passed" (1 point) or "failed" (0 points). The total score obtained from the sum of all the questions included in each set was recalculated over a maximum score of 10 points so that each set of questions could be scored between 0 and 10. The high quality of the performance was considered when the total score was equal to or greater than 8 points.

Figure 7. Intervention, monitoring, and supervision activities in the three groups of the study.

	Kita (High Supervision)	Kayes (Light Supervision)	Bafoulabé (no Supportive Supervision)
Baseline	**A**	**A**	**A**
	B	**B**	**B**
Implementation	**C**	**C**	**C**
	D- E	**D**	
Data analysis and field coordination	**F**	**F**	
	G	**G**	
Validation data and study coordination	**H**	**H**	**H**
	I	**I**	**I**

A	Socio-Economic Survey
B	Training of trainers, nurses at HFs, training of CHWs during 21 days in the package of iCCM. Training module of the MoH was used. CHW developed an internship post-training at HFs for 6 consecutive weeks.
C	Recruitment and treatment of children diagnosed as SAM without medical complications.
D	Monthly supervision of the CHWs on the iCCM package by supervisors of Action against Hunger together with the DTC from the MoH with the supervision checklist from the iCCM Policy
E	Monthly specific nutrition supervision of the CHWs by doctors from AAH with the supervision checklist from CMAM policy of the country.
F	Monthly meeting at health area level involving staff from the HFs, CHWs, and Action against Hunger supervisors, to follow up and analyze data, evaluate the need for RUTF.
G	Monthly meeting at a district level involving the focal point of the MoH and physicians of Action against Hunger, to analyze and validate data.
H	Technical committee meetings, providing expertise and advice on technical issues, tools, and materials (3 meetings during the recruitment period).
I	Steering committee meetings are responsible for the validation of the protocol, action plan, and results of the study.

HFs (health facilities), CHWs (community health workers), iCCM (integrated community case management),MoH (ministry of health), SAM (severe acute malnutrition), CMAM (community management acute malnutrition), RUTF(ready to use therapeutic food).

4.5.2 Data collection

Informed consent was sought from all participants, both from the socioeconomic and coverage. All the information was collected by Action Against Hunger supervisors using the Open Data Kit or Microsoft Excel spreadsheets® (82). Disaggregated data from the admission and discharge of each child were collected from the registers of HFs or CHW's site. In the two intervention groups of Kita and Kayes, the five sets of variables related to iCCM activities described above were collected during supervision monthly from direct observation of CHW performance using the iCCM checklist of the MoH. In the high supervision group of Kita, the 8 sets of variables related to nutrition activities described above were collected during the supervision every month using the checklist of the MoH for CMAM programs.

4.5.3 Statistical analyses

For data analyses, the Kolmogorov–Smirnov test with Lilliefors correction was used to assess the normal distribution of continuous variables. A t-test or Mann–Whitney test was used to compare means or medians when appropriate. To compare discharge outcomes, chi-square tests were applied considering Yates's correction when the minimum expected count for a category was five cases or fewer. All statistical analyses were performed with IBM®SPSS v.25 software.

4.5.4 Ethical considerations

The study was approved by the Ethical Committee in Bamako (decision Nº 13/2017CEINRSP). All the participants (mothers and children's caregivers) were asked to sign a formal consent form before starting participation in the project. The study was registered in the ISRCTN registry https://doi.org/10.1186/ISRCTN14990746

5. RESULTS

5 RESULTS

The results are presented with each of the studies published

5.1 Can community health workers manage uncomplicated severe acute malnutrition? A review of operational experiences in delivering severe acute malnutrition treatment through community health platforms

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ORIGINAL ARTICLE

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Can community health workers manage uncomplicated severe acute malnutrition? A review of operational experiences in delivering severe acute malnutrition treatment through community health platforms

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Abstract

Community health workers (CHWs) play an important role in the detection and referral of children with severe acute malnutrition (SAM) in many countries. However, distance to health facilities remains a significant obstacle for caregivers to attend treatment services, resulting in SAM treatment coverage rates below 40% in most areas of intervention. The inclusion of SAM treatment into the current curative tasks of CHWs has been proposed as an approach to increase coverage. A literature review of operational experiences was conducted to identify opportunities and challenges associated with this model. A total of 18 studies providing evidence on coverage, clinical outcomes, quality of care, and/or cost-effectiveness were identified. The studies demonstrate that CHWs can identify and treat uncomplicated cases of SAM, achieving cure rates above the minimum standards and reducing default rates to less than 8%. Although the evidence is limited, these findings suggest that early detection and treatment in the community can increase coverage of SAM in a cost-effective manner. Adequate training and close supervision were found to be essential to ensure high-quality performance of CHWs. Motivation through financial compensation and other incentives, which improve their social recognition, was also found to be an important factor contributing to high-quality performance. Another common challenge affecting performance is insufficient stock of key commodities (i.e., ready-to-use therapeutic food). The review of the evidence ultimately demonstrates that the successful delivery of SAM treatment via CHWs will require adaptations in nutrition and health policy and practice.

KEYWORDS

children, community health workers (CHWs), integrated community case management (iCCM), severe acute malnutrition (SAM), treatment

Abbreviations: CHWs, community health workers; CMAM, community-based management of acute malnutrition; iCCM, integrated community case management; MUAC, mid-upper arm circumference; OTP, outpatient therapeutic feeding programme; RUTF, ready-to-use therapeutic food; SAM, severe acute malnutrition; UNICEF, United Nations children's fund; WHO, World Health Organization
[The copyright line for this article was changed on 12 March 2019 after original online publication.]

1 | INTRODUCTION

According to the latest joint child malnutrition estimates, 16.9 million children under 5 years of age worldwide (2.5%) are suffering from severe acute malnutrition (SAM; United Nations children's fund [UNICEF], World Health Organization [WHO], and World Bank [WB], 2017). Children suffering from SAM are over nine times more likely to die than those who are well nourished (Black et al., 2008). As part of the global nutrition targets, the world has committed to reducing and/or maintaining the level of wasting to less than 5% by 2025 (WHO, UNICEF and World Food Programme [WFP], 2014).

Over the past two decades, there have been significant shifts in the way the world addresses SAM. The first global guidance produced in the 1990s recommended inpatient care in hospitals and the closely monitored use of therapeutic milk formulas for treatment by doctors and other experienced senior health professionals (WHO, 1999). This approach had several practical limitations, for instance, it is a fixed-capacity approach and has high opportunity costs for families and caregivers (Rogers, Myatt, Woodhead, Guerrero, & Álvarez, 2015). As a result of these and other barriers, it is estimated that inpatient models of care for SAM rarely reached more than 4–10% of the children suffering from SAM in the areas of intervention (Collins et al., 2006).

During the early 2000s, ready-to-use therapeutic foods (RUTFs) were introduced. The nutritional composition of these products is similar to therapeutic milk formulas but without the need for water to be added, which significantly reduces the risk of bacterial contamination and eliminates the need for refrigeration (UNICEF, 2013a). Around the same time, the community-based management of acute malnutrition (CMAM) model was introduced, allowing children with uncomplicated SAM to be diagnosed at the local level and referred to an outpatient therapeutic feeding programme (OTP) at health centres.

In 2006, a review of 33 outpatient programmes was published showing improved outcomes among programmes using RUTF over those that did not (Ashworth, 2006). The growing body of evidence demonstrating the effectiveness and potential for increased coverage through this facility-based approach ultimately led to its endorsement by United Nations agencies (WHO, WFP, United Nations System Standing Committee on Nutrition [SCN], and UNICEF, 2007) and its integration into national health systems beyond emergency contexts (United States Agency for International Development [USAID], 2008a). More recent systematic reviews and meta-analyses found that children receiving RUTF at community level were 51% more likely to achieve nutritional recovery than those who attended inpatient facilities (Lenters, Wazny, Webb, Ahmed, & Buhtta, 2013). These reviews also found that RUTF-based protocols are more effective at reducing mortality of acute malnourished children in various emergency contexts (Akparibo, Lee, & Booth, 2017).

The success and potential of the CMAM model rested on its capacity to achieve high levels of coverage. At 90% coverage, SAM treatment was found to be the most impactful and cost-effective nutrition intervention, capable of saving between 285,000 and 482,000 lives per year (Bhutta et al., 2013). However, in reality, few CMAM services ever achieve this level of coverage. A study carried out by Rogers et al. (2015) included data from 21 low-middle-income countries and found that the mean treatment coverage of CMAM programmes was less than 40%. The analysis went on to identify caregivers' awareness of the condition and/or availability of services, distance, and high opportunity costs as the most important barriers affecting coverage of outpatient, facility-based treatment for SAM (Puett & Guerrero, 2015; Rogers et al., 2015).

Key messages

- As many as 60% of children with severe acute malnutrition (SAM) do not receive the treatment they need.
- Distance, weekly follow-up visits, and transportation-related costs have been reported as key barriers to accessing treatment for SAM at health facilities.
- Community health workers, with adequate training and supervision, can deliver high-quality treatment for SAM at community level.
- Scaling-up management of SAM through community health workers requires that key issues regarding training, supervision, motivation, and supply chain be adequately considered in the design of such services.

These challenges are not unique to the treatment of SAM. Over the years, public health services have sought ways of making key child survival interventions more integrated and accessible to those who need it. Integrated community case management (iCCM) was introduced to improve uptake of services in areas where access to facility-based health services is poor. The iCCM approach is based on the training of non-medical community health workers (CHWs) to provide selected curative services, mainly to diagnose and treat diarrhoea, malaria, and pneumonia among children 2–59 months (Young, Wolfheim, Marsh, & Hammamy, 2012). Given the effect of nutritional status on the recovery of infectious diseases (Ibrahim, Zambruni, Melby, & Melby, 2017), the iCCM protocol also includes the identification and referral of SAM children 6–59 months. The CHW identifies SAM through mid-upper arm circumference (MUAC) measurement and bilateral oedema assessment (WHO and UNICEF, 2011). However, CHWs are only able to act on SAM cases when services exist at facility level, and there is limited documented evidence on the effectiveness of these referrals. A report of interventions integrating nutrition into iCCM (Friedman & Wolfheim, 2014) describes iCCM as a logical platform, a possible missed opportunity, for increasing the coverage of uncomplicated SAM treatment, as well as an opportunity for preventing malnutrition altogether.

The aim of the present review is to contribute to the assessment of the impact of empowering CHWs to diagnose and treat SAM by summarizing the results of previous operational experiences and identifying the opportunities and challenges associated with this innovative approach.

2 | METHODS

A search for peer-reviewed articles and grey literature was conducted to identify all relevant studies published between January 2005 and

February 2018. The search strategy was developed using the Population–Intervention–Comparison–Outcome framework (Schardt, Adams, Owens, Keitz, & Fontelo, 2007). This search strategy focused on the following: (a) Population: children from 6 to 59 months diagnosed with SAM, without medical complications; (b) Intervention: therapeutic food treatment provided by CHWs; (c) Comparison: outpatient treatment at health centres provided by medical staff; and (d) Outcome: clinical outcomes (cure, default, and death rates), treatment coverage, quality of care, and/or cost-effectiveness.

The search relied on PubMed, Cochrane Library, ClinicalTrials.gov, LILACS, African Index Medical, and Google Scholar databases. Additional grey literature was reviewed using OpenGrey and the Emergency Nutrition Network sites. The following keywords were used during the search: "Severe Acute Malnutrition"; "Marasmus"; "Kwashiorkor"; "Community Health Worker"; "Community Nutrition Worker"; "Community Health Agent"; "Health Extension Worker"; "Lady Health Worker"; "Health Promoters"; "Health Aids"; "Health Volunteers"; "Treatment"; "Ready-to-Use Therapeutic Food"; "RUTF"; "local level"; "home-based"; and "household level."

Results of the search are shown in the PRISMA flow diagram (Figure 1). The initial search resulted in 190 peer-reviewed articles and 188 technical reports from grey literature. Most of the peer-review articles were excluded as they focused on facility-based interventions without CHWs in the treatment of uncomplicated SAM. In relation to grey literature, only articles that provided outcome figures were ultimately included. A total of 18 articles on implementation experiences providing outcomes were included in the review.

3 | RESULTS

The search found a total of nine countries in which CHWs were reported to have played an active role in the provision of treatment for SAM: Angola, Bangladesh, Ethiopia, India, Malawi, Mali, Pakistan, South Sudan, and Togo. In the case of Togo, the search found limited information relating to the location of the programme, and the overall number of CHWs and SAM cases involved (377 and 1,483, respectively; UNICEF, 2013b), which led to its exclusion from this review.

Apart from Ethiopia, all the examples found were small-scale pilot projects, supported by international non-governmental or United Nations agencies (Table 1). Ethiopia is the only programme that is implementing this model at the national level as part of its Health Extension Programme. The scaling-up of SAM treatment through CHWs started after the 2008 drought emergency, which resulted in a dramatic increase in SAM cases. By 2012, the programme had reached 622 districts, 7,137 health posts, and 16,947 CHWs (UNICEF, 2012).

Table 2 shows that apart from Angola, all interventions have relied primarily on female CHWs, especially in contexts where no payment was involved. All projects added SAM treatment into an existing iCCM programme, except Angola and Malawi where CHWs treat severe and moderate acute malnutrition in a more vertical or stand-alone manner. In the case of South Sudan, there are two different cadres acting together, community nutrition workers delivering SAM treatment and community drug distributors who oversee infectious disease treatment (pneumonia, diarrhoea, and malaria).

Olaniran, Smith, Unkels, Bar-Zeev, and van den Broek (2017) recently published a methodological framework to categorize and define CHWs cadres with the aim to facilitate health policy formulation, programme planning, and research. According to the framework, the CHW cadres treating SAM differ widely in terms of literacy, pre-service training, and remuneration. In most of the countries in where interventions are taking place, there is a clear policy regarding the required profile of the CHWs providing iCCM services. However, the requirements for those CHWs who treat SAM outside the health facilities are not yet defined. For example, in Malawi, iCCM is performed by health surveillance assistants, a salaried cadre included in the Public Health System structure (USAID, 2017), whereas SAM treatment is provided by volunteer cadres, or "village health aides," whose literacy and remuneration is not clear (Amthor, Cole, & Manary, 2009; Linneman, Matilsky, Ndekha, Manary, & Maleta, 2007).

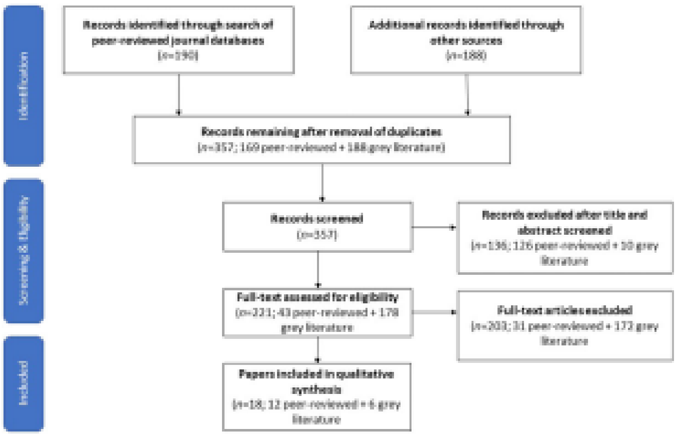

FIGURE 1 PRISMA flow diagram of literature revised and accepted for the review

TABLE 1 General description of programmes in where severe acute malnutrition treatment is provided by community health workers

Country (region)	Organization in charge and partners	Period	SAM prevalence in the region	SAM treatment inside iCCM	No. CHWs treating SAM per study area	CHWs location distance	Therapeutic food provider	References
Angola (Bié, Huambo, Kwanza Sul, and Zaire)	World Vision, UNICEF, People in Need, Africare, and Ministry of Health	2012–2013	4% to 5%	No[b]	1 per 2 to 5 villages	3-km max from communa	RUTF UNICEF	- World Vision (2014) - Morgan, Bulten, and Jalipa (2015)
Bangladesh (Barisal)	Save the Children and Feinstein International Centre	2009–2010	N/F	Yes	55 per one upazila	N/F	RUTF UNICEF	- Sadler, Puett, Mothabbir, and Myatt (2011) - Puett, Coates, Alderman, Sadruddin, and Sadler (2012) - Puett, Coates, et al. (2013) - Puett, Sadler, et al. (2013) - Puett, Alderman, Sadler, and Coates (2015)
Ethiopia (national)	Ministry of Health and UNICEF	Since 2010	2% National estimation	Yes	16,947 national	N/F	RUTF UNICEF	- UNICEF (2012) - Miller et al. (2014) - Mangham-Jefferies, Mathewos, Russell, and Bekele (2014)
India (Melghat)	MAHAN trust (local NGO)	2011–2012	7.1%	Yes	14	N/F	MAHAN LTFMN (local product)	- Dani et al. (2016)
Malawi[a] †(Southern region) ‡(Machinga District)	UNICEF and WFP	†2005–2006 ‡March–July 2006	N/F	N/F	N/F	N/F	†, ‡Project peanut butter (local RUTF)	- †Linneman et al. (2007) - ‡Amthor et al. (2009)
Mali (Kita)	Action against Hunger and National Nutrition Direction	2014–2016	1.2% to 2.4%	Yes	18 per three communes	5 km from health centre	RUTF UNICEF	- Álvarez-Morán, Alé, Charle, et al. (2018) - Álvarez-Morán, Alé, Rogers, and Guerrero (2018) - Rogers, Martínez, et al. (2018)
Pakistan (Dadu, Sindh)	Action against Hunger and Aga Khan University	2015–2016	N/F	Yes	72 per three union council	10- to 25-min walk from households	RUTF UNICEF	- Rogers, Ali, et al. (2018)
South Sudan (Northern Bahr el Ghazal)	Malaria consortium	2010–2011	5.3% to 9.3%	Yes	50 per two counties	5 km from health centre	RUTF UNICEF	- Keane (2013)

Note. CHWs: community health workers; iCCM: integrated community case management; N/F: data not found; NGO: Non Governmental Organization; RUTF: ready-to-use therapeutic food; SAM: severe acute malnutrition; UNICEF: United Nations Children's Fund; WFP: World Food Programme.

[a]In Malawi, two independent studies have been identified: †one broader in southern region (Linneman et al., 2007) and ‡one more restricted to Machinga District of the same region (Amthor et al., 2009).

[b]Children with SAM were referred to government mobile health clinics in each municipality because CHWs are not allowed to administer drugs.

TABLE 2 Profile of the community health workers that are carrying out severe acute malnutrition treatment by country of intervention

Country	Name of the cadre	Gender; education level	Remuneration	Duration of training	Diseases treated[b]	Potential beneficiaries by CHW	CHWs per each supervisor	Additional c support CH
Angola	Community health activist	Mostly men; literate	Volunteers (receiving allowance/incentives)	N/F	SAM, MAM	100 houses	10 to 100	None
Bangladesh	CHWs	Woman; 8th grade minimum	Volunteers (receiving allowance/incentives)	2 days for SAM	Pneumonia, diarrhoea, ARI, SAM	150–225 houses (875 potential users)	25 to 40	None
Ethiopia	Health extension workers	Women; 10th grade minimum	Government salary	1 year	Pneumonia, diarrhoea, ARI, malaria, severe febrile disease, measles, acute ear infection, anaemia, SAM	2 CHWs by 5,000 potential users	N/F	Volunteer h workers a developm (voluntee SAM scre follow-up
India	Village health workers	Women; semi-literate	Volunteers (receiving allowance/incentives)	N/F	Fever, diarrhoea, ARI, otitis media, malaria, SAM	900 people	N/F	None
Malawi[a]	Village health aides/ community health aids	N/F	N/F	†1 month (4-day practice) ‡5-day theory + 5-day practice	Just SAM	N/F	N/F	None
Mali	*Agent de Santé Communautaire*	Both; 9th grade minimum	Government salary	15-day ICCM (6 days of SAM)	Pneumonia, diarrhoea, malaria, SAM	1 CHW per 1,500 potential users	N/F	*Relais* comm (illiterate; counsel a screening
Pakistan	Lady health workers	Women; 8th grade minimum	Government salary	27 days (15-day theory + 12-day practice); 10 days of CMAM	Diarrhoea, ARI, SAM	200 houses	N/F	None
South Sudan	Community nutrition workers	Both; literate	Volunteers (receiving allowance/incentives)	5-day specific SAM training and on-job refreshes	Just SAM	N/F	15	Community (illiterate, providers

Note. ARI: acute respiratory infection; CHWs: community health workers; ICCM: integrated community case management; MAM: moderate acute malnutrition; N/F: data not found; SAM: severe a

[a]In Malawi, two independent studies have been identified: †one broader in southern region (Linneman et al., 2007) and ‡one more restricted to Machinga District of the same region (Amthor et al., 2

[b]Only diseases diagnosed and treated by the CHWs are mentioned, although most of them also play an active role on immunization and supplementation campaigns and on counselling and demonstra and community for the prevention of other infectious diseases and to promote behaviour change (feeding, care, and hygiene practices). Lady health workers of Pakistan also have a main role in r (including the provision of contraceptive pills or injectable)

3.1 | Clinical outcomes

The review found relevant differences in the treatment protocols used by the different projects (Table 3). The project in India used weight-for-height or weight-for-age as inclusion criteria but not MUAC. In contrast, five of the eight programmes used MUAC as the only anthropometric measurement for inclusion and discharge. In Angola, severe and moderate acute malnutrition were treated as one condition with

TABLE 3 Protocol for the management of severe acute malnutrition performed by community health workers in each intervention

Country (reference)	Admission criteria[a]	Systematic treatment	Discharge criteria
CMAM protocol (USAID, 2008b)	- MUAC < 110 mm or - WHZ < −3 Z-score of WHO standard or - Bilateral pitting oedema (+ and ++ grades)	Follow-up visits: Weekly or biweekly - RUTF dose in relation to child's weight - Amoxicillin - Mebendazole/other antihelminth - Vitamin A	Depending on admission cause: - No oedema in two consecutive weeks and - MUAC > 110 mm (minimum 2 months of treatment) and/or - WHZ > −2 Z-score of WHO standard for two consecutive visits and/or - Weight gain <20% from admission weight (discharge as non-respondent)
Angola (Morgan et al., 2015)	- MUAC < 125 mm and/or - Bilateral pitting oedema (+ and ++ grades)	Follow-up visits: N/F - Patients with MUAC < 115 mm supplied with two suchets of RUTF per day and those with MUAC between 115–125 with one suchet/day - Antibiotic[b] - Albendazole[b] - Vitamin A[b]	- MUAC > 125 mm + no oedema - Children kept in the programme for two extra weeks after discharge to prevent relapse
Bangladesh (Sadler et al., 2011)	- MUAC < 110 mm and/or - Bilateral pitting oedema (+ and ++ grades)	Follow-up visits: Weekly - RUTF dose in relation to child's weight - Antibiotic - Albendazole - Folic acid + vitamin A	Depending on inclusion reason: - MUAC > 110 mm and had gain at least 15% of their admission weight - MUAC > 110 mm and no oedema in two consecutive weeks
Ethiopia (Ethiopian Federal Ministry of Health, 2007)	- MUAC < 110 mm and/or - Bilateral pitting oedema (+ and ++ grades)	Follow-up visits: N/F - RUTF dose in relation to child's weight - Antibiotic - Albendazole/mebendazole	No oedema for 14 days + reach target weight gain related to inclusion weight
India (Dani et al., 2016)	- WHZ or WAZ < −3 Z-score of WHO standard or - Bilateral pitting oedema (+ and ++ grades)	Follow-up visits: Weekly MAHAN-LTFMN given 4 times a day during 90 days/ ration dose in relation to child's weight	Weight gain up to 15% of inclusion weight
Malawi [†](Amthor et al., 2009) [‡](Linneman et al., 2007)	[‡]WHZ < −3 Z-score of WHO standard or bilateral pitting oedema (+ and ++ grades) [†]MUAC < 115 mm or WHZ < −3 Z-score of WHO standard or bilateral pitting oedema (+ and ++ grades)	[†,‡]Follow-up visits: Biweekly [†, ‡]One jar (260 g) of RUTF per day	[†, ‡]No oedema and WHZ > −2 Z-score of WHO standard
Mali (Álvarez-Morán, Alé, Charle, et al., 2018)	- MUAC < 115 mm or - WHZ < −3 Z-score or - Bilateral pitting oedema (+ and ++ grades)	Follow-up visits: Weekly - RUTF dose in relation to child's weight - Antibiotic -Albendazole -Vitamin A	No oedema for two consecutive visits + MUAC >125 mm or weight gain > 15%
Pakistan (Rogers, Ali, et al., 2018)	- MUAC < 115 mm or - Bilateral pitting oedema (+ and ++ grades)	Follow-up visits: Weekly - RUTF dose in relation to child's weight - Antibiotic - Folic acid	No oedema + MUAC > 125 mm
South Sudan (Keane, 2013)	- MUAC < 115 mm or - Bilateral pitting oedema (+ and ++ grades)	Follow-up visits: N/F - RUTF dose in relation to child's weight - Amoxicillin - Mebendazole/other antihelminth - Vitamin A	No oedema + MUAC > 125 mm in two consecutive visits

Note. MUAC: Mid-upper arm circumference; N/F: data not found; RUTF: ready-to-use therapeutic food; WHO: World Health Organization; WAZ: weight-for-age; WHZ: weight-for-height.

[a]All interventions included as inclusion criteria that children had passed the appetite test and had no other medical complications. In Malawi, two independent studies have been identified: [†]one broader in southern region (Linneman et al., 2007) and [‡]one more restricted to Machinga District of the same region (Amthor et al., 2009).

[b]Given at government mobile health clinics because CHWs are not allowed to administer drugs.

a single admission criteria (MUAC < 125 mm). The Angola and Malawi programmes used a fixed dosage, rather than having CHWs calculate the dose according to the weight of each child. These discrepancies in the protocols used limits the capacity for comparative analysis.

Discharge outcomes of children admitted to these models of treatment are shown in Table 4. Apart from India, all the other cases meet the SPHERE Minimum Standard in Humanitarian Response (The Sphere Project, 2011) with more than 75% of children cured, as well as death and default rates lower than 10% and 15%, respectively. Likewise, these results are in line with those reported in a review of CMAM programmes developed in 12 countries from 2011 to 2013 (Save the Children, 2015). This report shows that from the 107,589 children receiving treatment in 24 different OTPs, 82.6% recovered, 9.2% defaulted, and 0.4% died.

The results achieved in Mali were the highest found in the review, with 94.2% of children successfully rehabilitated or cured in the intervention group. This result corresponds to a combined model of treatment with some children treated at health facilities and others by CHWs at household level, depending on the location of the households. The cure rate achieved in the control group (children treated at health facilities without any CHW delivering treatment) was 88.6%. In comparison, the probability of being cured in the intervention model was higher after adjusting for sex, oedema, and MUAC at admission (risk ratio: 1.89; 95% confidence interval [1.09, 3.27], P = 0.022; Álvarez-Morán Alé, Charle, et al., 2018). The projects in Angola, Malawi, and Bangladesh also achieved cure rates above 90% of children enrolled.

Default rate is generally defined as the proportion of children who were absent for two consecutive weekly sessions. The Bangladesh intervention reported the highest default rate (7.5%), with distance reported as the primary barrier to access (Sadler et al., 2011). The lowest default rate was reported in Malawi where only 3.6% children defaulted from the programme (Amthor et al., 2009). In Mali, default rates were twice as high in the facility-only control group (10.8%) compared with facility and CHWs intervention group (4.5%; risk ratio: 0.43, 95% confidence interval [0.24, 0.77], P = 0.005; Álvarez-Morán, Alé, Charle, et al., 2018). Researchers linked improved access to treatment to the proximity of CHWs.

All interventions reviewed reported low death rates, ranging from 1.4% in Malawi to 0.1% in Bangladesh. Most interventions reported "early detection" (enrollment of children with MUAC and/or weight for height just below the admission criteria) and the associated reduction in the risk of complications and mortality among the most notable benefits of this approach. In Mali, there were more children with oedema at admission in the OTP control group (4.7%) than in the group with OTP plus CHWs (0.7%). Moreover, children in the intervention group were also twice less likely to need to be referred to stabilization centres within 24 hr of admission (Álvarez-Morán, Alé, Charle, et al., 2018).

3.2 | Treatment coverage

Even though the focus of these interventions was to increase treatment coverage, only three studies reported coverage outcomes (Bangladesh, Mali, and Angola). All coverage estimates were generated directly, using the semi-quantitative evaluation of access and coverage/simplified lot quality assurance sampling evaluation of access and coverage methodologies (USAID, 2012). In Bangladesh, the CHW-based intervention achieved coverage of 89%, one of the highest coverage rates recorded by a SAM treatment intervention. In contrast, its monitoring data showed that in places where treatment was provided solely on an inpatient basis, caregivers refused to attend treatment citing opportunity costs (no one to carry out household activities, transport costs, etc.) as the primary barrier (Sadler et al., 2011).

In Mali, two coverage surveys (baseline and endline) were carried out. At baseline, the treatment coverage was estimated to be 43.9% in the intervention group and 43.8% in the control group. After a year, the coverage of SAM treatment achieved in the intervention group (treatment delivered at the health facilities with CHWs) was 86.7% compared with 43.9% in the control group during the same period (P < 0.001). These results show that when CHWs offer SAM treatment, more children access health services (Álvarez-Morán, Alé, Charle, et al., 2018). In Angola, coverage was estimated to be 82.1%

TABLE 4 Discharge outcomes in the experiences on SAM treated by CHWs

Country (reference)	Children enrolled	Intervention duration	Number of CHWs treating SAM	Cure rate (%)	Death rate (%)	Default rate (%)
Minimum standards (The Sphere Project, 2011)				>75	<10	<15
Angola (Morgan et al., 2015)	23,865	12 months	Over 2,000	93.8	1.0	4.8
Bangladesh (Sadler et al., 2011)	724	8 months	261	91.9	0.1	7.5
Ethiopia[a] (UNICEF, 2012)	703,878	8 months	N/F	82.1	0.7	5.0
India (Dani et al., 2016)	145	12 weeks	14	63.0	2.0	N/F
Malawi[b] (Amthor et al., 2009) (Linneman et al., 2007)	826 2,131	8 weeks 8 weeks	N/F N/F	93.7 89.0	0.9 1.4	3.6 7.4
Mali[a] (Álvarez-Morán, Alé, Charle, et al., 2018)	617	12 months	19	94.2	0.5	4.5
Pakistan[a] (Rogers, Alé, et al., 2018)	425	12 months	72	76.0	0.2	3.8
South Sudan (Keane, 2013)	3,564	12 months	45	89.0	1.0	6.0

Note. CHWs: community health workers; N/F: data not found; SAM: severe acute malnutrition.

[a]Results combined from inpatient and outpatient (health centres + health post) treatment.

[b]In Malawi, two independent studies has been identified: one broader in southern region (Linneman et al., 2007) and one more restricted to Machinga District of the same region (Amthor et al., 2009).

in those areas where CHWs were active. However, the authors referenced the limited number of CHWs available for implementation, the lack of RUTF, and poor transport as factors that limited the capacity to achieve a level of coverage in a uniform and sustainable manner (Morgan, et al., 2015).

3.3 | Quality of care

Of all the experiences reviewed, only four performed a specific study on the quality of care. In Bangladesh, the performance of 55 CHWs was assessed using an adaptation of the CMAM checklist, which included assessment, treatment, and counselling skills (Collins, 2004). The study found that 89.1% of the CHWs achieved 90% error-free SAM case management. All diagnostic items evaluated achieved over 92% error-free completion, all treatment-related elements were above 89%, and all educational messages delivered were correct in over 87% of cases (Puett, Coates, et al., 2013). The authors classified this as "good quality" based on previous quality of care studies (Degefie et al., 2009). In the same study, CHWs were perceived by the caretakers as "trustworthy" because they were perceived to be close to the community but also better informed and more knowledgeable on positive feeding and hygiene practices than themselves (Puett, Coates, et al., 2013). Another qualitative study carried out to assess perceptions of 49 CHWs about the barriers for quality care found that with limited time available, CHWs found it easier to provide curative services than behaviour change advice for SAM children (Puett et al., 2015). Results following the assessment of 338 CHWs showed that the integration of SAM treatment to ICCM services did not affect the quality of care of other curative and preventive interventions provided by CHWS, although it did require an additional time every week (globally 16.7 ± 6.9 hr per week compared with 13.3 ± 4.6 hr of those CHWs not treating SAM, $P < 0.001$). CHWs providing SAM treatment achieved better, error-free case management than those providing just ICCM (100% vs. 93.3%, $P < 0.05$; Puett et al., 2012).

In Mali, a quality of care study based on the assessment of 125 cases of uncomplicated SAM showed that 79.5% of cases received high-quality SAM management according to a composite indicator, which included all essential tasks (Álvarez-Morán, Alé, Rogers, & Guerrero, 2018). MUAC was correctly assessed in 96.8% of children and oedema in 78.4%. The appetite test was correctly done in 77.8% of cases. The highest result was achieved in the treatment section with a 100% correct RUTF administration. In addition, 94.3% of caretakers received essential nutritional counselling. In 75% and 100% of cases, other diseases, including malaria, pneumonia, cough, diarrhoea, fever, and vomiting, were well diagnosed and treated. The authors stipulated that the high level of accuracy could be associated with the high level of supervision provided during this pilot study.

In Ethiopia, a quality of care study found that just 64% of 137 CHWs provided correct global case management according to the Ethiopian ICCM Clinical Guidelines, which include assessment, classification, treatment, referral, and counselling (Miller et al., 2014). The study found some important differences depending on the disease: Seventy-nine per cent of CHWs correctly treated diarrhoea, and 72% correctly treated pneumonia; however, correct SAM treatment was only 59%. In addition, only 34% of CHWs made a correct assessment of severe illness (oedema was one of the most common errors), and half of children in need were referred to a health centre. As shown in Table 2, Ethiopian CHWs have the greatest workload, managing up to 16 health services (Workie & Ramana, 2013). A study conducted by Mangham-Jefferies et al. (2014) analysed how 131 CHWs allocated their time through all these assignments during a 1-week period. Results indicated that 5.5% of their workload was dedicated to nutrition tasks and that time was balanced between curative and preventive actions (2.9% and 2.7%, respectively).

In Pakistan, a quality of care study assessed 17 lady health workers attending 61 cases of SAM children (Rogers et al., 2018), though this represented a smaller sample size than used in other studies in the review. These CHWs were found to have achieved a high score in assessing oedema (87.5% error-free) but lower scores measuring MUAC and weight (57.4% and 60%, respectively). The appetite test was correctly performed in just 42% of the cases, and danger signs were accurately reported in 65% of them. Treatment with RUTF was adequate in dose and advice in 72% of cases. According to the facility survey tool (WHO, 2003), they provided correct medical and nutrition treatment to 68.0% of children. However, only 4% of cases received all the above services and key nutritional counselling messages correctly. The authors speculate that low performance could be linked to insufficient training on this component or the lack of motivation among CHWs.

With the exception of Bangladesh's project, none of the others reported impact of adding SAM treatment on the quality of services for other diseases covered by CHWs. This represents a significant evidence gap.

3.4 | Cost-effectiveness

The review found evidence on the cost-effectiveness of delivering SAM treatment via CHWs in only two contexts. In Bangladesh, the integrated model was compared with inpatient treatment care (Puett et al., 2013). The main costs reported related to programme management (salaries and overheads related to monitoring and supervision) accounted for 53% of the total costs. However, the authors highlighted that elevated management costs reflected the substantial start-up costs needed to establish new systems in the first year of services. They suggest that this cost structure would likely change over time due to economies of scale, as SAM treatment is integrated into ongoing non-government organization or government services. Using an activity-based cost model with a societal perspective that included costs incurred by providers and participants, researchers found the cost per child treated by CHWs to be US$165 and US$180 per child recovered, whereas inpatient treatment costs were estimated at US $1,344 and US$9,149, respectively. However, the authors also estimated that if coverage, recovery, and defaulting for inpatient treatment were improved by a factor of 20%, the costs would be reduced to US$520 per child treated and US$1,491 per child recovered. They also found that the community treatment cost per each disability-adjusted life year averted was US$26, compared with US $1,344 for the inpatient model. According to the WHO criteria

(Marseille, Larson, Kazi, Kahn, & Rosen, 2015), this community approach is highly cost-effective because each disability-adjusted life year avoided costs less than one per capita gross domestic product of the country. The authors argued that this result is comparable with the cost-effectiveness of other basic health interventions such as immunization, insecticide-treated bed nets, and tuberculosis treatment.

Additional cost-effectiveness evidence is provided by the Mali study, where services provided in the facility (control group) were compared with services provided in a facility and by CHWs at household level (intervention group; Rogers et al., 2018). Authors applied a similar societal perspective with an activity-based costing analysis. In the intervention area, the cost per child treated was US$244 and US $259 per child recovered. This was less expensive than standard outpatient care (US$442 and US$501, respectively). As in Bangladesh, supervision and monitoring was the highest cost, accounting for over half of the total costs. However, these results are based on an unequal number of children participating in each arm. If an equal scenario is modelled, outpatient care could be more cost-effective. Authors concluded that achieving good coverage is a key factor in influencing cost-effectiveness of CHWs delivering treatment for SAM. Considering cost to beneficiaries, households receiving treatment from CHWs spent half the amount of time on a weekly basis (2.15 vs. 3.92 hr) and three times less money on a weekly basis than households in the control group (US$0.60 vs. US$1.70).

The Ethiopia programme disaggregated costs by category, including RUTF (50%), service delivery including training and supervision (33%), logistics (12%), and other supplies and equipment (5%). Overall, it was estimated that the average cost per treated child was US$110, ranging from US$90 to US$152. This figure is based on only costs incurred by implementers, which remains sensitive to a range of factors including number of SAM cases treated, programme length, and accessibility of the programme sites (UNICEF, 2012).

4 | DISCUSSION

Available evidence on the treatment of acute malnutrition by CHWs is still scarce and comes from studies designed and implemented in considerably different ways. Therefore, their results cannot be compared directly and are not generalizable. Most of the experiences found were supported by international non-governmental organizations and were implemented in small geographic areas, limiting the ability to extrapolate the results across wider or different contexts. Ethiopia is the only country where decentralized care for acute malnutrition is implemented by the government at a national scale. Though this programme represents a unique example of what can be achieved at scale, the review found no published evidence of the coverage or clinical outcomes achieved.

This review found that operational experiences in delivering treatment for SAM through CHWs have generated a range of different results. Like much of the evidence on CHW performance, training and supervision have been identified as key determinants of success. The Mali programme has already embarked on a new study comparing three different models of training and supervision to better understand how to best support the implementation of this approach at scale (Charle, 2018). Yet the evidence found by this review already points to key determinants including incentives and motivation, literacy level, information management, supply chain of RUTF, and policy environment.

4.1 | Incentives and motivation

Incentives have been widely described as a critical determinant of CHW motivation and retention (Bhutta, Lassi, Pariyo, & Huicho, 2010; Pallas et al., 2013; Zulu, Kinsman, Michelo, & Hurting, 2014) and thus a key consideration for their involvement in future scale-up plans for the treatment of SAM. In Bangladesh, CHWs felt that their salary was inadequate for their workload, which reportedly led to increased pressure from their families to prioritize domestic responsibilities (Puett et al., 2012). In Pakistan, where lady health workers normally receive remuneration for new activities, failure to provide additional financial remuneration for adding SAM treatment to their workload was identified by the authors as a critical factor behind the low quality of care provided (Rogers, Ali, et al., 2018).

Incentives were also found to be a key determinant of programmes where CHWs focused purely on the management of acute malnutrition. In Angola, staff were initially expected to receive in-kind incentives (e.g., mobile phone credit), but as the limitations of this approach became clear, the intervention switched to financial compensation to maintain CHW involvement. Staff emphasized the need to design a compensation scheme before implementation (Morgan et al., 2015). In South Sudan, cash incentives were made depending on the completion of timely, high-quality reports. Additional bonuses to encourage excellence were also found to be critical (Keane, 2013).

Other experiences have reported sources of motivation beyond economic rewards, mostly based on improvement of self-efficacy and social recognition, which is reflected in the quality of training. In Bangladesh, CHWs who had acquired skills on treating SAM had higher feelings of competence due to visible changes in children recovering from SAM. In contrast, CHWs providing only ICCM services reported frustration in encountering many malnourished children in their communities who did not respond to counselling or referral alone (Puett et al., 2012). This is consistent with previous studies that have found that CHWs who perform curative tasks, such as SAM treatment, feel more recognized by the community (Kok et al., 2015).

In addition to ensuring quality of care, regular supervision and training were also identified as a source of motivation for CHWs, in part because they reinforce a sense of belonging and connection to the programme (Strachan et al., 2012). The provision of equipment with recognizable symbols can provide a sense of pride and lead to improved status of CHWs in their communities (Bhutta et al., 2010; Strachan et al., 2012). With this in mind, the South Sudan intervention provided CHWs with branded clothing, flashlights, drug boxes, hand soap, safe water storage, and long-lasting insecticidal nets. These items were distributed with the additional aim of helping CHWs demonstrate healthy behaviour and practices in their communities (Keane, 2013).

In Mali, the positive results achieved by the pilot were linked to the profile of the CHWs involved; they were all salaried, all had a minimum of 2 years of health training, and all had worked as CHWs between 1 and 5 years in the same community where they lived (improving their social recognition; Álvarez-Morán, Alé, Charle, et al., 2018; Álvarez-Morán, Alé, Rogers, & Guerrero, 2018).

4.2 | Literacy and information management

Literacy was found to play a significant role in the way CHWs were ultimately involved in SAM treatment. Most of them had low literacy levels with a maximum of 10 years of primary education (Table 2). In the South Sudan intervention, the implementing team originally tried to use a single provider cadre, though finally it was deemed necessary to split functions, due to the largely illiterate community drug distributors. Therefore, a new literate cadre of community nutrition workers was formed, whose responsibility was the treatment of uncomplicated SAM cases (Keane, 2013).

The recruitment of CHWs on the basis of literacy alone would have significant implications on gender equality, especially in contexts with low rates of school attendance among women (Strachan et al., 2012). Previous reviews have proposed that in the context of scaled ICCM, monitoring systems must accommodate the wide variation in levels of literacy and skill, as programmes usually cannot invest time in testing and refining their procedures and tools (Guenther et al., 2014). Mobile phone systems (known as mHealth) have been proposed as an alternative for recording data, suggesting that it could improve accuracy and reduce time and costs (Källander et al., 2013). In Mali, Chad, South Sudan and India there are ongoing efforts to develop new protocols and tools to empower low-literate CHWs to treat SAM (Tesfai, Marron, Kim, & Makura, 2016). These protocols have modified entry, follow-up, and discharge protocols in favour of simple anthropometric criteria (MUAC), which has in turn been modified to facilitate longitudinal follow-up by CHWs. Additional changes have been made to weighing scales, allowing low-literacy CHWs to determine the appropriate dosage based on a child's weight using colour zones within the scale, with each colour corresponding to the number of sachets required per day. As shown in Table 3, some of the reviewed interventions had also simplified criteria for diagnosis, treatment, and discharge of SAM children compared to the standard outpatient protocol.

4.3 | Supply chain management

Under the current ICCM protocol, CHWs dispense oral rehydration salts solution, zinc, amoxicillin, and an antimalarial drug (Young et al., 2012). The current protocol for treatment of SAM generally involves two additional products: albendazole/mebendazole for deworming and RUTF (USAID, 2008b). It is estimated that RUTF purchasing and distribution represent about half of the total cost of SAM treatment (Emergency Nutrition Network, 2012). In the cost-effectiveness studies carried out in Mali and Bangladesh, RUTF reflected 13% and 24% of the total budget, respectively (Puett, Sadler, et al., 2013; Rogers, Martínez, et al., 2018). The proven effectiveness of RUTF on CMAM programmes had led to an increase in product demand (UNICEF, 2017). UNICEF is currently the major global purchaser and provider of RUTF and, as can be seen in Table 1, is also the provider of supplies for many interventions. The high product cost, high weight, and volume of RUTF needed for treatment make its integration into national supply chains more challenging (Komrska, Rock-Kopczak, & Swaminathan, 2013).

In most of the interventions in which CHWs treat SAM, running out of RUTF stock over the course of the study or intervention was one of the most important barriers cited for scaling-up implementation. This issue has been identified as one of the top five barriers of access to treatment in countries with less than 50% SAM coverage, as it negatively impacts default rates (Puett, Swan, & Guerrero, 2013). Running out of stock can have direct and indirect consequences for these programmes: In South Sudan, staff reported that running out of stock was affecting community perceptions of the intervention and impacting future attendance and uptake (Keane, 2013). Apart from India, all the reviewed studies supplied CHWs with RUTF in the health centres. In Angola, the intervention aimed to address the challenge of RUTF distribution by providing CHWs with bicycles to facilitate the transport of supplies. This approach was ultimately replaced by hiring local, three-wheeled motorbikes, as it proved more efficient and effective in distributing larger amounts of RUTF across difficult terrain (Morgan et al., 2015; World Vision, 2014). The review found no documented evidence of the efficiency or effectiveness of different modalities for supplying CHWs with RUTF, making it an important evidence gap to be addressed by future research projects.

4.4 | Policies and protocols

As the projects reviewed have shown, provisioning of SAM treatment by CHWs demands adaptations to national and global policies and guidelines. Some authors have speculated that the inclusion of SAM treatment into this package could cause tensions between government directorates of health and nutrition, mainly due to management structures and funding availability (Friedman & Wolfheim, 2014). In some contexts, such as Angola, this would require a revision of national guidelines concerning the distribution of antibiotics and other essential drugs by CHWs. National nutrition guidelines would also have to be modified to simplify protocols. A report on the policy and programme options to improve nutrition in Ethiopia suggests that to achieve full integration of SAM treatment into the Health Extension Programme, modifications of the CMAM protocol should be explored to find ways to reduce cost and dependency on (imported) RUTF products (Ljungqvist, 2015). The Combined Protocol for Acute Malnutrition Study (ComPAS), currently implemented in South Sudan and Kenya, is exploring some of these potential protocol modifications. The study aims to assess the effectiveness and cost-effectiveness of a reduced and standardized dose of RUTF to treat severe and moderate acute malnutrition (Bailey et al., 2018; Lelijveld et al., 2018). Reduced dosage of RUTF has already shown potential in trials in Myanmar, where a reduced dosage protocol used to treat over 3,000 children with SAM achieved 90.2% recovery with 2.0% of default rates, 0.9% of non-respondents, and no deaths registered (James et al., 2015).

A review of policy challenges facing ICCM in sub-Saharan Africa has shown that the most critical actors for new policy development are technical officers within the Ministry of Health supported by key development partners, particularly WHO, UNICEF, the USAID, and its collaborating agencies (Bennett, George, Rodriguez, Shearer, & Diallo, 2014). This review also showed that senior policymakers, particularly those with a clinical background, are initially resistant to changes due to concerns about CHWs treating more complex conditions, and experience has shown that shifting these perceptions takes time. It is therefore crucial that major nutrition and health agencies support the introduction of SAM treatment into ICCM mainly through the development of statement papers, standardized protocols, tools, and training courses as done previously for CMAM (USAID, 2008b; WHO, WFP, SCN and UNICEF, 2007). This would encourage governments to generate their own context-specific evidence by learning and supporting the identification of key policy changes necessary to support interventions at scale.

5 | CONCLUSIONS

Most of interventions reached cure rates around 90% or above, and all achieved default and death rates below 7% and 1.5%, respectively. These results are similar or better than those reported by facility-based interventions, suggesting that CHWs have the potential to improve early detection and treatment of SAM children, thereby reducing the risk of medical complications. However, these results have generally been achieved by small projects supported by international non-governmental organizations, and there is very limited evidence on the implementation of these approaches at scale.

Three studies have assessed treatment coverage, achieving figures above 80% in all cases. However, more studies carried out at scale are needed to ascertain whether the integration of CHWs in the treatment of SAM could increase the current coverage of treatment. The review also found evidence to suggest that this approach can be more cost-effective compared with conventional inpatient and outpatient treatment models.

Ensuring high quality of care was found to be dependent on various key factors including the level of literacy, training, and supervision of CHWS, as well as the ability to keep them motivated through financial compensation and social recognition in the community. These and other determinants ultimately suggest that effectively scaling-up this approach will require various adaptations to health and nutrition policies and practice.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

CONTRIBUTIONS

NLE, PCC, AV, and SG performed the research. PCC, AV, and SG designed the research study and contributed essential reagents. NLE, PCC, and AV analysed the data. NLE and SG wrote the paper.

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5.2 Bringing severe acute malnutrition treatment close to households through community health workers can lead to early admissions and improved discharge outcomes.

PLOS | ONE

RESEARCH ARTICLE

Bringing severe acute malnutrition treatment close to households through community health workers can lead to early admissions and improved discharge outcomes

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Abstract

Severe acute malnutrition (SAM) affects over 16.6 million children worldwide. The integrated Community Case Management (iCCM) strategy seeks to improve essential health by means of nonmedical community health workers (CHWs) who treat the deadliest infectious diseases in remote rural areas where there is no nearby health center. The objective of this study was to assess whether SAM treatment delivered by CHWs close to families' locations may improve the early identification of cases compared to outpatient treatment at health facilities (HFs), with a decreased number complicated cases referred to stabilization centers, increased anthropometric measurements at admission (closer to the admission threshold) and similarity in clinical outcomes (cure, death, and default). The study included 930 children aged 6 to 59 months suffering from SAM in the Kita district of the Kayes Region in Mali; 552 children were treated by trained CHWs. Anthropometric measurements, the presence of edema, and other medical signs were recorded at admission, and the length of stay and clinical outcomes were recorded at discharge. The results showed fewer children with edema at admission in the CHW group than in the HF group (0.4% vs. 3.7%; OR = 10.585 [2.222–50.416], p = 0.003). Anthropometric measurements at admission were higher in the CHW group, with fewer children falling into the lowest quartiles of both weight-for-height z-scores (20.2% vs. 31.5%; p = 0.002) and mid-upper arm circumference (18.0% vs. 32.4%; p<0.001), than in the HF group. There was no difference in the length of stay. More children in the CHW group were cured (95.9% vs. 88.7%; RR = 3.311 [1.772–6.185]; p<0.001), and there were fewer defaulters (3.7% vs. 9.8%; RR = 3.345 [1.702–6.577]; p<0.001) than in the HF group. Regression analyses demonstrated that less severe anthropometric measurements at admission resulted in an increased probability of cure at discharge. The study results also showed that CHWs provided more integrated care, as they diagnosed and treated significantly more cases of infectious diseases than HFs (diarrhea: 36.0% vs. 18.3%, p<0.001; malaria: 41.7% vs. 19.8%, p<0.001; acute respiratory infection: 34.8% vs. 25.2%, p = 0.007). The addition of

SAM treatment in the curative tasks that the CHWs provided to the families resulted in earlier admission and more integrated care for children than those associated with HFs. CHW treatment also achieved better discharge outcomes than standard community treatment.

Competing interests: The authors have declared that no competing interests exist.

Abbreviations: CHWs, Community Health Workers; CMAM, Community Management of Acute Malnutrition; HFs, Health Facilities; iCCM, Integrated Community Case Management; INRSP, *Institut National de la Recherche en Santé Publique*; MUAC, Mid-Upper Arm Circumference; RUTF, Ready-to-Use Therapeutic Food; SAM, Severe Acute Malnutrition; WHZ, Weight-for-Height z-score.

Introduction

Severe acute malnutrition (SAM) is the most extreme and visible form of undernutrition, and children suffering from it require urgent treatment [1]. Severely acutely malnourished children are 11.63 times more likely to die than those who are well-nourished [2]. It is estimated that there are currently 16.6 million children under the age of 5 with severe wasting (2.4% worldwide) [3]. Over the last four decades, SAM treatment has shifted from small-scale inpatient treatment, which reached just 4–10% of affected children [4], to outpatient therapeutic feeding programs under the Community-based Management of Acute Malnutrition (CMAM) protocol [5] at health facilities (HFs), which has increased coverage to almost 40% [6].

This outpatient approach relies on the use of ready-to-use therapeutic food (RUTF), with a nutritional composition similar to therapeutic milk formulas used in the inpatient treatment, but it does not require either refrigeration or water to be prepared and can be safely consumed at the household level. The results of a systematic review and meta-analysis showed that children treated through this community approach were 51% more likely to recover than those treated at hospitals [7].

The Integrated Community Case Management (iCCM) strategy was developed to improve access to essential health services for children in hard-to-reach rural areas. Under the general iCCM protocol, pneumonia, diarrhea, and malaria are treated by nonmedical community health workers (CHWs) in their own villages. These CHWs are also encouraged to identify SAM cases through the assessment of mid-upper arm circumference (MUAC), but in most cases, they are not allowed to treat SAM [8]. All severely acutely malnourished children without other severe medical complications identified by the CHWs are referred to the nearest HFs to be admitted to a CMAM program. However, the effectiveness of these referrals is unknown, as they are seldom reported. A review on the coverage of CMAM programs in 21 low- and middle-income countries has identified the distance to the HFs as a main barrier for families to access SAM treatment [6].

Since 2010, efforts have been made to add SAM treatment to the curative tasks that CHWs can provide close to families, referred to as the iCCM+ approach. A review of the operational experiences of this approach has recently been published [9] and shows that programs implementing this new community approach can achieve better outcomes in terms of recovery and defaulter rates than standard CMAM programs performed at HFs far away from the affected villages. This review also found that the iCCM+ model could potentially double the coverage of SAM treatment services, achieving over 80% treatment coverage in a cost-effective manner, reducing the time and money that the families would expend to treat their children at the health centers, which are usually located far away from their households [10,11].

The first general review of SAM management published by Collins et al. in 2006 [4] stated that the severity and prognosis of SAM and the determinants of successful treatment are primarily dependent on the time of presentation. The increase in coverage achieved by the CHW-delivered approach was hypothesized to bring about improvements in early presentation or admissions when children have relatively less severe forms of the condition and few medical complications [9].

In 2018, Mali had 4.1 million people in need of humanitarian assistance, and almost one in five Malians was in a state of food insecurity, which is an increase from 2.5 million in 2016 [12]. According to the Human Development Index, Mali is the 182th poorest country in the world out of a total of 189 countries [13], and global acute malnutrition affects 10.7% of children, 2.6% of whom are severely acutely malnourished. Outside the conflict zone, the Kayes Region has the highest prevalence of global acute malnutrition (14.2% with a 2.6% SAM) due to erratic rains that limit dietary diversity, poor hygiene and sanitation conditions, and inadequate access to clean water [13, 14]. In 2010, the Malian government approved the iCCM of essential care to be delivered by CHWs (*Agents de Santé Communautaire*) in villages located 5 km or more from a health center. Each CHW has a catchment area of approximately 700 people from 2–3 villages, and they are supported by a volunteer cadre (*Relais Communautaire*) who are in charge of screening and referrals, as well as communication activities aimed at effecting social and behavioral change. In 2016, there were 2,377 active CHWs, but it is estimated that 4,876 are needed for full health coverage [15].

The study aimed to assess whether providing treatment close to families through CHWs (by including SAM management in the curative services of the iCCM protocol they provide) could diminish severity at admission, leading to better discharge outcomes than those associated with the CMAM standard outpatient treatment already provided in the health centers typically located far away from the families in a rural area of the Kayes Region in Mali.

Methods

The sample consisted of 930 children aged 6 to 59 months suffering from SAM in seven communes of the Kita district of the Kayes Region in southwest Mali. All the children were enrolled in the multicenter and prospective study, with the aim of exploring the potential of including SAM treatment as part of the services delivered by CHWs to improve affected family access and coverage. The study was approved by the Ethical Committee of the National Institute for Research in Public Health (*Institute National de la Recherche en Santé Publique, INRSP*). The intervention was carried out for twelve months between February 2015 and February 2016.

The original study was carried out in two distinct health areas. In one of them, the standard CMAM protocol was applied whereby that severely acutely malnourished children were treated only in the HFs (control group: 4 HFs). In the other area, the iCCM+ protocol was applied; in addition to HFs, treatment by CHWs close to the households was added (intervention group: 3 HFs + 17 CHWs). The results of the coverage and effectiveness of this combined outpatient treatment model with medical staff at HFs plus CHWs at the household level have been previously published elsewhere [16]. According to Malian protocols, CHWs previously received two weeks of training from health staff on iCCM and CMAM techniques, with one month of on-site practice at the HF. During the study period, they received a 3-day refresher training and attended monthly meetings at the HF. Their sociodemographic characteristics and the quality of care provided are published elsewhere [17].

The present work is based on a secondary data analysis of previous study data consisting of the disaggregation of children by their treatment provider independent of the health area (HF vs. CHW), with the aim to assess whether providing treatment close to households through CHWs allows children to be admitted into treatment earlier and in a relatively less severe condition, with a positive impact on the treatment outcomes compared to standard care at the HFs. Accordingly, the intervention group consisted of all the children assessed and treated by the 17 CHWs in their communes (Tambaga, Bougarabaya, and Kobiri) and the comparison control group consisted of all the children assessed and treated in the seven HFs that covered the same three communes, along with four others (Guenikoro, Kassaro, Dafela, and Sebekoro). Both treatment providers used the same tools and followed the same protocols and criteria for initial assessment, admission, follow-up, and discharge of the children according to the National requirements; thus, the main difference between the two treatment models was the convenience of accessing CHWs (CHWs typically assess and treat children closer to the households compared to HFs) and the education degree of the providers (nonmedical CHWs compared to doctors or nurses at HFs).

At the time of admission, all the children were assessed for edema, diarrhea, vomiting, fever, cough, malaria, dermatosis, and conjunctival pallor. A malaria test was also performed in children with a temperature above 38°C or suspected of having the disease. Patients with severe medical complications or children who were not able to successfully complete an appetite test were referred from the CHW site or the HF to stabilization centers for inpatient treatment. Anthropometric assessments were also performed to evaluate weight (kg), height (cm), and the MUAC (mm). The inclusion criteria in both groups were those recommended by the World Health Organization (WHO) [18]: the presence of mild bilateral edema or a MUAC under 115 mm or weight-for-height z-score (WHZ) less than -3 according to the WHO growth reference [19].

All children meeting these criteria received weekly rations of RUTF according to their weight (170 Kcal/kg/day). Recovery was defined as the absence of edema and two consecutive weekly WHZ measurements above -1.5 or MUAC readings above 125 mm. Other reasons for exclusion included death, nonresponse (failure to gain weight within 14 days or weight loss during the first seven days after admission or during two consecutive follow-up visits or a total loss of 5% at any time during treatment) and default (absence at two consecutive weekly visits). The length of stay was calculated as the days elapsed between the admission and discharge dates. To ensure treatment quality, both the CHWs and medical personnel in the HFs were supervised twice a month by specialized Action Against Hunger staff and every three months by the project's technical committee together with the staff of the INRSP.

Statistical analyses were performed with SPSS v.25 software. The normal distribution of quantitative variables was assessed with the Kolmogorov-Smirnoff test with Lilliefors correction. All variables showed a nonnormal distribution, so the Mann-Whitney test was applied to compare their central tendency and dispersion parameters. For proportion comparisons, a chi-square test was used, and Yates's correction or the Monte Carlo exact test was applied when the minimum expected count for a category was fewer than 5 cases. For variables related to the admission moment, a logistic regression analysis was carried out to assess crude and adjusted odds ratios (ORs), and for those related to stay and discharge, the ORs were estimated applying the Cochran-Mantel-Haenszel method to adjust for confounders.

Results

A total of 552 children (59.4% of the total) were treated by CHWs in their communities, and 378 children (40.6%) received traditional outpatient treatment by medical staff in the health facilities. The comparison groups did not differ in terms of sex ratios (CHWs: 58.2% female; HFs = 56.6% female; $p = 0.641$) or age (mean age: CHWs 14.58 ± 8.46 months vs. HFs 14.15 ± 7.67 months, $p = 0.698$; ≤12 months: CHWs 56.2% vs. 59.5%, $p = 0.308$). Table 1 shows the distribution of the children according to admission type. More children were new admissions in the HF group than in the CHW group, while readmissions (children re-enrolled after abandonment with an absence of less than two months), relapses (children re-enrolled after more than two months of

Table 1. Distribution of children according to the reason for admission by each model of outpatient treatment.

	Community Health Workers		Health Facilities		Comparison (p value)
	n	%	n	%	
New admission	462	83.7	347	91.8	<0.001
Readmission	13	2.4	2	0.5	0.030
Relapse	25	4.5	7	1.9	0.028
Transfer from URENAS	9	1.6	5	1.3	0.705[NS]
Transfer from URENI	43	7.8	17	4.5	0.045

[NS]: No significant difference / URENAS: *Unité de Récupération et d'Education Nutritionnelle* = Unit for outpatient severe nutritional recovery and education; URENI: Unité de Récupération et d'Education Nutritionnelle Intensive = Unit for intensive nutritional recovery and education.

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absence or after being discharged as cured), and transfers from stabilization centers were more prevalent in the CHW group than in the HF group.

The results of the medical assessments at admission are shown in Table 2. There was no difference between the models in the proportion of children who had to be referred to stabilization centers due to severe medical complications. However, 3.7% of the children in the HF group were affected by edema, which was significantly higher than 0.4% in the CHW group. After adjusting for sex and age, the probability of edema at admission was markedly higher in children admitted for treatment at a health center than those presenting for treatment by a CHW (OR = 10.585, 95% confidence interval (C.I.) [2.222–50.416], p = 0.003). In contrast, diarrhea (OR = 1.512, 95% C.I. [1.049–2.179], p = 0.027) and malaria (OR = 2.554. 95% C.I. [1.838–3.548], p<0.001) were more prevalent in children assessed by CHWs than in children admitted to HFs. In both groups, approximately one-quarter of the sample reported coughing, and one-third had a fever.

The analysis of anthropometric measurements at admission included only new cases and relapse cases, given that children requiring readmission or transfer had already started their treatment, which could influence their measurements at readmission time. Children with edema were also been excluded from this analysis since their WHZ was affected. Fig 1 shows the comparison of WHZ and MUAC at admission according to the two models. The HF

Table 2. Presence of disease signs during the medical assessment at admission according to the two models of outpatient treatment.

	Community Health Worker treatment		Health Facility treatment		Comparison (p value)
	n	%	n	%	
Referred at admission[*]	28	5.1	22	5.9	0.615
Edema	2	0.4	14	3.7	<0.001
Other signs:					
Diarrhea	104	18.8	51	13.5	0.032
Vomiting	52	9.4	47	12.4	0.143[NS]
Fever	195	35.3	123	32.5	0.379[NS]
Cough	153	27.7	93	24.6	0.290[NS]
Dermatosis	0	0.0	4	1.1	0.056[NS]
Pale Conjunctiva	2	0.4	12	3.2	0.001
Malaria tests performed:	511	92.6	319	84.4	
Positive results	201	39.3	65	20.4	<0.001

[*]Children who were referred to the URENI (*Unité de Récupération et d'Education Nutritionnelle Intensive* = Unit for intensive nutritional recovery and education) / NS: Not significant difference

https://doi.org/10.1371/journal.pone.0227939.t002

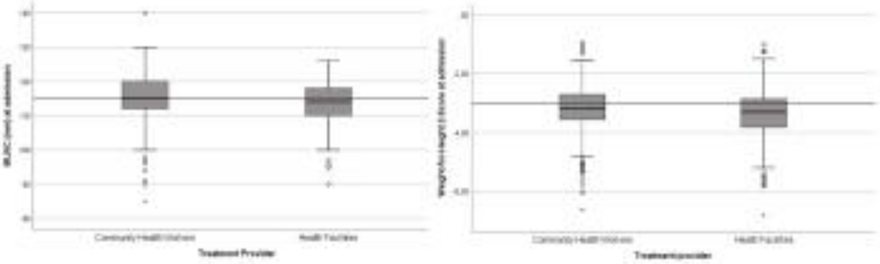

Fig 1. Anthropometric measurements of the children at admission according to the two models of outpatient treatment. Inclusion criteria for severe acute malnutrition treatment is marked with a discontinuous line.

https://doi.org/10.1371/journal.pone.0227939.g001

group had a slightly lower weight (6.30 ± 1.04 kg vs. 6.49 ± 1.14 kg; p = 0.026) and slightly lower WHZ (-3.40 ± 0.82 vs. -3.23 ± 0.75; p<0.001) than the CHW group, although the groups did not differ in height (HFs 70.59 ± 6.10 cm; CHWs 71.13 ± 6.44 cm; p = 0.340).

Fig 2 shows the distribution of the children according to WHZ quartiles calculated for the whole sample. The proportion of children who fell into the lowest quartile was higher in the HF group (p = 0.002) than in the CHW group. Considering only those children admitted with a WHZ < -3 (n = 498), the proportion with the most severe condition (≤ -3.89 z-score) was also higher in the HF group than in the CHW group (44.7% vs. 33.8%, p = 0.013; OR adjusted by sex and age = 1.596, 95% C.I. [1.107–2.302], p = 0.012).

Similar results were found for MUAC at admission. The median values differed between the models, with the HF group showing the lowest value, at 114 mm [interquartile range (IQR) 110–118], compared to 115 mm [IQR 112–120] in the CHW model (p<0.001). Fig 2 also shows that the proportion of children who fell into the lowest quartile for MUAC in the HF group was almost double that in the CHW group (p<0.001). Considering only those children with a MUAC <115 mm (n = 378), the proportion with the most severe condition (≤110 mm) was markedly higher in the HF group than in the CHW group (60.8% vs. 39.6%, p<0.001; OR adjusted by sex and age = 2.350, 95% C.I. [1.551–3.563], p<0.001).

In the children who recovered, the CHW group had a median length of stay of 39 days (IQR 29–51), and the HF group had a median length of stay of 42 days (IQR 28–49), with no significant difference (p = 0.740) between the two. However, slightly more children in the HF group (54% vs. 47%; p = 0.075) than in the CHW group remained in treatment for more than 40 days (almost 6 weeks), which is the median stay considering both groups together. The linear regression analyses were adjusted by age, included all 930 children admitted to treatment, and showed an inverse association between WHZ at admission and length of stay (B coefficient = -1.985, 95% C.I. [-3.517–-0.453], p = 0.011), although the MUAC at admission did not show this same association (p = 0.185). The proportion of children who were absent for one or more nonconsecutive visits during treatment was higher in the HF group (25.9% vs. 17.0%, p = 0.003; OR adjusted by sex, age and key variables that differed at admission as edema, relapses and readmissions = 1.534, 95% C.I. [1.059–2.222], p = 0.024) than in the CHW group. Fig 3 shows that the other signs and diseases assessed during the SAM treatment (diarrhea, malaria, and acute respiratory infection) were more prevalent in the CHW group than in the HF group.

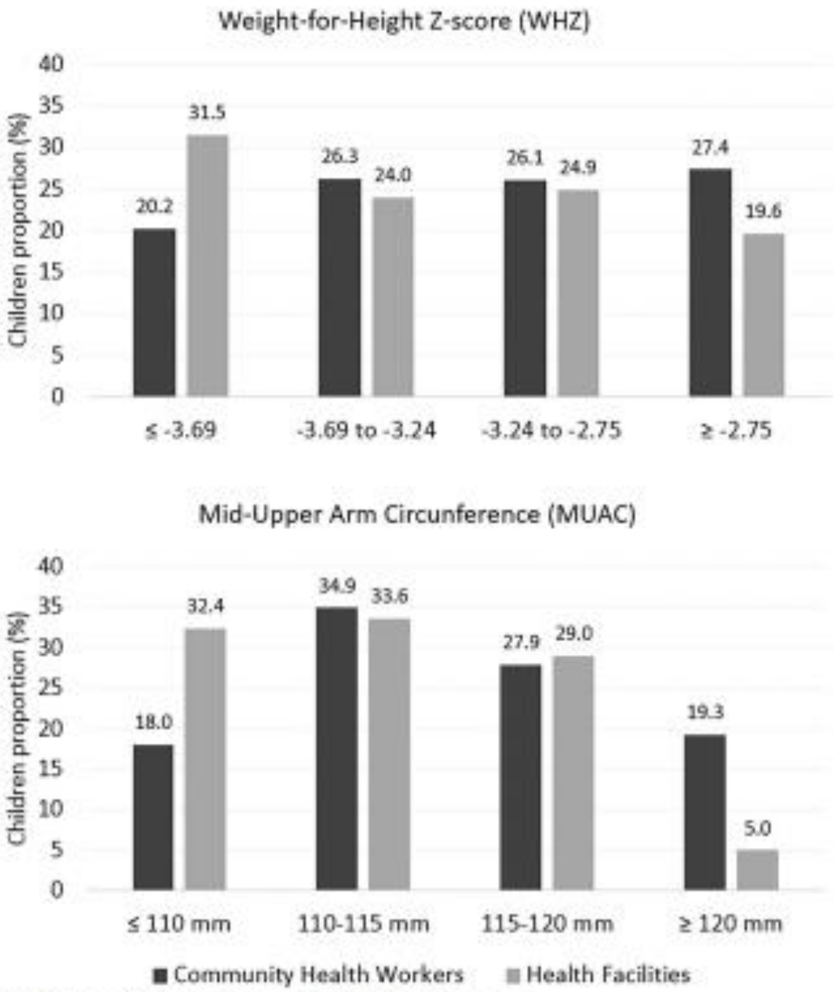

Fig 2. Distribution of children according to the quartiles of MUAC and WHZ at admission.

https://doi.org/10.1371/journal.pone.0227939.g002

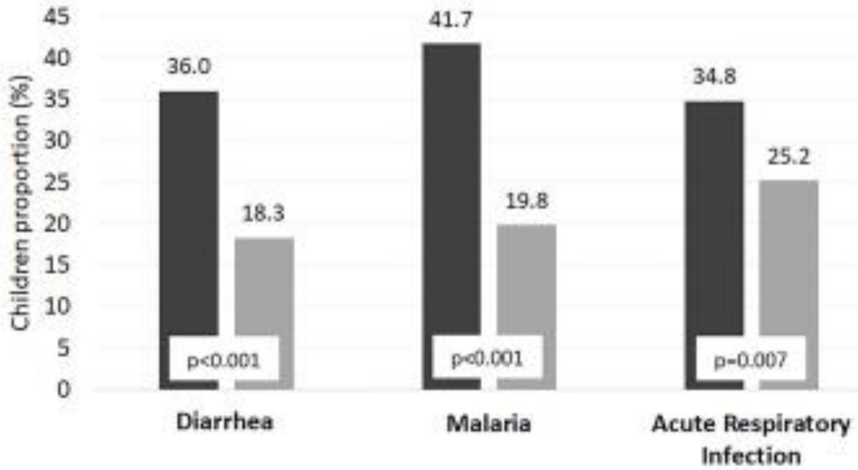

Fig 3. Proportion of other diseases detected during outpatient treatment of severe acute malnutrition compared between the two models.

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The results at discharge are shown in Table 3. The proportion of cured children was lower in the HF group than in the CHW group (88.7% vs. 95.9%), and the probability of not being cured in the HF group at the end of the treatment was 3.3 times higher than that in the CHW group after adjusting for sex, age, and conditions at admission. The proportion of children who defaulted from treatment was also higher in the HF group (9.8% vs. 3.7%), and the children's probability of being discharged because of default was more than three times higher in the HF group than in the CHW group. The probability of death did not differ significantly even though the proportion of fatal cases in the HF group was almost triple that in the CHW group (1.5% vs. 0.4%). Only three children in the CHW group were discharged as nonresponsive (0.6%). Nonresponder rates between the two groups could not be compared, as this data was not included in the national protocols, nor was it collected at the HF level. No significant difference was found in the proportion of children who had to be referred to nutritional stabilization centers during treatment due to complications (HFs 7.2% vs CHWs 9.5%, $p = 0.224$).

Table 3 also summarizes the evolution in the anthropometric measurements of the children discharged as cured; no significant differences were found between the two models. Finally, when including all children regardless of their treatment provider ($n = 930$), adjusted regression analyses proved that increased WHZs and MUACs at admission (less severe condition) are associated with a higher probability of being cured after treatment (Table 4).

Discussion

According to recent assessments in a rural region of Mali, malnutrition is the main avoidable factor related to child mortality [21]. This study shows that children receiving SAM treatment from CHWs generally exhibited a less severe stage at admission, with lower rates of edema and

Table 3. Treatment outcomes considering the two models of severe acute malnutrition outpatient management.

Discharge Outcomes[a]	Community Health Workers n = 487		Health Facilities n = 336		OR [95% C.I.][b]	p value
	n	%	n	%		
Cure	467	95.9	298	88.7	3.311 [1.772–6.185]	<0.001
Default	18	3.7	33	9.8	3.345 [1.702–6.577]	<0.001
Death	2	0.4	5	1.5	2.748 [0.579–13.043]	0.309[NS]
Anthropometric improvement in cured children[c]	n = 466		n = 295		n = 466	
	Median	IQR	Median	IQR		
Weight gain						
Total (kg)	1.30	1.20–1.80	1.30	1.20–1.80	0.577[NS]	
Per day (gr/kg)	5.45	3.63–7.52	5.45	3.63–7.52	0.976[NS]	
MUAC gain						
Total (mm)	13.00	10.00–13.00	13.00	10.00–13.00	0.050[NS]	
Per day (mm)	0.33	0.22–0.50	0.33	0.22–0.50	0.050[NS]	

IQR: Inter-Quartile Range; NS: Not significant; OR: Odds Ratio; SD: Standard deviation

[a] Chi-square test comparing proportions among discharge outcomes between models: p<0.001

[b] Cochran-Mantel-Haenszel test adjusted by sex, age and the key variables with differences at admission (edema, relapse and readmission) considering the Health Facility model over the Community Health Worker model (RR of not being cured, RR of defaulting and RR of death)

[c] Calculated according to standardized indicators for CMAM programs [20], excluding those children with edema at admission.

[d] Nonparametric Mann-Whitney test was applied based on the nonnormal distribution of the variables.

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better anthropometric condition compared to children treated at HFs. A previous analysis on the cost-effectiveness of this new approach for SAM management with CHWs as treatment providers showed that families can save half the time and one-third of the money that it would cost to treat their children at the HFs [22]. This cost-saving could prevent families from delaying the initiation of required nutritional treatment, allowing children to be admitted in a relatively less severe condition.

The results also show that increased MUACs and WHZs at admission were associated with an increased probability of successful recovery. This is consistent with other publications assessing these two models of treatment in Malawi [23]. The Malawi study also found that children with relatively low anthropometric measurements at admission were more likely to default from the program or achieve poor clinical outcomes. A recent systematic review found that the strongest and most consistent risk factor for relapse after SAM treatment in CMAM programs is low anthropometric measurements at admission [24]. Another study in India reported that children with a MUAC under 105 mm at admission had a 6.46 times increased risk of SAM a year after discharge, although they did not find any significant association with a low WHZ [25]. Various studies have found evidence that high severity at admission is

Table 4. Association of anthropometric measurements at admission with the probability of cure at discharge.

	Unadjusted univariate logistic regression analysis		Adjusted univariate logistic regression analysis[a]	
	β coefficient [95% C.I.]	p value	β coefficient [95% C.I.]	p value
MUAC	1.052 [1.027–1.078]	<0.001	1.074 [1.047–1.102]	<0.001
WHZ	1.519 [1.242–1.858]	<0.001	1.603 [1.292–1.988]	<0.001

C.I.: Confidence Interval; MUAC: Middle-Upper Arm Circumference; WHZ: Weight for Height Z-score.

[a] Adjusted by sex, age and key conditions at admission (edema, readmission and relapse).

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associated with an increased risk of death after discharge. In Bangladesh, it was found that severe wasting, considered a WHZ < -4, was associated with a 3.64 times higher probability of death three months after the end of treatment [26]. In the same setting, Kerac et al. [27] showed that the death hazard ratio 90 days after discharge decreased with each increased anthropometric measurement unit at admission (HR adjusted for age, edema, and HIV status; 0.80 per cm of MUAC and 0.75 per WHZ unit). Evidence of this relationship between severity at admission and mortality after discharge has also been found for other anthropometric indicators of growth and nutritional status, such as weight-for-age, height-for-age, and head circumference [26–28].

Studies on the other diseases managed under the iCCM protocol have previously demonstrated this reduction in the risk of morbidity and mortality based on early treatment. A systematic review concluded that pneumonia managed by CHWs was associated with a 32% reduction in mortality [29], and other studies have reported that this figure increased to 70% [30]. Similar results have been reported for the early treatment of malaria in several countries [31]. This study found that CHWs detected and treated more cases of infectious diseases both at admission and during treatment than HFs, with malaria detection and treatment showing the largest difference between the two groups. The decreased rates in the HF group could be related to the medical staff's high workload, which prevents the adequate allocation of time to assess other medical signs beyond acute malnutrition. Similar challenges have been reported with HIV testing in Malawi, where centers implementing CMAM were often overwhelmed by the workload involved in managing acute malnutrition [32]. On the other hand, a previous study on an iCCM+ program in Bangladesh demonstrated that although including SAM treatment in the package of interventions delivered by CHWs increased their overall workload by an estimated three hours per week, this increase did not negatively affect the quality of care in the other preventive and curative services delivered [33]. However, further time allocation studies comparing the performance of HFs and CHWs are required.

In relation to the treatment duration of the recovered children, this study did not find a significant difference between both models of service delivery. However, an increased WHZ at admission was associated with a reduced length of stay. A study conducted in Ethiopia with 420 children found that starting treatment with a MUAC above 106 mm was significantly associated with a reduction in the amount of time needed to recover, but the decrease was only from 27 to 24 days [34]. In contrast, another study carried out in Burkina Faso involving 22,094 children showed that MUAC at admission was inversely associated with length of stay; specifically, it found that children admitted with a MUAC < 100 mm stayed for 46.6 days, while those with a MUAC between 116–118 stayed an additional ten days on average [35]. The study in Burkina Faso found an overall treatment duration of 52 days for children admitted with a MUAC < 115 mm or WHZ < -3, which is higher than the 42 days registered by the HFs in this study. The same length of stay (42 days) has been reported in other studies in Ethiopia, but they were based on a discharge criterion of 15% weight gain [36, 37]. One of them found that considering MUAC, a discharge criterion could mean increased length of stays, since they found that 20.6% of the children who showed a 15% weight gain would still be considered acutely malnourished if a MUAC < 115 mm criterion was applied [37].

The aforementioned iCCM+ study in Bangladesh [38] reported a length of stay of 37.4 ± 0.6 days, which is close to the 39 found in this study. However, the discharge criteria (MUAC > 110 mm and 15% weight gain) were different than those required by the Malian Health Ministry policy (MUAC > 125 mm or WHZ > -1.5). Nevertheless, the anthropometric improvement during treatment in both groups in this study was similar to what was reported in the Bangladesh study (weight: 6.7±0.1 g/kg/day; MUAC: 0.4 mm/day). A systematic review of the recovery of edematous children from inpatient and outpatient programs registered a weight gain after loss of edema of 2.7 to 4.0 g/kg/day and a MUAC gain of 0.2 to 0.3 mm/day [39], both of which were lower than those in this study. That review also concluded that the worst outcomes were observed in studies where the children received inpatient care for the first week, supporting the idea that severity at admission has an influence on recovery. Previous studies on therapeutic feeding programs have also demonstrated that the most severe kwashiorkor patients gain less weight on average than marasmic patients (2.70 g/kg/day and 3.16 g/kg/day, respectively) [36].

In relation to discharge outcomes, both models achieved the Minimum Standards in Humanitarian Response (<75% recovery, <10% death, and <15% default) [40]. However, compared to the CHW model of treatment, children treated at HFs had a higher probability of missing one or more visits during treatment, with a three times higher risk of ultimately defaulting from the program and a total risk of not being cured that was also 3.3 times higher. Proximity to treatment has previously been identified as a factor influencing recovery in CMAM programs [41, 42]. The results of this study show that increased anthropometric measurements at admission are directly associated with an increased probability of being cured after treatment. The combination of early treatment and close follow-up due to the proximity of CHWs performing integrated management of childhood diseases could be the reason for the high effectiveness of iCCM+ interventions compared to the treatment provided at health centers [9]. Furthermore, the recovery rate achieved by CHWs in this study (95.5%) was the highest of all the iCCM+ experiences published to date, which range from 60.0% in India to 93.8% in Angola [8,43]. Only one study in Ethiopia found that treatment by CHWs was associated with worse outcomes than treatment at HFs, with a 1.5 times higher probability of nonrecovery [44].

There were limitations to this study. As mentioned above, this was a secondary analysis of data recorded for a study with a different design in which HFs plus CHWs were part of the intervention area, and only some of the HFs were part of the control area. Moreover, follow-up weight and height were not recorded, limiting the analysis of anthropometric evolution during treatment. Further studies assessing the long-term status of children who recovered with each treatment delivery model are needed to ascertain whether the iCCM+ approach has an effect on reducing relapse and mortality rates over time.

Conclusions

The addition of SAM treatment into the curative tasks provided closer to the families by the CHWs can result in a reduction in the severity at admission and fewer absences and defaults during the treatment compared to standard CMAM care provided at health facilities generally located farther away. CHWs also detected and treated more cases of diarrhea, malaria, and acute respiratory infection, which allows SAM to be tackled in a more integrated manner. Accordingly, CHWs achieve better discharge outcomes with higher recovery rates and fewer defaulters than treatment provided by medical staff at health centers.

Supporting information

S1 Data.
(XLSX)

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Supervision: José Luis Álvarez, Antonio Vargas, Saul Guerrero.

Validation: Pilar Charle-Cuellar.

Writing – original draft: Noemi López-Ejeda.

Writing – review & editing: Pilar Charle-Cuellar, Franck G. B. Alé, José Luis Álvarez, Antonio Vargas, Saul Guerrero.

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5.3 Effectiveness and coverage of treatment for severe acute malnutrition delivered by community health workers in the Guidimakha region, Mauritania

children

MDPI

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Effectiveness and Coverage of Treatment for Severe Acute Malnutrition Delivered by Community Health Workers in the Guidimakha Region, Mauritania

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Abstract: Geographical and economic access barriers to health facilities (HF) have been identified as some of the most important causes of the low coverage of severe acute malnutrition (SAM) treatment. The objective of this study is to assess the effectiveness and coverage of SAM treatment delivered by community health workers (CHWs) in the Guidimakha region in Mauritania, compared to the HF based approach. This study was a nonrandomized controlled trial, including two rural areas. The control group received outpatient treatment for uncomplicated SAM from HF, whilst the intervention group received outpatient treatment for uncomplicated SAM from HF or CHWs. A total of 869 children aged 6–59 months with SAM without medical complications were included in the study. The proportion of cured children was 82.3% in the control group, and 78.4% in the intervention group, we found no significant difference between the groups. Coverage in the intervention zone increased from 53.6% to 71.7%. In contrast, coverage remained at approximately 44% in the control zone from baseline to end-line. This study is the first to demonstrate in Mauritania that the decentralization model of CHWs treating SAM improves acute malnutrition treatment coverage and complies with the international quality standards for community treatment of acute malnutrition. The non-randomized study design may limit the quality of the evidence, but these results could be used by political decision-makers as a first step in revising the protocol for acute malnutrition management.

Keywords: severe acute malnutrition (SAM); community health workers (CHW); integrated community case management (iCCM); mid-upper arm circumference (MUAC); coverage

1. Introduction

Food insecurity and malnutrition are often high and widespread, with seasonal peaks pushing millions into crisis in Mauritania [1]. The 2019 SMART survey indicated that the national nutrition situation remains serious, with a prevalence of global acute malnutrition (GAM), defined by a weight-for-height z-score (WHZ) of less than −2 or the presence of oedema of 11.2%, and a prevalence of severe acute malnutrition (SAM), defined as a WHZ of less than −3 or oedema, of 1.8% [2]. Children suffering from SAM have an increased risk of serious illness and death, primarily from acute infectious diseases [3–6]. In the Guidimakha region, located in the extreme south of Mauritania, the GAM prevalence in 2019 was 17%, and SAM was 2.9%, which remains a serious situation and one of the worst in the country [2]. This prevalence was higher than the emergency thresholds defined by the World Health Organization by a prevalence of GAM superior to 10% [7].

Geographical and economic access barriers to health facilities (HF) have been identified as one of the most important causes of the low coverage of malnutrition treatment [8]. The geographical distribution of health structures covering a radius of 0–5 km, is unequal in Mauritania. This deprives populations of the contribution that health workers could make in the fight against malnutrition [9]. Action Against Hunger carried out a survey in 2019 to evaluate the coverage of SAM treatment in Guidimakha. Distance to the HF was shown to be one of the main reasons why people do not have access to SAM treatment. This situation has become evident in the Nutrition Causal Analysis (NCA) performed in the area [10]. The isolation of certain localities in Guidimakha makes it challenging to access essential services. Among the recommendations were suggestions to improve geographical access to health posts and health centres and increase health-related activities in the most remote villages [10].

In 2017, Mauritania identified the community approach through the training of community health workers (CHWs) and the reactivation of community health units as one of the major actions to ensure that all people have access to health services. These CHWs, according to government policy, are responsible for the promotion of good hygiene and feeding practices, the treatment of malaria, diarrhoea, and pneumonia; and to identify and refer children suffering acute malnutrition in the community using mid-upper arm circumference (MUAC) [11].

At the international level, during the COVID-19 pandemic, UNICEF and the Global Nutrition Cluster have made a strong recommendation that countries should adopt different modalities of simplified approaches to increase coverage of acute malnutrition and reduce the pandemic's impact on malnourished children. Among these actions, the decentralization of SAM treatment with CHWs has been included [12]. Evidence regarding the effectiveness of this approach is emerging [13]. However, most of these results were related to small pilot studies. Further analysis is needed to evaluate the quality of care and coverage in other contexts and how to adapt and integrate the approach into the country's policies.

This study tested the hypothesis that the integration of SAM treatment as part of the iCCM package currently delivered by CHWs in Mauritania will improve the early identification of cases and better access to treatment services, and clinical outcomes of SAM treatment (including cure, death and in particular defaulter) will improve. The objective of this study is to assess the effectiveness and coverage of SAM treatment delivered by CHWs in the Guidimakha region in Mauritania compared to the HF based approach.

2. Materials and Methods

This study was a nonrandomized controlled trial conducted in an agro-pastoral region of Guidimakha. The control zone involved the communes of Ould Yengé and Dafor in the Department of Ould Yengé and the commune of Baydiam of the Khabou Department with a total population of 35,562 habitants. The intervention zone included the communes of Sélibabi and Hassi Cheggar in the Department of Sélibabi with a total population of 44,885 habitants [14]. Children in the control zone received outpatient treatment for uncomplicated SAM from HF, while in the intervention group zone they received outpatient treatment for uncomplicated SAM from HF or CHWs. The intervention area had 10 HF and 12 CHWs, and the control area included 6 HF. To assess the comparability of both zones, a two-stage cross-sectional cluster survey was conducted before implementing the intervention. The first level of sampling consisted of villages covered by HF in each zone, and the second level consisted of households in selected villages. Data collection took place from 7 June to 25 June 2018. NutriSurvey.ena delta software was used to calculate the needed sample size based on the prevalence of SAM as measured by MUAC, which was estimated to be 4.9%, desired level of accuracy 3%, design effect of 1.5 with an average household size of 5.5, 16% of children under five years and 6% of non-response household [15,16]. The total number of households to be surveyed was 218 in each zone (30 clusters with seven households each). When a household was selected, all children aged 6 to 59 months were included for MUAC measurements and oedema testing and demographic and socio-economic variables described in Table 1 were collected.

Table 1. Socioeconomic characteristics of the population in study zones.

	Control		Intervention		*p* Value
	n	% (95% C.I.)	*n*	% (95% C.I.)	
Demographics	724		730		
Female proportion	310	42.8 (40.2–45.5)	332	45.5 (42.8–48.1)	0.307
6–59 month children	501	69.2 (65.7–72.6)	518	71.0 (67.7–74.3)	0.464
Global Acute Malnutrition	36	7.2 (5.2–9.8)	34	6.6 (4.7–9.0)	0.695
Severe Acute Malnutrition	2	0.4 (0.1–1.4)	2	0.4 (0.4–1.4)	0.973
House characteristics	223		212		
Cement floor	17	7.6 (4.5–11.9)	52	24.5 (18.9–30.9)	<0.001
Handmade earth brick roof	50	22.4 (17.1–28.5)	36	17.0 (12.2–22.7)	0.154
House in property	197	88.3 (83.4–92.2)	179	84.4 (78.8–89.0)	0.234
Potable water in the house	12	5.4 (2.8–9.2)	18	8.5 (5.1–13.1)	0.201
Potable water closes to household	111	49.8 (43.0–56.5)	92	43.4 (36.6–50.4)	0.185
Health care access barriers	223		212		
Cost	112	50.2 (0.43–0.57)	101	47.6 (40.8–54.6)	0.590
Distance	107	48.0 (41.3–54.8)	105	49.5 (42.6–56.5)	0.747
Family disagrees	4	1.8 (0.5–4.5)	6	2.9 (1.1–6.1)	
Sick child treatment preference	223		212		
Medication of health center	124	55.6 (48.8–62.2)	170	80.2 (74.2–85.3)	<0.001
Traditional self-medication (herbs)	15	6.8 (3.8–10.9)	9	4.2 (2.0–7.9)	0.257
Self-medication (street drugs)	28	12.5 (8.5–17.6)	15	7.1 (4.0–11.4)	0.556
Traditional medicine	56	25.1 (19.6–31.3)	18	8.5 (5.1–13.1)	<0.001

The CHWs in the intervention zone received 21 days of training based on the basic health assistance package of integrated community case management (iCCM), using the training module of the Ministry of Health. The trainers were the health district management team together with Action Against Hunger staff. This training included health promotion, infant and young child feeding (IYCF) practices, hygiene practices, family planning, neonatal care, and management of diarrhoea, malaria, and pneumonia. As treatment of acute malnutrition is not considered part of the activities that CHWs in Mauritania must carry out, Action Against Hunger supported the Ministry to do this part and ensure the quality of care. A pre- and post-test was administered to all participating CHWs to ensure that the knowledge had been acquired correctly. During the study, CHWs received periodic supportive supervision by the healthcare-responsible staff from the HF and Action Against Hunger supervisors. Training modules can be found in supplementary materials.

The study took place between November 2018 and July 2019. The inclusion and exclusion criteria defined in the national protocol for the management of acute malnutrition were applied [17]. All children aged 6 to 59 months presented to a HF or to a CHW's site, and/or detected by community volunteers (Relais Communautaires in French) or mobile clinics with mild or moderate oedema (+, ++), a MUAC less than 115 mm, and/or a WHZ less than −3 were included in the analysis. All severe oedema cases (+++), children with other severe medical conditions, or those who failed the appetite test were referred for inpatient treatment [18,19]. Non complicated cases were treated at home. These children received 170 kcal/kg/day of ready to use therapeutic food (RUTF) to be consumed at home. The children were rechecked once a week until they reached one of the program's exit criteria, MUAC > 125 mm, and/or WHZ > 1.5. They also received amoxicillin (50–100 mg/kg/day divided twice a day for five days) and one single dose of 500 mg of mebendazole at the first visit for deworming.

To compare treatment effectiveness between the two zones, outcomes of treated children were examined. The primary outcome was the proportion of cured children, defined by an absence of oedema and WHZ equal to or greater than 1.5 or/and MUAC > 125 mm during two consecutive weeks. Secondary outcomes were the proportion of defaulters defined the child being absent at two follow-up visits and the proportion of nonresponse defined by proportion of children not reached recovery after three months of treatment. Medical referral was considered when severe signs of illness appeared, oedema did not disappear, absence of weight gain in non-oedematous patients for 21 days or weight loss. Disaggregated information was collected from each child from the patient cards. The WHZ value was calculated through WHO Anthro software with the recorded anthropometric data of weight and height [20]. The length of stay in treatment was calculated from the date of admission and the date of discharge. The number of RUTF sachets received during the entire treatment was also recorded.

To assess the possible impact of treatment by CHWs on the treatment coverage, two surveys were conducted in each zone at the baseline (June 2018) and end-line (June 2019) of the study applying the SQUEAC (semi quantitative evaluation of access and coverage) standardized methodology [21]. The statistical analysis was performed with SPSS v.26. The normality of the continuous variables was tested with the Shapiro–Wilk test. Depending on the result, the central parameters were compared with Student's t-test for normal and the Mann–Whitney test for non-normal parameters. The comparison of percentages was made through crossed tables, applying the chi-square statistic with Yates' correction when the expected cases were less than 5 in more than 20% of the cells. The Mantel-Haenszel chi-square test was applied to compare the final treatment coverage adjusted to the baseline coverage data. For the analysis of the treatment outcomes, a Cox regression analysis was performed to obtain the time-adjusted probability (hazard ratio) until the outcome occurred. A 95% confidence level applied in all analyses, considering significant p values below 0.05.

A steering committee was set up in Nouakchott, composed of the responsible staff from the Mauritanian Ministry of Health, academics of Nouakchott University, a team from the Public Health Research Institute, NGOs, and United Nations agencies such as WHO and UNICEF. The objectives of this committee were to rigorously monitor the operational implementation of the project and make recommendations, if necessary, discuss the evolution of indicators related to the research, and ensure that the technical aspects of the research protocol were respected. Informed consent was sought from all participants, both from the socioeconomic and coverage surveys and parents or guardians of children included in the study. The study received approval from the Ethical Committee of the Ministry of Health in Nouakchott, 25 October 2018.

3. Results

The results of the baseline socioeconomic survey are shown in Table 1. Study zones did not differ in demographic variables, acute malnutrition prevalence, or house characteristics, except for the house floor, in which there was a higher proportion of cement floors in the intervention zone (24.5% [18.9–30.9] vs. 7.6% [4.5–11.9] ($p < 0.001$)), showing better conditions. There were also no differences in the main barriers to access to health. However, they differed in terms of treatment preferences for the sick child: the control group resorted more to traditional healers (25.1% vs. 8.5%, $p < 0.001$), while the intervention zone resorted more to formal health structures (80.2% vs. 55.6%, $p < 0.001$).

At the beginning of the study, prevalence of acute malnutrition in children under five was similar in both zones, and there was no difference between coverage of SAM treatment.

In the intervention group 618 children were treated and in the control group 251. Among treated children, there were no differences in sex proportion (females in intervention: 56.5%, $n = 350$; in control: 52.2%, $n = 131$; $p = 0.252$) or age of children included (intervention: 15.7 ± 8.9 months, control: 15.3 ± 8.3 months, $p = 0.631$), with most children under 24 months (intervention: 90.2%, $n = 559$; control: 93.2%, $n = 234$; $p = 0.151$).

Most children in both groups came from active screening in the community without differences between groups (intervention: 59.0% vs. control: 54.4%, $p = 0.211$). Spontaneous referrals (children who arrived directly to the HF or CHWs to receive malnutrition treatment) were higher in the control group (43.2% vs. 33.2%, $p = 0.006$); and passive screening cases (children who arrived at the HF or CHWs, to receive treatment for other disease and was identified as malnourished) were higher in the intervention group (3.8% vs. 0.4%, $p = 0.006$). No differences were found for patients referred from other structures (control: 2.0% vs. 3.9%, $p = 0.151$) or for active screening where most of the cases treated came from (control: 54.4% vs. 59.0%, $p = 0.211$).

No significant differences were found in the proportion of cases with oedema between the control (4 cases) and intervention groups (1 case) (0.4% vs. 0.7%, $p = 0.956$). The CHWs did not register any cases of oedema within the intervention group. Table 2 shows the results regarding anthropometric severity at admission. No significant differences were found between the control and intervention groups for the median values of MUAC or WHZ or the proportion of children in the most severe ranges of both anthropometric indicators. This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

Table 2. Anthropometric measurements at admission by study group.

Study Groups	Control	Intervention	p Value
MUAC indicators	$n = 251$ median (IQR)	$n = 618$ median (IQR)	
MUAC (mm)	112 (115–120)	112 (115–120)	0.478
MUAC quartiles *	% (n)	% (n)	
Q1 < 110 mm	8.4 (21)	9.1 (56)	0.744
Q2 ≥ 110 mm to <115 mm	32.3 (81)	31.7 (196)	0.873
Q3 ≥ 115 mm to <120 mm	24.7 (62)	26.4 (163)	0.610
Q4 ≥ 120 mm	34.7 (87)	32.8 (203)	0.030
Weight-for-Height indicators	$n = 239$ median (IQR)	$n = 601$ median (IQR)	p value
Weight (kg)	6.70 (5.90–7.50)	6.70 (5.95–7.50)	0.854
Height (cm)	72.0 (67.0–77.0)	72.0 (67.5–77.0)	0.374
WHZ	−3.26 (−3.61–−2.80)	−3.31 (−3.84–−2.78)	0.135
WHZ ranges *	% (n)	% (n)	
Q1 < −3.76	20.9 (50)	27.3 (164)	0.056
Q2 ≥ −3.76 to <−3.29	25.5 (61)	24.5 (147)	0.747
Q3 ≥ −3.29 to <−2.78	29.3 (70)	24.1 (145)	0.122
Q4 ≥ −2.78	24.3 (58)	24.1 (145)	0.966

* Quartile values calculated for the whole sample (control + intervention). IQR: Interquartile range; MUAC: Middle-Upper Arm Circumference; WHZ: Weight for Height z-score. WHZ measure was unknown for 12 children in the intervention group and 17 children in the control group.

However, inside the intervention group, children who attended HF to be treated by nurses, showed a significantly lower MUAC than those treated by the CHWs. Additionally, the number of cases with a MUAC lower than 110 mm was five times lower among CHWs (1.9% vs. 10.5%) than in HF (Table 3). The remaining variables showed no significant differences between groups.

Table 3. Anthropometric measurements at admission by treatment provider within the intervention group.

Intervention Group	Health Staff	CHWs	p Value
MUAC indicators	n = 512 median (IQR)	n = 106 median (IQR)	
MUAC (mm)	115 (111–120)	116 (114–120)	0.015
MUAC quartiles *	% (n)	% (n)	
Q1 < 110 mm	10.6 (54)	1.9 (2)	0.005
Q2 ≥ 110 mm to <115 mm	32.0 (164)	30.2 (32)	0.711
Q3 ≥ 115 mm to <120 mm	25.4 (130)	31.1 (33)	0.222
Q4 ≥ 120 mm	32.0 (164)	36.8 (39)	0.623
Weight-for-Height indicators	n = 496 median (IQR)	n = 105 median (IQR)	p value
Weight (kg)	6.70 (5.90–7.48)	6.80 (6.15–7.80)	0.179
Height (cm)	72.0 (67.0–77.0)	75.2 (98.7–78.0)	0.370
WHZ	−3.31 (−3.86–−2.79)	−3.31 (−3.75–−2.63)	0.366
WHZ quartiles *	% (n)	% (n)	
Q1 < −3.76	27.8 (138)	24.8 (26)	0.522
Q2 ≥ −3.76 to <−3.29	24.0 (119)	26.7 (28)	0.565
Q3 ≥ −3.29 to <−2.78	25.4 (126)	18.1 (19)	0.112
Q4 ≥ −2.78	22.8 (113)	30.5 (32)	0.094

* Quartile values calculated for the whole sample. IQR: Interquartile range; MUAC: Middle-Upper Arm Circumference; WHZ: Weight for Height z-score.

Treatment outcomes are summarized in Table 4. Among children seen on admission, treatment outcome was available to 81.1% (705/869). Outcomes were unknown for 42 children (16.7% of total admission) in the control group, and for 122 (19.7%) in the intervention group. No significant differences were found between the control and intervention groups for any of the treatment exit reasons. The proportion of cured, defaulters and deaths in the intervention group met the established international standards of >75%, <15%, and <10% [22]. There were no deaths or children who did not respond to nutritional treatment, indicating good quality of performance. There were no differences in the cured children's anthropometric evolution, with an average weight gain of 4.7 g/kg/day.

Table 4. Treatment outcomes and anthropometric improvement of children compared by study groups.

Whole Sample	Control (n = 209)		Intervention (n = 496)		Comparison
Treatment outcomes	n	%	n	%	**HR (95% C.I.); p value** [2]
Cured	172	82.3	379	76.4	0.967 (0.807–1.159); 0.719
Default	8	3.8	18	3.6	0.915 (0.395–2.121); 0.836
Nonrespondent	0	0	0	0	
Medical reference	20	9.6	67	13.5	1.297 (0.733–2.294); 0.732
Internal transference	9	4.3	32	6.5	1.659 (0.760–3.625); 0.204
Death	0	0	0	0	
Anthropometric gain [1]	n	**Median (IQR)**	n	**Median (IQR)**	p value [3]
Total weight (g/kg)	161	197.2 (157.9–254.3)	356	209.7 (164.6–255.2)	0.283
Daily weight (g/kg/day)	161	4.68 (3.17–7.11)	356	4.73 (3.39–7.35)	0.426
Total MUAC (mm)	168	11.0 (8.0–15.0)	364	13.0 (9.0–16.0)	0.059
Daily MUAC (mm/day)	168	0.27 (0.17–0.41)	363	0.29 (0.20–0.43)	0.139

[1] Considering only those children discharged as cured and excluding oedema cases; [2] Crude coefficients; [3] Mann–Whitney Test; C.I.: Confidence Interval; HR: Hazard Ratio; IQR: Interquartile Range; MUAC: Middle-Upper Arm Circumference. Treatment outcome was unknown for 122 children in the intervention group and 42 children in the control group.

Within the intervention group, the treatment results obtained by the CHWs were analysed comparatively with the health staff in the HF group (Table 5). There were also no significant differences found in the proportion of cured children or defaulters. The proportion of cases that needed to be referred for medical complications was lower with

CHWs, although this difference did not reach statistical significance. A higher proportion of internal transfers, to other HF and/or CHWs site to follow up and finish their treatment, was found in the children treated by CHWs, the difference was statistically significant. There was a more significant gain in total MUAC in patients treated in HF, but that difference disappeared when calculating the average daily gain.

Table 5. Treatment outcomes and anthropometric improvement of children within the intervention group compared by the treatment provider.

Intervention Group	**HEALTH STAFF (n = 418)**		**CHWs (n = 78)**		**Comparison**
Treatment outcomes	n	%	n	%	**HR (95% C.I.); p value** [2]
Cured	319	76.3	60	76.9	1.135 (0.860–1.498); 0.373
Default	16	3.8	2	2.6	0.384 (0.051–2.909); 0.354
Nonrespondent	0	0	0	0	
Medical reference	64	15.3	3	3.8	0.246 (0.060–1.019); 0.053
Internal transference	19	4.5	13	16.7	4.436 (2.146–9.170); <0.001
Death	0	0	0	0	
Anthropometric gain [1]	n	**Median (IQR)**	n	**Median (IQR)**	**p value** [3]
Total weight (g/kg)	298	211.4 (163.9–261.5)	58	196.2 (168.4–232.5)	0.403
Daily weight (g/kg/day)	298	4.63 (3.35–7.54)	58	5.49 (3.76–8.38)	0.056
Total MUAC (mm)	305	13.0 (9.5–17.0)	59	12.0 (7.0–14.0)	0.011
Daily MUAC (mm/day)	305	0.29 (0.19–0.43)	59	0.29 (0.21–0.48)	0.749

[1] Considering only those children discharged as cured and excluding oedema cases; [2] Crude coefficients; [3] Mann–Whitney Test; C.I.: Confidence Interval; HR: Hazard Ratio; IQR: Interquartile Range; MUAC: Middle-Upper Arm Circumference. Treatment outcome was unknown for 28 children treated by CHWs and 94 children treated at the HF level.

Among children discharged as cured, the recovery time was 45 days. No significant differences were found between the control and intervention groups (45.3 vs. 45.8, p = 0.969). Within the intervention group, children treated by the CHWs, recovered more quickly than those children treated at HFs (37.3 vs. 46.2, p = 0.004). The proportion of children in treatment longer than six weeks within the intervention group, was lower in children treated by CHWs comparing with those treated at HF (28.3% vs. 50.9%, p = 0.001). In line with the treatment time, the total consumption of RUTF was significantly lower in children treated by CHWs in the intervention group (93.4 vs. 110.3, p = 0.035).

The results of the treatment coverage surveys are shown in Figure 1. At the beginning of the study, the coverage did not differ significantly between zones. After a year of incorporating CHWs as treatment providers at the community level outside the HF, coverage in the intervention zone increased significantly from 53.6% to 71.7%. In contrast, coverage remained at approximately 44% in the control zone from baseline to end-line which does not reach the 50% established internationally as the minimum standard for treatment coverage in rural areas [22]. This final coverage between the control and intervention groups is statistically significant after adjusting for initial coverage (Mantel-Haenszel Chi-square p = 0.012).

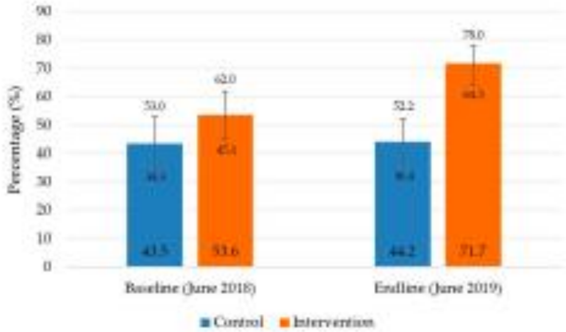

Figure 1. Baseline and end-line coverage assessment of noncomplicated severe acute malnutrition treatment compared by study groups.

4. Discussion

These findings regarding treatment outcomes are consistent with the evidence emerging from several small-scale pilot studies regarding the effectiveness and coverage of CHWs treating SAM. Wilunda et al. in a non-inferior-quasi experimental study in Tanzania, comparing treatment outcomes between CHWs and HFs, showed that CHWs obtained a proportion of cured children of 90.5% and a proportion of defaulters of 6.5% [23] Kozouki et al. working with low literacy CHWs in South Soudan, reached 75% of children cured of SAM [24]. In this present study, we found no significant differences in terms of cured and defaulted proportion in children between the control and intervention group. The results in both groups comply with the international Sphere standard that establishes that the cured proportion should be above 75% and defaulter proportion under 15% of the total of discharged children [22] López Ejeda et al., in a review of operational experience about CHWs, analysed 12 peer-review and eight grey literature articles, where CHWs reached cured and defaulter proportions of children similar to those mentioned above [25].

Data on the effect of treatment of SAM by CHW in coverage were less often reported; only three of these studies included coverage assessments, those located in Bangladesh [26], Angola [27], and Mali [28]. In Bangladesh, the CHW-based intervention achieved 89% coverage, one of the highest coverage rates recorded by an SAM treatment intervention in the scientific literature. In Mali, after one year of project implementation, the intervention group reached 86.7% coverage. In Angola, the coverage was estimated at 82.1% in the areas where CHWs treated acute malnutrition. These results are similar to the present study, where we obtained 71.7% coverage in the intervention group, a massive increase compared with the control group, which observed no significant changes of treatment coverage after one year.

In this study, there was a large difference in number of children treated in the two groups: 618 in the intervention group vs. 251 in the control group, a 146% difference. Total population in the intervention group was 44,885 habitants, and 35,562 habitants in the control group, 26% higher in the intervention group. A difference in incidence between the two zones cannot be excluded, but we have no direct measure of SAM incidence in the two zones, and we have no reason to believe this was the explanation. Pre and post survey in the intervention group suggested a large increase in coverage from 44.2 to 71.7%, a 62% increase. Both pre and post intervention coverages were estimated with large confidence intervals, and a larger increase than the point estimate is plausible. The increase coverage may be the main explanation of the larger number of treated children in the intervention area. This result is consistent with our hypotheses that CHWs can increase coverage of acute malnutrition treatment. Zulu and Perry 2021, in a recent series found that the large-scale involvement of CHWs in the health care system has a huge potential for accelerating universal health coverage and improving population health [29].

We found no significant difference in median MUAC and WHZ between the control and intervention groups on admission. However, when we analysed the CHWs and the HFs separately within the intervention group, there was a significant difference between the median MUAC of 116 mm and 115 mm in the HF group. The percentage of children in the lowest quartile of MUAC (<110 mm) was also lower within the CHWs, 1.9% vs. 10.5% in HF on admission. These results are consistent with the hypothesis of an earlier case detection resulting from the increased coverage of screening. Our results with MUAC are consistent with those found by Lopez-Ejeda et al. in Mali, where children treated by CHWs in the lowest quartile were 18% vs. 32.4% at HF, and the median MUAC at admission was 115 mm compared to 114 mm at HF [30]. No difference was found in our study when considering the WHZ criteria at admission.

The work presented here has some limitations. This study was not a randomized controlled trial (RCTs), and thus, we could not rule out that our results were due, to some extent, to differences among areas independent of our intervention. The follow-up period was short and confounding factors could not be fully regulated. The study area was supported by an international NGO and hence, may reflect performance levels associated with well-supported interventions.

Randomized controlled trials (RCTs) are rightly regarded as the gold standard for clinical decision-making purposes, especially in evaluating new drugs or dosages. However, randomization is often not feasible in the evaluation of public health interventions in low-resource settings. Randomization, without further analyses for adequacy and plausibility, is not sufficient to support public health decision making, regardless of the level of the power of the statistical significance achieved. An intervention that works well in a given setting proved by an RCT may be ineffective elsewhere, presenting a huge challenge to international health recommendations. Proper evidence-based public health intervention must rely on a variety of types of evidence, often in combination [31,32].

5. Conclusions

This study is the first to demonstrate in Mauritania that the decentralization model of CHWs treating SAM improves acute malnutrition treatment coverage and complies with the international quality standards for community treatment of acute malnutrition. Coverage is key in determining the impact of SAM treatment [33,34]. This evidence could be used by political decision-makers as a first step in revising the protocol for acute malnutrition management within primary health care policy. These results are in line with the evidence found in other countries indicating that the integration of SAM treatment into the package of activities of CHWs can effectively contribute to universal health coverage.

Our results open the door to new studies applying other simplified approach protocols [35]. Combining these protocols with decentralized treatment with CHWs would have great potential in emergency contents such as the current COVID-19 pandemic and isolated or insecure areas with limited access to health services.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/children8121132/s1, Training modules files.

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5.4 Impact of Different Levels of Supervision on the Recovery of Severely Malnourished Children Treated by Community Health Workers in Mali

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Impact of Different Levels of Supervision on the Recovery of Severely Malnourished Children Treated by Community Health Workers in Mali

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Abstract: (1) Background: The Ministry of Health in Mali included the treatment of severe acute malnutrition (SAM) into the package of activities of the integrated community case management (iCCM). This paper evaluates the most effective model of supervision for treating SAM using community health workers (CHWs). Methods (2): This study was a prospective non-randomized community intervention trial with two intervention groups and one control group with different levels of supervision. It was conducted in three districts in rural areas of the Kayes Region. In the high supervision group, CHWs received supportive supervision for the iCCM package and nutrition-specific supervision. In the light supervision group, CHWs received supportive supervision based on the iCCM package. The control group had no specific supervision. (3) Results: A total of 8112 children aged 6–59 months with SAM without medical complications were included in the study. The proportion of cured children was 81.4% in those treated by CHWs in the high supervision group, 86.2% in the light supervision group, and 66.9% in the control group. Children treated by the CHWs who received some supervision had better outcomes than those treated by unsupervised CHWs ($p < 0.001$). There was no difference between areas with light and high supervision, although those with high supervision performed better in most of the tasks analyzed. (4) Conclusions: Public policies in low-income countries should be adapted, and their model of supervision of CHWs for SAM treatment in the community should be evaluated.

Keywords: severe acute malnutrition (SAM); community health workers (CHW); integrated community case management (iCCM); supportive supervision; scaling-up interventions

1. Introduction

In Africa, 14 million children suffer from severe acute malnutrition (SAM), a form of malnutrition with an increased risk of death [1,2]. The use of appropriate prevention and management interventions for SAM could prevent 61% of SAM cases and almost 350,000 deaths per year globally [3]. To address these high rates of acute malnutrition, the community management of acute malnutrition (CMAM) approach was developed in the 2000s. This approach involves the timely detection of SAM in the community and outpatient treatment at health facilities (HFs) with ready-to-use therapeutic foods (RUTFs) for cases without medical complications [4]. In most low and middle-income countries, geographic and economic barriers to HF access are responsible for the low coverage of CMAM programs [5].

In Mali, the prevalence of global acute malnutrition, which is defined as a weight-for-height z-score (WHZ) of less than −2 or the presence of edema, is 10% (95% CI: 9.1–11.0), and the prevalence of SAM, which is defined as a WHZ of less than −3 or edema, is 2.0% (95% CI: 1.6–2.4), showing a serious situation. It is estimated that 34% of children's deaths in Mali are related to malnutrition. The annual cost per child with malnutrition is estimated at 265.5 billion of CFA francs, corresponding to 4.06% of the gross domestic product [6].

The World Health Organization (WHO) supports universal health coverage, meaning that all individuals and communities should receive the health services they need without suffering financial hardship. The objective is to double health coverage by 2030 while ensuring the quality of services and cost-effectiveness of interventions [7]. To contribute to this target, WHO has made a strong recommendation to support the integration of community health workers (CHWs) into health systems as human resources that contribute to reducing infant mortality [8]. The results of a systematic review suggest that CHWs reduce inequity in health related to the place of residence, gender, education, and socio-economic status [9].

There is evidence regarding the effect that CHWs within the integrated community case management (iCCM) initiative have on the reduction in infant mortality related to malaria, diarrhea, and respiratory infections and on the treatment coverage of these diseases [10]. Evidence of how these CHWs can treat SAM and their effect on treatment coverage, effectiveness, and mortality is emerging. A review evaluating the effectiveness and coverage of SAM treatment with CHWs concluded that most of the interventions reached a cured ratio of approximately 90% [11]. These results have generally been achieved by small projects supported by non-governmental organizations (NGOs), and there is limited evidence at the regional or national level. Another systematic review of the use of middle-upper arm circumference (MUAC) by frontline workers to detect SAM cases concluded that the use of MUAC by CHWs increases the diagnosis and treatment coverage of SAM [12]. However, there is a need to identify factors that influence the performance of CHWs when scaling up this intervention [13].

In 2014–2016, a pilot study in Mali developed by the Direction de Nutrition of the Ministry of Health (MoH), the "Institut National de Recherche en Santé Publique" of Bamako, Action against Hunger (AAH), and The Innocent Foundation concluded that allowing CHWs to treat SAM reduces the defaulter ratio without compromising treatment outcomes and can lead to improved access to treatment [14]. This study showed that well trained and supervised CHWs are capable of managing cases of uncomplicated SAM and suggested that such a strategy could increase access to the quality of treatment in the country [15]. The intervention is cost-effective, and households receiving CHW-delivered care spent nearly half the amount of time and three times less money than those with SAM treatment received at an HF [16]. With this evidence, in 2015, the MoH of Mali included the treatment of SAM as part of the package of activities to be implemented by CHWs in his policy "Soins Essentiels dans la Communauté, Guide National de la Mise en Oeuvre" [17].

There is little evidence on the best approach to train and supervise CHWs in large-scale treatment programs integrated with other health activities. The objective of this research was to define the most effective level of supervision when scaling up SAM treatment using CHWs in Mali.

2. Materials and Methods

This was a prospective non-randomized community intervention trial with two intervention groups and one control group that compared the outcomes obtained with community treatment of SAM children under different levels of supervision.

2.1. Settings

This study was conducted from October 2017 to October 2018 in Mali in 3 different districts of the Kayes Region, including all the HFs and CHWs placed in those areas: Kita (50 HFs and 90 CHWs), Kayes (49 HFs and 45 CHWs), and Bafoulabé (21 HFs and 34 CHWs). Figure 1 summarizes all the study stages (A to I), highlighting activities that have been carried out differently in each of the three study groups. These activities are described in more detail below, indicating each case, which stage of Figure 1 corresponds to each activity.

	Kita (High Supervision)	**Kayes (Light Supervision)**	**Bafoulabé (no Supportive Supervision)**
Baseline	A	A	A
	B	B	B
Implementation	C	C	C
	D E	D	
Data analyse and field coordination	F	F	
	G	G	
Validation data and study coordination	H	H	H
	I	I	I

A	**Socio Economic Survey**
B	Training of trainers, nurses of health facilities (HF) and training of community health workers (CHWs) during 21 days in all the package of integrated case community management (iCCM). The training module of the Ministry of Health was used. CHW developed an internship post training at health facilities during 6 consecutive weeks.
C	Recruitment and treatment of children diagnosed as severe acute malnourished without medical complications.
D	Monthly supervision of the CHWs on all the iCCM package by supervisors of Action against Hunger together with the Center's Technical Director (DTC) from the MoH with the supervision checklist from the iCCM Policy in the country.
E	Monthly specific nutrition supervision of the CHWs by doctors from Action against Hunger (AAH) with the supervision checklist from the community management acute malnutrition (CMAM) policy of the country.
F	Monthly meeting at health area level involving staff from the HF, CHWs, and AAH supervisors, to follow up and analyze data, evaluate the need for ready to use therapeutic food (RUTF).
G	Monthly meeting at a district level involving the focal point of the Ministry of Health and physicians of AAH, to analyze and validate data.
H	Technical committee meetings responsible for providing expertise and advice on technical issues, tools, and materials (three meetings during the recruitment period).
I	Steering committee meetings responsible of validation of the protocol, action plan, and results of the study.

Figure 1. Intervention, monitoring, and supervision activities in the three groups of the study.

A socio-economic cross-sectional survey was implemented before the intervention in September–October 2017 in all 3 areas to check their comparability (Figure 1A). The survey was administered to 1350 randomly selected households with a two-stage cluster sampling design: In the first stage, 30 villages were randomly selected in each of the 3 intervention groups, and in the second stage, 15 households were randomly selected within each village. Empty households, households without children, or households with children absent were not replaced. The head of the household or mother of the children was interviewed after their informed consent was obtained.

The baseline survey had different parts: (1) general information, such as date, name of the village, name of the health area, and household characteristics (e.g., family size, members by sex and age, and number of children under five); (2) living conditions, sanitation and hygiene infrastructure, and construction material of the house, socio-economic status, and the sources of income; (3) complementary feeding practices and calculation of the food consumption score (FCS) using the frequency of consumption of different food groups consumed by a household during the 7 days before the survey according to the World Food Programme guidelines [18]. This index considers the frequency of consumption of 9 food groups, each with a specific associated weight according to its nutritional importance. Poor diet diversification is defined by a score of 21 or less; (4) type of healthcare usually provided for children and the behavior of mothers/caregivers when the children are sick (presentation to a HF, traditional medicine, or self-medication); and (5) prevalence of acute malnutrition in children under the age of five diagnosed with a low MUAC.

2.2. Intervention

At the beginning of the study, all CHWs in each of the 3 groups received 21 days of training based on the package of iCCM using the training module of the MoH. The trainers were the health district management team together with AAH staff. This training included health promotion, infant and young child feeding (IYCF) practices, hygiene practices, family planning, neonatal care and management of diarrhea, malaria, pneumonia, and acute malnutrition. A pre and post-test was administered to all participants to ensure that the knowledge had been acquired correctly. As the time allocated to SAM, treatment in the training module seemed insufficient to ensure the quality of care, the study included a post-training internship for the CHWs at the HF level in the 3 study groups once a week for 6 consecutive weeks on the day of management of acute malnutrition at the HF. The objective of this internship was to reinforce the implementation of the appetite test, assessment of admissions and discharge criteria, and referral of children with complica-tions to inpatient care. Information related to socio-demographic characteristics was col-lected for all the CHWs during the training (Figure 1B).

2.3. SAM Management

All children who were 6–59 months old, presented to a HF or to a CHW's site, and were diagnosed as having uncomplicated SAM were eligible for the study. Children identified at the community level as having SAM received treatment directly from the CHWs without being referred to a HF. The treatment of children with SAM by CHWs was progressively introduced during the first 3 months of the study, as CHWs were participating in the internship training at the HF level at the beginning of the study in November and December 2017.

Admission criteria to the program followed Mali's National CMAM protocol: MUAC < 115 mm and/or WHZ < −3 based on the WHO growth standard and/or bilateral edema were used at HFs, but only MUAC and bilateral oedema were used at the CHW level [19]. In all 3 groups, clinical outcomes were evaluated. Curation was defined as a child with a WHZ ≥ -1.5 or MUAC $\geq$ 125 mm and absence of nutritional oedema during two consecutives visits. A defaulter case was defined as a child who missed two consecutive follow-up visits (14 days); a referred case was a case transferred to an inpatient care facility for treatment due to complications; and death referred to children who died during treatment.

Children with SAM received a weekly ration of RUTF of 170 kcal/kg/day until recovery. They also received systemic treatment with amoxicillin (50–100 mg/kg/day twice a day for five days) and one single dose of 500 mg of mebendazole at the first visit for deworming (Figure 1C).

2.4. *Supervision of the Management of SAM in Different Districts*

In the 3 study groups, the country's CMAM and iCCM protocol was applied with different levels of supportive supervision. The control group was the district of Bafoulabé, where SAM treatment was delivered at the HF and CHW levels with the expected supervision recommended by the MoH but without any support from the AAH. In the Kayes district, light supervision was applied for which the AAH supervised the iCCM component of the program more closely. In the Kita district, high supervision was applied for which in addition to the close supervision of the iCCM activities, the CHWs also received monthly nutrition-specific supervision, and both were supported by the AAH.

The supervision period was from February 2017 to October 2018. Supportive supervision was planned to occur on a monthly basis and focused on identifying and solving problems and strengthening the health system from the community and included all the packages of the iCCM activities. As part of the supervision, the center's technical director (DTC) had to complete a checklist and a booklet to assess the implementation of the recommendations made at each visit [17]. The checklist used in the iCCM activity supervision applied to the Kita and Kayes districts had 5 sets of questions: (1) clinical examination of the sick child with 13 different items collected; (2) newborn monitoring with 12 items; (3) family planning with 4 items; (4) IYCF with 3 items; and (5) hygiene and sanitation with 7 items (Figure 1D). The complete checklist is shown in the Supplementary Material A.

In the Kita district, extra nutrition-specific supervision was implemented to assess the quality of care and performance provided by the CHWs, to identify training needs, to check the maintenance of equipment, to assess input and storage management, to check data collection and the quality of statistics, to assess the care of beneficiaries, and to identify implementation problems of SAM management. The checklist used during the nutrition-specific supervision applied in the Kita district was the same as the list included in the national CMAM protocol normally applied at HFs. This checklist has 8 set of questions: (1) Anthropometric and medical equipment; (2) Identification of danger signs; (3) Systematic screening; (4) Admission and discharge criteria application; (5) Appetite test performance; (6) Nutritional treatment; (7) Systematic medical treatment; and (8) IYCF promotion (Figure 1E). The complete checklist is shown in the Supplementary Material A.

For each question, the performance of the CHW was classified as "passed" (1 point) or "failed" (0 points). The total score obtained from the sum of all the questions included in each set was recalculated over a maximum score of 10 points so that each set of questions could be scored between 0 and 10. A high quality of performance was considered when the total score was equal to or greater than 8 points.

2.5. *Follow-Up and Monitoring Intervention Framework*

Monthly meetings were held at the health area and district level with staff from the MoH (DTC of HF, CHWs, and nutrition focal point) and Action against Hunger's staff (supervisors and physicians). The objective of these meetings were data monitoring and validation (Figure 1F,G). Two committees were set up at the beginning of the study. A technical committee responsible for providing expertise and advice on technical issues, tools, and materials and steering committee responsible of validation of the research protocol, approve the achievements and ensure compliance with the project's strategic focus. Both committees were under the leadership of the MoH. They had a meeting every three months (Figure 1H,I).

2.6. *Data Collection and Analyses*

All the information was collected by AAH supervisors using the Open Data Kit or Microsoft Excel spreadsheets® [20]. Disaggregated data from the admission and discharge of each child were collected from the registers of each HF or CHW's site. In the two intervention groups of Kita and Kayes, the five sets of variables related to iCCM activities described above were collected during supervision on a monthly basis from direct observation of CHW performance using the iCCM checklist of the MoH. In the high supervision group of Kita, the 8 sets of variables related to nutrition activities described above were collected during the supervision every month using the checklist of the MoH for CMAM programs. For data analyses, the Kolmogorov–Smirnov test with Lilliefors correction was used to assess the normal distribution of continuous variables. A t-test or Mann–Whitney test was used to compare means or medians when appropriate. To compare discharge outcomes, chi-square tests were applied considering Yates's correction when the minimum expected count for a category was five cases or fewer. All statistical analyses were performed with IBM®SPSS v.25 software.

2.7. Outcomes

The primary outcome of the study was the proportion of cured children in each district among those admitted with SAM at the HF or CHW level. Secondary outcomes were the proportion of defaulters, deaths, and references with complications and the quality of care provided by the CHWs during the iCCM supportive supervision and nutrition-specific supervision.

2.8. Ethical Approval

The study was approved by the Ethical Committee in Bamako (decision N° 13/2017CE-INRSP). All the participants (mothers and children caregivers) were asked to sign a formal consent form before starting participation in the project. The study was registered in ISRCTN registry https://doi.org/10.1186/ISRCTN14990746.

3. Results

3.1. Baseline Characteristics of the 3 Study Areas

Out of the 1350 selected households, 130 were not included in the survey due to the absence of children in the household or an empty household. Information was collected from a total of 1220 houses: 412 in Kita, 407 in Kayes, and 401 in Bafoulabé. The main results of the survey are shown in Table 1. The areas were similar in terms of the number of children under the age of five in the families, children with acute malnutrition, and children with access to healthcare services. Some significant differences were found in living conditions, with a higher number of people having access to clean water, sand floor houses, and thatched-roof houses in Bafoulabé. By the other hand, this group is the one with poor dietary diversity. Regarding health care provision for sick children, no significant difference was found between the three groups.

Table 1. Baseline socio-economic characteristics in the three study groups.

Socio-Economic Item	Kita (High Supervision)	Kayes (Light Supervision)	Bafoulabé (No Supplemental Supervision)	p-Value
Number of Surveyed Households	412	407	401	
Demographics				
Sex of survey respondents (M/F)	[illegible]	[illegible]	[illegible]	
Age of survey respondents (Mean ± SD)	[illegible]	[illegible]	[illegible]	[illegible]
Number of children under 5 years of age per household (Mean ± SD)	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Living Conditions				
Latrine available	[illegible]	[illegible]	[illegible]	[illegible]
Clean water available	[illegible]	[illegible]	[illegible]	[illegible]
Sand floor houses	[illegible]	[illegible]	[illegible]	[illegible]
Thatched roof houses	[illegible]	[illegible]	[illegible]	[illegible]
Socio-Economic Status				
Food consumption score (Mean ± SD)	[illegible]	[illegible]	[illegible]	[illegible]
Poor dietary diversity	[illegible]	[illegible]	[illegible]	[illegible]
Health Care Provision for the Sick Child				
Health center	[illegible]	[illegible]	[illegible]	[illegible]
Traditional medicine	[illegible]	[illegible]	[illegible]	
None	[illegible]	[illegible]	[illegible]	

F: female; M: male; MUAC: middle-upper arm circumference; NS: non-significant result; SD: standard deviation.

The socio-demographic profile of the CHWs involved in the study is shown in Table 2. The level of school attendance was lower in Bafoulabé's CHWs than in those from Kita and Kayes. More CHWs had more than 2 years of experience working as CHWs in Bafoulabé than in Kita and Kayes. Regarding the population covered in the catchment area, 13.3% of CHWs in the Kita group covered a population under 700 habitats, compared with Bafoulabé, where almost half of the CHWs, 41.1%, cover a population of 700 people. On the other hand, Kita's group has a higher number of CHWs, 45%, who covered over 1500 inhabitants compared with the other two groups. CHWs in Bafoulabé and Kita were located further away from the HFs.

Table 2. Baseline demographic profile of the community health workers in the 3 study groups.

Demographic Item	Kita (High Supervision)	Kayes (Light Supervision)	Bafoulabé (No Supportive Supervision)
Number	90	45	34
Sex (M/F)	0.34	0.73	1.61
Years of Schooling			
9 years	6 (6.6%)	8 (17.7%)	18 (52.9%)
10–11 years	79 (87.7%)	31 (68.8%)	12 (35.2%)
12–13 years	5 (5.6%)	6 (13.4%)	4 (11.9%)
Average Number of Years Working As Chws			
<1 year	20 (22.2%)	8 (17.8%)	3 (8.8%)
2–4 years	14 (15.5%)	4 (8.9%)	6 (17.6%)
>4 years	56 (62.2%)	33 (73.3%)	25 (73.5%)
Population Covered in The Catchment Area by Chws			
Mean ± SD	1374.0 ± 665.4	1170.8 ± 499.1	1200.7 ± 747.3
<700 hab	12 (13.3%)	8 (17.7%)	14 (41. 1%)
700–1500 hab	37 (41.1%)	25 (55.6%)	15 (44.1%)
>1500 hab	41 (45%)	12 (26.7%)	5 (14.7%)
Distance to the Health Facility			
Mean ± SD	29.6 ± 17.8	28.6 ± 17.7	31.4 ± 15.0
<5 km	1 (1.1%)	0 (0%)	0 (0%)
5–15 km	15 (16.8%)	12 (26.6%)	4 (11.7%)
16–30 km	37 (41.5%)	16 (35.5%)	15 (44.1%)
31–45 km	22 (24.7%)	15 (33.3%)	6 (17.6%)
>45 km	15 (15.7%)	2 (4.4%)	9 (26.4%)

CHWs: community health workers; F: female; hab: habitants; M: male; SD: standard deviation.

3.2. *Outcome of Treatment in the Study Areas*

The results on the effectiveness of SAM treatment are shown in Table 3. A total of 3320 children with uncomplicated SAM received outpatient treatment at the health structures in the Kita district (527 treated by CHWs and 2793 at HFs); 1930 children, at the health structures of Kayes (350 CHWs and 1580 HFs); and 862, in Bafoulabé (313 CHWs and 549 HFs).

Table 3. Outcomes of severe acute malnutrition treatment of children aged 6 to 59 months compared by study group and treatment providers.

Treatment Outcomes	All Districts %, (95% CI)	KITA High Supervision, %, (95% CI)	KAYES Light Supervision, %, (95% CI)	BAFOULABE No Supported Supervision, %, (95% CI)	Comparison Between Districts * (p Value)
Cured	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CHWs	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Health facilities	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Provider comparison (p value)	[illegible]	[illegible]	[illegible]	[illegible]	
Defaulted	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CHWs	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Health facilities	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Provider comparison (p value)	[illegible]	[illegible]	[illegible]	[illegible]	
Transferred	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CHWs	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Health facilities	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Provider comparison (p value)	[illegible]	[illegible]	[illegible]	[illegible]	
Death	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CHWs	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Health facilities	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Provider comparison (p value)	[illegible]	[illegible]	[illegible]	[illegible]	

CHWs: community health workers; CI: confidence interval. * Comparison between districts: [a] Kita vs. Kayes; [b] Kita vs. Bafoulabé; [c] Kayes vs. Bafoulabé.

The proportion of cured children was 81.4% in Kita, 86.2% Kayes, and 66.9% in Bafoulabé. The group without supported supervision, Bafoulabé, had a significantly lower proportion of cured children than the other groups. The Kayes district, the group that did not receive an extra nutrition-specific supervision, had the highest proportion of cured children. Bafoulabé is the only district that has not reached the Sphere Standard for humanitarian interventions set in 75% of children cured. The cure rates obtained by the CHWs in Kita district are significantly lower than those of the HFs despite having received nutrition-specific supervision, while no differences are found in Kayes' district. In the case of Bafoulabé, the CHWs obtain even higher cure rates than the health personnel in formal health structures.

The proportion of defaulters was 6.4% in Kita, 1.8% in Kayes, and 15.3% in Bafoulabé with a non-significant difference between care providers in Kita but with better results with the CHWs in Kayes. In Bafoulabé, when we analyze the difference between care providers, CHWs had a defaulter ratio of 6.4% compared to 20.4% in the HF. When the three groups were pooled together, the defaulter ratio was 6.1%, with no significant difference between care providers.

The proportion of children transferred was 11.7%, 11.9%, and 16.9% in Kita, Kayes, and Bafoulabé, respectively. These figures include both those who developed a medical complication and those who did not properly respond to nutritional treatment, showing a reduction or stagnation in weight or the MUAC gain. The proportion of transferred children was significantly higher in Bafoulabé than in the other two districts. In Kayes, the proportion of transferred children was significantly lower with the CHWs, but the opposite was found for Kita and Bafoulabé, where it was significantly higher with the CHWs than with the HFs. The proportion of deaths was 0.4%, 0.1%, and 0.8% in Kita, Kayes, and Bafoulabé, respectively. Non-significant differences between care providers were found.

3.3. Supervision and Performance Scores of the CHWs

3.3.1. iCCM Activities

There were no differences between the average number of supervisions for iCCM activities received by the CHWs of the Kita and Kayes districts (5.2 ± 1.8 vs. 4.6 ± 2.3, respectively, $p = 0.105$). However, in the high supervision area of Kita, there was a higher proportion of CHWs who received more than 5 supervisions during the nine months of the study from February to October 2018 (68.6% vs. 44.4% in Kita; $p = 0.007$). In contrast, in the district of Bafoulabé, which was not supported by the AAH, only 1 out of 35 CHWs was supervised during that period.

The results on the quality assessment of the CHWs' performance on the iCCM activities in Kita and Kayes during the supervision are shown in Table 4. The CHWs from Kita had a significantly higher score for most of the tasks assessed for clinical examination of the sick child. Regarding nutrition items is remarkable: danger signs assessment CHWs in Kita have achieved a score of 9.85, evaluation of weight 9.57, temperature 9.87, measurement of the MUAC 9.59, breath movement assessment 9.64, use of the rapid diagnostic test for malaria 9.56, and correct triage they achieved a score of 9.58. However, most scores achieved by the CHWs of both groups were above 8 points for a maximum of 10.

Table 4. Average score obtained by the community health workers in the Kita and Kayes study groups for iCCM supervision of curative and preventive tasks from a maximum of 10 points.

iCCM Items	KITA (High Supervision) Mean ± SD	KAYES (Light Supervision) Mean ± SD	p Value
Clinical Examination of The Sick Child	9.33 ± 1.00	8.81 ± 1.37	<0.001
Newborn Monitoring	8.25 ± 2.22	8.13 ± 1.66	0.708 [NS]
Family Planning	8.78 ± 1.96	8.28 ± 2.15	0.009
IYCF Promotion	6.20 ± 3.60	7.18 ± 3.02	0.003
Hygiene and Sanitation Promotion	8.67 ± 1.21	7.67 ± 1.81	<0.001

iCCM: integrated community case management; IYCF: infant and young child feeding; [NS]: non-significant result; SD: standard deviation.

In contrast, in the set of items related to IYCF, which was part of the iCCM package, the mean score was 6.20 in Kita and 7.18 in Kayes, and only 44.7% and 55.1% of CHWs in Kita and Kayes, respectively, obtaining a score of 8 or above. Detailed results by item can be found in Supplementary Material B.

3.3.2. Nutrition Activities

As mentioned previously, nutrition supervision was only implemented for the CHWs from the Kita district under high supervision. On average, each CHW was supervised 5.4 ± 1.9 times for the nutrition-specific activities during the nine-month supervision period. The average score obtained was over 8 points in all the sets of questions analyzed, except for the IYCF activities, where the obtained average score was 4.9 for a maximum of 10. The detailed results by item can be found in the Supplementary Material B.

At the end of the study in October 2018, 100% of CHWs systematically screened all children for concomitant diseases, properly performed the appetite test, and correctly identified the danger signs. Oedema was correctly assessed by 98.9% of CHWs; 98.8% made a good identification of SAM children with colored MUAC tape; 98.4% correctly applied the admission and discharge criteria; 87.3% gave the needed systematic treatment; and 96.8% gave RUTF according to the national protocols. In contrast, the lowest score was achieved for IYCF promotion, and only 56.7% of CHWs provided nutritional counseling to pregnant women.

3.3.3. Relationship between Supervision Activities and Treatment Outcomes

The association between the number of supervisions received by the CHWs and their quality of performance with the proportion of children cured after being treated for uncomplicated SAM is shown in Table 5. No significant difference was found between CHWs who received supervision above or below the median of 5 supervisions for the iCCM or nutrition-specific supervisions. The mean quality of performance score was obtained for all the CHWs, and the proportion of children cured in those reaching a score under and above the median was compared. Likewise, no significant difference was found for the iCCM or nutrition-specific supervisions. However, the median score was very high in both cases, with values above 9 over a maximum of 10.

Table 5. Outcomes of treatment provided by the community health workers of Kita and Kayes compared by the number of supervisions received for iCCM tasks and nutrition-specific tasks and the score obtained for those supervisions.

iCCM Supervision (Kita and Kayes Districts)			
Number of supervisions received (N = 100)	Less than 5 supervisions * (N = 34)	More than 5 supervisions * (N = 66)	Comparison
Cured % (IQR)	87.5 (66.7–100.0)	91.4 (66.7–100.0)	p = 0.064 [NS]
Score obtained in the clinical examination of the sick child (N = 93)	Less than 9.35 points * (N = 48)	9.35 points or more * (N = 45)	Comparison
Cured % (IQR)	85.7 (66.7–100.0)	100.0 (66.7–100.0)	p = 0.520 [NS]
Nutrition Supervision (Kita District)			
Number of supervisions received (N = 61)	Less than 5 supervisions * (N = 13)	5 supervisions or more * (N = 48)	Comparison
Cured % (IQR)	90.0 (56.3–100.0)	85.7 (66.7–100.0)	p = 0.884 [NS]
Score obtained in the nutrition supervision (N = 61)	Less than 9.22 points * (N = 29)	9.22 points or more * (N = 31)	Comparison
Cured % (IQR)	83.3 (63.1–100.0)	83.3 (66.7–100.0)	p = 0.331 [NS]

iCCM: integrated community case management; IQR: inter-quartile range; [NS]: non-significant result; * In the iCCM supervision, the p50 of supervision was 5 and the p50 of the score obtained during the supervision was 9.35 points of 10. In the nutrition-specific supervision, the p50 of supervision was 5, and the p50 of the score obtained during the supervision was 9.22 points of 10.

The detailed results of the univariate linear regression analysis are shown in the Supplementary Material C. None of the variables on the number of supervisions received or the quality of performance achieved in either the iCCM or nutrition-specific supervisions showed a statistically significant association with the percentage of children cured after treatment.

4. Discussion

This study examined the effects of different levels of supervision when decentralized treatment of SAM was scaled up at a regional or national level. It showed that supportive supervision resulted in improved outcomes compared with a non-supervised model, but there was no difference between areas with light and high supervision. The two groups with supervision met the Sphere standards. They obtained a cured ratio over 75% and a defaulter ratio less than 15%; in contrast to CHWs in the control group, the three groups obtained a mortality ratio less than 10% [21]. The performance of CHWs was higher in the high supervision district, but there was no relationship between the scores obtained from the tests and treatment outcomes.

To the best of our knowledge, this is the first study examining the effect of the level of supervision of CHWs delivering SAM treatment in a project being scaled up. Previous pilot studies have evaluated the effects of supportive supervision on clinical outcomes in reduced groups of CHWs but not in large scale projects. In general, these pilot studies suggested a positive impact of supervision on the performance of CHWs. Lazzerini et al. found that supportive supervision of CHWs significantly increased the number of children enrolled in the nutritional programs in Uganda [22]. In Ethiopia, the score obtained for service delivered by CHWs who received monthly supervision was higher than in the control group [23]. A study conducted in South Africa concluded that CHWs neglected the treatment of SAM without complications due to the lack of supportive supervision [24]. The synthesis of qualitative and quantitative assessment at the community level suggested that the lack of supervision was a challenge in the performance of CHWs in Madagascar [25]. In a systematic review, Ballard et al. identified supervision as a key intervention that is likely to improve the performance of CHWs in different health interventions not including the management of malnutrition [26].

Our results show a lack of impact of the level of supervision on treatment outcomes, which is consistent with the results of two reviews of non-nutritional programs, suggesting that the intensity of supervision had no major impact on the performance of CHWs. In a review of the impact of supervising CHWs in low-income countries, Zill et al. concluded that increasing the frequency of supervision did not necessarily lead to increased effectiveness, and the quality of supervision could play a more important role in the impact of this type of intervention [27]. In a systematic review about primary healthcare supervision, Bosch-Capablanch et al. also suggested that reducing the frequency of supervision could save costs, reducing supervisor salaries and travel cost, without a detrimental effect on performance [28]. However, another systematic review of the factors that affect the performance of CHWs showed that supervision increases the credibility and trust of families [29].

The lack of impact of extra monthly nutrition-specific supervision on the recovery of malnourished children could be explained by different factors. We suspect that many of the questions included in the evaluation grids were not adapted to the specific problems faced by CHWs, which are different from those faced by the health staff at HF-like structures, the organization of the space, reception and flow of patients, and staff responsibilities. Some items, such as the identification of danger signs during clinical examination, stock, and monitoring tools were already included in the supervision of the iCCM activities and may have had no additional impact on the outcomes as initially expected.

Our study did not analyze other actions performed during supportive supervision that could have had a positive effect on the performance of CHWs, such as the resolution of problems between the supervisor and the CHWs or the avoidance of problems with the supply of RUTF and systematic treatment. Furthermore, our study did not examine the effects of the salaries of CHWs. A systematic review by Rowe et al. suggests that economic incentives or integration within the formal health system may have an effect when several of these interventions are performed simultaneously.

To our knowledge, Mali is the first country in West Africa to make progress in scaling up SAM treatment with CHWs at the national level. Our results highlight the need to evaluate each component of a health and nutrition intervention, particularly, the supervision level. The technical committee of the project lead by the Directorate of Nutrition of the MoH and formed by representatives of the Regional and District Directorate of the MoH, the Regional Federation of Community Associations (FERASCOM), the World Food Programme, UNICEF, and other NGOs in addition to the AAH has made some recommendations based on the results of this study: (i) adaptation of the iCCM training module, including 2 days for acute malnutrition and the addition of a post-training internship at the health facility level; (ii) integration of nutrition supervision within the iCCM supervision activities and adaptation of the CMAM protocol supervision checklist at the CHW level; (iii) adaptation of the DTC supervision frequency of the CHWs so that the first 3 months when SAM treatment is integrated into the package of iCCM, CHWs will be supervised on a monthly basis and bimonthly supervision thereafter according to the performance and needs of the CHWs; and (iv) increase in the energy of coordination meetings at all levels of implementation (regional, district, health area, and village) with community leaders and community groups.

The work presented here has some limitations. This study was not a randomized control trial, and thus we could not rule out that our results were due to some extent to differences among districts independent of our intervention, as suggested by the survey of background socio-economic factors. The CHWs in the 3 districts started progressively treating children with SAM, depending on the availability of equipment. Therefore, the analysis we presented does not reflect the work of the 169 CHWs during the entire 10 months of the study, and some supervision checklists had missing data, which may limit our conclusions. The RUTF supply was ensured by the AAH, and no stock-out was registered, which means that these results may not be applicable in settings with RUTF stock-outs.

5. Conclusions

This study is the first to demonstrate in West Africa that supportive supervision of CHWs improves acute malnutrition treatment outcomes. Our results suggest that the decentralized service delivery model with CHWs may be one of the key solutions for policy makers to tackle malnutrition in Mali. We recommend following a supportive supervision model, including items related to the SAM management within the country's existing CHW monitoring sheet, to carry out single joint supervision of all their activities. Likewise, it is advisable to follow up more closely on the service's implementation set-up, but it could be spaced out to a bi-monthly follow-up after confirming that the treatment is being given with quality. Along with the supervision system, policymakers should ensure the supply chain of RUTF, the salary or motivation of the CHWs, and the health information system at the community level to make the decentralized SAM treatment a sustainable intervention. These policy makers, following the recommendations drawn from the study, can scale up treatment with CHWs in other regions of the country. Along with this intervention, the country should continue the analyses regarding how to ensure the chain supply chain and the health information system at the community level; and how these CHWs need to have their salary and motivation to make their work a sustainable intervention.

Supplementary Materials: The following are available online at https://www.mdpi.com/2072-6643/13/2/367/s1, Supplementary A: Table A-1—Checklist for the supervision of iCCM activities; Table A-2—Checklist for the nutrition-specific supervision. Supplementary B: Table B-1—Average score from a maximum of 10 obtained by the community health workers in Kita and Kayes districts for the curative and preventive tasks assessed on the iCCM supervisions from January to October 2018; Table B-2—Average score obtained by the community health workers on the nutrition-specific supervisions in Kita district from January to October 2018. Supplementary C: Table C-1—Univariate linear regression analysis to assess the influence of the number of supervisions received by the community health workers and their quality of performance on the proportion of children discharge as cured; Table C-2—Univariate logistic regression analysis to assess the influence of the number of supervisions received by the community health workers and their quality of performance on the probability of reaching 75% of cured children which is the minimum stablished by the SPHERE Standards in disaster response (https://spherestandards.org/humanitarian-standards/).

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Informed Consent Statement: Written Informed consent was obtained from all subjects/patients involved in the study.

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6.DISCUSSION

6 DISCUSSION

6.1 Can community health workers manage uncomplicated severe acute malnutrition? A review of operational experiences in delivering severe acute malnutrition treatment through community health platforms

The evidence regarding the decentralized treatment of SAM with CHWs is emerging. In most of the published articles, the intervention has been carried out in specific health zones within pilot projects, and they were supported by international NGOs. Ethiopia is the only MoH that has implemented SAM treatment with CHWs at scale in the whole country. The review of operational experiences has identified key actions for the success of the CHW approach, among them the training and supervision of human resources have been mentioned in all the studies reviewed. The discussion has analyzed several key factors of this intervention: RUTF chain supply, salaries, motivation, literacy of CHWs, policy and coordination between decisions makers.

6.1.1 RUTF chain supply

One of the major challenges of the intervention is the integration of RUTF into the country's supply chain so that it can be made available at the community level. The current iCCM protocol includes the use of antibiotics, zinc, and antimalarial drugs by CHWs. For the management of SAM cases, albendazole/mebendazole and RUTF need to be added to these drugs (83). During the last years, there has been an increase in the demand of RUTF. UNICEF is the main provider of RUTF (84). In the cost-effectiveness studies developed in Bangladesh and Mali, RUTF was 24% and 13% of the total budget respectively (85), (86). A synthesis from lessons of MoH experiences of scaling-up the CMAM approach concludes that RUTF represents about half of the total cost of SAM treatment (87), (88).

Along with the high costs of RUTF, stock-outs have been reported in different studies as one of the most important barriers to the treatment of SAM in the communities (64). Except in India, procurement of RUTF was done from referral HFs. Keane *et al* in South Soudan showed how RUTF stock-outs hurt community perception and confidence to seek treatment (89). In Angola, local transport support was necessary to ensure the arrival of RUTF to the CHWs' place of work (44).

6.1.2 Salaries and motivation

The salary/motivation of CHWs has long been discussed as one of the key factors for scaling up the intervention, which we need to take into consideration if we want to integrate SAM treatment into the package of iCCM activities (45), (90), (91). Lady health workers in Pakistan used to receive a financial motivation for the new activities and campaigns that they develop in the community, and this was not the case in the study. Rogers *et al.* identified the lack of this financial motivation as one of the reasons for the poor performance of SAM treatment (92). The workload of CHWs in Bangladesh increased when SAM treatment was included in their activities but maintained quality of care of curative and preventive services. Effectively treating children with SAM appeared to increase their motivation (93). Similar results were evident in studies where CHWs treated only SAM. The Angola study was designed at the beginning with CHWs receiving in-kind incentives, but it was necessary later on to switch to a financial motivation to maintain CHWs' commitment to treating malnutrition (44). In South Soudan, financial motivation was necessary to be able to monitor treatment and have a high quality of reporting (89).

Some studies have shown other types of motivation beyond financial remuneration. Capacity-building, training and supervision promote CHWs' self-esteem and sense of being part of a system outside their communities (94). The first CHWs who were trained in curative tasks and not only health promotion activities had a feeling of acceptance and social recognition by their community (87). In the Bangladesh study, CHWs who had been trained in SAM treatment felt a greater sense of competence in seeing children cured of the disease, while untrained CHWs felt frustrated for not covering the children in need (93).

Other actions, such as providing equipment in the workplace as well as identifying material, can generate a sense of pride in the CHWs and is a source of motivation to improve the quality of their work (95). Thus, in the South Sudan study, drinking water kits, soap, medicine boxes, and impregnated mosquito nets were distributed, which at the same time served to showcase and promote good practice and behavior in the community (89).

In Mali, key element of the success for CHWs was a minimum training of 2 years, and a salary from the MoH, and a 5 years' experience of working in their communities, which gave them recognition and acceptance in their villages (43), (96).

6.1.3 Literacy and information management

The review has shown how different levels of literacy influence the monitoring and follow-up of the iCCM intervention. In this sense, new technologies are an opportunity to improve the quality and reduce the costs associated with data collection (97), (98).

Literacy was identified as a key issue for the scaling up of SAM treatment with CHWs. In countries as Mali, South Soudan, or Chad, new tools and protocols were developed and adapted to be used by low literacy CHWs. They are mainly based on the use of a single anthropometric method of diagnosis through a 5 coloured MUAC, as well as adapted scales that allow the calculation of the correct quantity of RUTF (99).

6.1.4 Policies and protocols

There is a need to adapt national protocols and policies, to include SAM treatment into the package of iCCM activities. Angola needs to adapt its policy to allow the use of antibiotics by CHWs and to simplify the national protocol. In the case of Ethiopia, the only country that has successfully scaled-up the treatment of SAM within the extended health program, it has been suggested that to truly integrate the treatment of malnutrition, it is necessary to reduce the costs associated with RUTF (100). In Myanmar, a reduced dosage of RUTF to treat more than 3,000 children resulted in a proportion of cured over 90% and a proportion of defaulters under 5% (101). The Combined Protocol for Acute Malnutrition Study (ComPAS) in Kenya and South Sudan is looking for evidence in order to modify the current protocol to allow the use of a single product for the treatment of SAM and MAM and a single diagnostic criterion (102), (103).

Some authors have highlighted how this intervention can lead to a lack of understanding between the nutrition and primary health care directorates within the ministries themselves (42). A review of iCCM policies in sub-Saharan Africa has identified the senior staff of the MoH as the key actors for the success of this intervention, as they may offer some resistance to the changes related to treatment at the community level (104). To influence these policymakers, a higher involvement and support of UN agencies and international organizations has been suggested. They can develop new tools and protocols and, sign agreements to enable countries to adapt the management of acute malnutrition policies for the scaling up of the intervention (32).

6.2 Bringing severe acute malnutrition treatment close to households through community health workers can lead to early admissions and improved discharge outcomes.

The study demonstrates that SAM's decentralized treatment model with CHWs leads to the early identification of children with better anthropometric status at admission as well as fewer complications compared to children receiving treatment at HFs. The cost-saving of the intervention found in previous studies suggests that this approach makes it easier for families to seek treatment at an early stage of the disease (86).

The findings show that an increase of WHZ and/or MUAC at admission results in an increased probability of being discharged as cured. Similar results were found in the Malawi study where children admitted to the program with lower anthropometric conditions resulted in a higher proportion of defaulters and a lower proportion of cured children (105).

Several studies analyze the relationship between anthropometric criteria at admission with relapse of SAM and mortality. In India, a child with a MUAC at admission lower than 105 mm had a higher risk of relapse after one year of being discharged as cured (106). A systematic review concluded that low anthropometric at admission is the main risk factor for relapse after being discharged from a malnutrition program (107). Regarding the association between anthropometric and mortality, in Bangladesh children with WHZ, <-4 on admission were associated with a higher probability of death after 3 months of discharge from treatment (108). In Malawi, Kerac *et al.* (109). showed that the death hazard ratio 90 days after discharge decreased with each increased anthropometric measurement unit at admission. John *et al.* in Nigeria, and the two studies mentioned above, have also shown the relationship between other severity indicators at admission (HAZ, WAZ) with relapses and mortality, (108), (109), (110).

Our study did not give evidence of a significant difference of the length of stay between children treated with CHWs compared with those treated at HFs (39 vs. 42 days, no significant difference). In Ethiopia, a study with 420 children showed that SAM cases admitted with a MUAC above 106 mm had a lower length of stay in the program compared to others (27 vs. 24 days) (111). A study conducted in Burkina Faso with 22,094 children has had paradoxical results about the length of stay at the nutritional program. Children with a MUAC below 116 were found to have a shorter length of stay than those with a MUAC at admission between 116 and 118. This result is related to the criteria used for discharge, percentage of weight gain rather than a fixed threshold of MUAC or WHZ. Weight gain increases in parallel with MUAC, and is higher during the first weeks of treatment, so that paradoxically the more severe children are admitted, the earlier they would reach the 15% weight gain used as discharge criterion and this results in a shorter length of stay. The overall length of stay in the study was 52 days for children with MUAC < 115mm, higher than 42 days at HFs in our study (112). The same length of stay (42 days) has been reported in other studies in Ethiopia, but they were based on a discharge criterion of 15% weight gain (113). In this second study, Mengesha *et al*, found the same paradoxical results as the Burkina Faso study, with a shorter length of stay when the 15% weight of gain is used for discharged criteria. This has resulted in a higher proportion of non-response children who did not reach the cut-off of MUAC > 125 mm because of a shorter time for nutritional recovery.

In the Bangladesh study, length of stay was 37.4 days, a similar result as the 39 days in our study. The improvement in gain weight and MUAC was also similar in both studies (weight: 6.7±0.1 g/kg/day; MUAC: 0.4 mm/day) (114). A systematic review related to children admitted with oedema showed that they had a lower weight gain and a lower gain of MUAC than those registered in the present study. This study also highlighted how children with oedema admitted as inpatients have poorer outcomes compared with those treated in outpatient care, which also supports the present work on the effect of severity at admission in nutritional recovery (115).

Both models of service delivery reached international Sphere standards (61). Moreover, children treated with CHWs have less probability of missing any visit compared with those receiving treatment at HFs, and this results in a higher proportion of defaulter's children when they are treated at HFs. Other factors like closeness to CMAM programs have been reported as having an impact on children's recovery (116).

The early detection and the close follow-up because of the proximity of CHWs can explain the good performance achieved by CHWs treating SAM (117). The study in Mali achieved the highest cured proportion of children, 95.5% within the iCCM intervention, compared with the intervention in Angola and India, where even if they reach international Sphere standard, the proportion of cured children was lower than in Mali (43) (44) (118). Ethiopia was the only case where CHWs had worse outcomes in SAM treatment compared with HFs (119).

Different studies have already concluded the effectiveness of CHWs in reducing morbidity and mortality due to pneumonia and malaria (120), (121), (122). In our study, the integration of SAM treatment into the iCCM package has resulted in a higher proportion of children identified with malaria and other infectious diseases, compared to those treated at HFs. The smaller proportion in the HFs group could be explained by the workload of nurses.

Similar results were found in Malawi with the HIV program, where the workload of SAM treatment did not allow nurses the identification of HIV cases (123). Further analysis related to the use of time and CHWs performance is needed.

6.3 Effectiveness and coverage of treatment for severe acute malnutrition delivered by community health workers in the Guidimakha region, Mauritania

The present study has confirmed that CHWs achieved Sphere standards when treating SAM at the community level in the rural area of Mauritania (61). They registered a cured proportion of children of 76.4% and a defaulted proportion of 3.6%. No significant difference was found between the control group at HFs and the intervention group with CHWs. Our results are consistent with López Ejeda *et al* analysis of operational experience of CHWs treating SAM in 12 peer reviews and 8 papers from the grey literature (117). More recent studies have shown similar findings. Kozouki *et al.* in South Soudan working with low literacy CHWs where they reach 75% of children discharged as cured (124). In a non-inferior-quasi experimental study in Tanzania, comparing SAM treatment at HFs, with treatment delivery by CHWs, Wilunda *et al.* have evidenced a proportion of 90.5% of cured children and a proportion of 6.5% of defaulters, when children are treated by CHWs (125).

Less evidence is available regarding the effect of CHWs in coverage of acute malnutrition. Only 3 studies within the revision of operational experience mentioned above, have analyzed this data. Mali was the country that reached a higher increase in coverage. After one year of the project, the intervention group with CHWs increased coverage of SAM treatment to 86.7% (43). Similar to this result, CHWs in Bangladesh registered coverage of SAM treatment of 89% and Angola obtained coverage of 82.1% where CHWs were treating acute malnutrition (114), (44). These findings are consistent with the present study, where the intervention group has reached a coverage of SAM treatment of 71.7% a large increase compared with the control group where coverage was the same at the end of the study.

The present study has shown a large difference between the number of children admitted in both studied groups, 618 in the intervention group with CHWs, compared with 251 in the control group. The total population in both groups was similar, and we have no reason to suspect an incidence difference in both areas. The coverage assessments at the beginning and one year after the implementation show an increase in coverage from 44.2% to 71.6%, both estimated with a large confident interval. These findings suggested that the increase in coverage is responsible for the higher number of children treated in the intervention group. This confirms our study hypotheses that CHWs can increase coverage of acute malnutrition. Zulu et Perry proved that the integration of CHWs within the health system can contribute to UHC (126).

We have found no significant difference in admission criteria between the intervention and control groups. Conversely, there were significant differences in median MUAC when we analyze CHWs and HFs within the intervention group. MUAC at admission was 116 mm with CHWs, compared with 115 mm at HFs. These results are similar to those found by Lopez-Ejeda *et al* in Mali, where the median of MUAC at admission was 115mm with CHWs, compared with 114 mm at HFs (127). No difference was found in our study when considering the WHZ criteria at admission.

6.4 Impact of Different Levels of Supervision on the Recovery of Severely Malnourished Children Treated by Community Health Workers in Mali

This study analyzed the effect of different levels of SS when scaling up SAM treatment at a regional level with CHWs. The two intervention groups with SS improved outcomes of SAM treatment compared with the control group and reached Sphere standards, but no significant difference was found between high and light SS groups.

In a systematic review, Ballard *et al.* identified supervision as a key factor that can improve the performance of CHWs in different health interventions, not including SAM treatment (128). Previous pilot studies have analyzed the possible impact of SS in treatment outcomes of SAM children. In Uganda Lazzerini *et al*, demonstrated that SS increased children admitted in CMAM program (129). A study carried in South Africa, identified the lack of SS as responsible for neglected SAM treatment by CHWs (130). Similar results were found in Ethiopia where CHWs who received monthly supervision obtained better outcomes and scores in delivery SAM treatment, and in Madagascar where lack of SS has shown to be a challenger in the performance of CHWs (131), (132).

Our study did not show an impact of the level of SS on the performance of CHWs treating SAM. The findings are consisting with two reviews of non-nutritional intervention where Bosch-Capablanch *et al*. concluded that reducing the frequency of SS in a program could save costs, and reduce salaries and travel costs, without having a negative impact on the performance of CHWs (133). And Zill *et al*, demonstrated that increase frequency of SS does not significantly lead to an increase in the performance of CHWs, while the quality of the SS could have a more important impact on the intervention (134). As previously analyzed, respect and trust by the communities increase when CHWs are supported and supervised by health authorities (96).

The authors explained the lack of impact of the extra nutrition-specific supervision as follows: some questions related to the identification of danger signs, monitoring tools, and stock out the follow-up, were already in the iCCM supervision grid. Other items included in the nutrition-specific grid were adapted to the management of acute malnutrition at HFs levels. These included human resources roles and responsibilities, and children triage, which do not necessarily reflect the need of CHWs place. The use of both grids and the two SS has led to no additional impact, as expected at the beginning of the study. Our study has not analyzed other factors that could have had an impact when done together with SS, such as the avoidance of stock out of RUTF and/or solving problems of CHWs.

To the best of our knowledge, Mali is the first country in West Africa to make progress in scaling-up SAM treatment with CHWs at the regional level. The country's technical committee made some recommendations based on the finding of this study: 1) include 2 days of acute malnutrition treatment into the iCCM country training module and an internship at HFs level; 2) integrate nutrition supervision into the iCCM supervision grid ;3) adaptation of the nurse's supervision frequency to the CHWs place after the training, and according to the performance of CHWs; and 4) support coordination meetings on health issues with the community at district and regional level.

6.5 Limitations of the study

There are a few limitations in each of the studies presented in this thesis.

The part of the study related to early admissions was a secondary analysis of data recorded for a study with a different design in which HFs plus CHWs were part of the intervention area, and only some of the HFs were part of the control area. Moreover, follow-up weight and height were not recorded, limiting the analysis of anthropometric evolution during treatment. Further studies assessing the long-term status of children who recovered with each treatment delivery model are needed to ascertain whether the iCCM approach influences reducing relapse and mortality rates over time.

Both field studies in Mauritania and Mali were not randomized controlled trials, and thus, we could not rule out that our results were due to some extent to differences among areas, independent of our intervention. The follow-up period was short and confounding factors could not be fully ruled out. The study area was supported by an international NGO and hence, may reflect performance levels associated with well-supported interventions. The RUTF supply was ensured by the Action against Hunger, and no stock-out was registered, which means that these results may not be applicable in settings with RUTF stock-outs.

In Mali scaling up study, the CHWs in the 3 districts started progressively treating children with SAM, depending on the availability of equipment. Therefore, the analysis we presented does not reflect the work of the 169 CHWs during the entire 10 months of the study, and some supervision checklists had missing data, which may limit our conclusions.

7. CONCLUSIONS

7 CONCLUSIONS

1. Proportions of SAM children treated by CHWs who were cured, defaulted, or died, reached international Sphere standards. The results are similar or better than those reported by HF-based interventions.

2. CHWs have the potential to improve the early detection and treatment of SAM children, thereby reducing the risk of medical complications. On admission, children receiving SAM treatment from CHWs have less frequent oedema and have a better anthropometric condition compared to children treated at HFs.

3. Coverage of SAM treatment increases when the service delivery model of treatment with CHWs is available in targeted pilot studies in different contexts.

4. Supportive Supervision in scaling up the intervention of CHWs results in improved outcomes compared with non-supervised CHWs. The two intervention groups met international Sphere standards in terms of cured, defaulted, and proportion in discharged children. In contrast, control group with CHWs without supervision did not reach Sphere standards.
5. The level of supportive supervision did not have the expected impact on SAM treatment outcomes. No significant difference was found in the performance of CHWs between the group with a high level of supervision and the one with a light level of supervision.
6. Factors like quality of supervision and trust of families influence treatment outcomes in addition to the number of supervisions.

7. Incentives and motivation are critical determining factors of CHWs retention and key considerations for their involvement in future scale-up plans for the treatment of SAM.

8. The effectiveness of different modalities for supplying CHWs with RUTF, is an important evidence gap in the health delivery model with CHWs that needs to be addressed by future research projects.

9. Provisioning of SAM treatment by CHWs demands adaptations to national and global policies and guidelines. The support of major nutrition and health agencies is crucial in the introduction of SAM treatment into iCCM through the development of statement papers, standardized protocols, tools, and training courses, as done previously for CMAM protocol.

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ANNEXES

ANNEXE 1. RESEARCH PROTOCOL MALI 1

ANNEXE 2. RESEARCH PROTOCOL MAURITANIA

ANNEXE 3. RESEARCH PROTOCOL MALI 2