



ABBOTT CENTER FOR
MALNUTRITION
SOLUTIONS



MID-UPPER ARM
CIRCUMFERENCE (MUAC)

Malnutrition and the MUAC Z-Score Tape

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EXECUTIVE SUMMARY

Malnutrition is a threat to children's long-term health and development. A simple tool called the Mid-Upper Arm Circumference (MUAC) z-score tape was developed in 2019 in response to the need for a single-step estimation of nutritional status across a broad age and body type range, without formal training or the need for reference charts and calculators. The MUAC z-score tape integrates a population comparison called a z-score, which expands functionality across four categories and further simplifies its use in resource-restricted settings.

MUAC is a validated anthropometric measure initially used in clinical settings in the 1950s. A MUAC tape offered a simple, quick way to identify children at high risk of malnutrition. The MUAC z-score tape builds upon this by expanding the age range and screening population and adding overnutrition to help address different varieties of malnutrition and the risk of noncommunicable diseases. The tape also integrates z-scores to provide additional information without reference charts or calculators, and increases the ability to track through various malnutrition stages to help support early identification.

MALNUTRITION

The World Health Organization (WHO) defines malnutrition as deficiencies or excesses in nutrient intake, imbalance of essential nutrients, or impaired nutrient utilization.¹ Malnutrition encompasses undernutrition and overnutrition. Undernutrition can be defined as wasting (below healthy weight-for-height) and/or stunting (below healthy height-for-age). Overnutrition includes overweight or obesity (above healthy weight-for-height). Malnutrition can occur due to a combination of factors, including lack of proper nutrition, poor diet quality, inadequate feeding practices, and an illness or condition that challenges food intake and/or nutrient absorption. Proper nutrition is influenced by access, availability and affordability of nutritious foods. Malnutrition weakens immunity, increases susceptibility to illness, and increases the risks of chronic diseases, morbidity and mortality.

¹World Health Organization. Malnutrition. 2024. <https://www.who.int/health-topics/malnutrition>

MID-UPPER ARM CIRCUMFERENCE (MUAC) TAPE

The MUAC tape was initially used in clinical settings in the 1950s as a screening tool for acute malnutrition. The tool was quickly taken up in multiple countries because it's easy to use, relatively inexpensive to produce and easy to transport, especially in resource-restricted and limited settings.²

In 1999, WHO defined severe malnutrition in children as weight-for-height below three standard deviations and/or the presence of edema. In 2006, WHO published child-growth standards for attained weight and height to replace the previously recommended 1977 National Center for Health Statistics (NCHS)/WHO child-growth reference and produced standards of Mid-Upper Arm Circumference, or MUAC. These standards have been endorsed by international bodies, such as the United Nations System Standing Committee on Nutrition, the International Union of Nutritional Sciences and the International Pediatric Association, and more than 90 countries globally.³

As a result, the MUAC tape has been instrumental in managing malnutrition in resource-restricted settings for over a half-century. It is often a better predictor of death and complications from malnutrition – both in the hospital and in the community – and it can offer a better sense of how long a child has been suffering from malnutrition, when compared with other measures. It is easier and less costly to implement than height- and weight-based tools and remains effective when a child's body composition is altered by malnutrition.

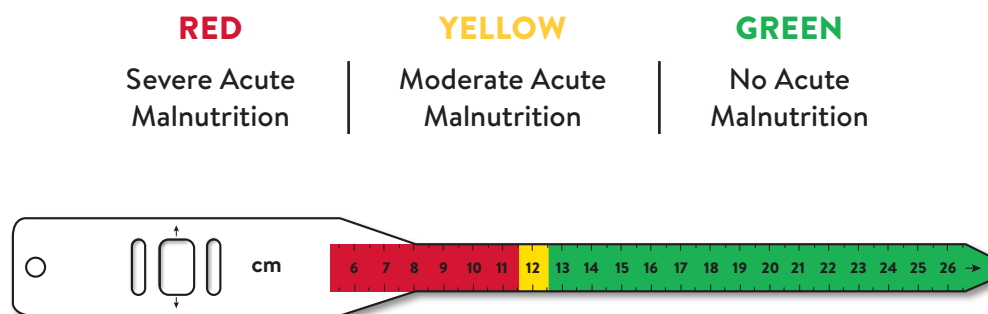


FIGURE 1 – ORIGINAL MUAC TAPE

²Glasman J. Measuring Malnutrition: The History of the MUAC Tape and the Commensurability of Human Needs. 2018. doi:10.1353/hum.2018.0001

³World Health Organization. *WHO child growth standards and the identification of severe acute malnutrition in infants and children: A Joint Statement by the World Health Organization and the United Nations Children's Fund.* World Health Organization; January 2009.

MUAC Z-SCORE TAPE

Since its initial use, there has been a need for a single-step estimation of nutritional status across a broad age and body type range, without formal training or the need for reference charts and calculators. To address this need, investigators at Children’s Mercy Hospital (Kansas City, Missouri, U.S.) developed the MUAC z-score tape in 2019, using Centers for Disease Control and Prevention (CDC) data. The MUAC z-score tape, currently licensed under Abbott, builds upon the original MUAC tape. It expands the age range and screening population and adds overnutrition to help address different varieties of malnutrition and the risk of noncommunicable diseases. The tape also integrates z-scores to provide additional information without reference charts or calculators, and increases the ability to track through various malnutrition stages to help support early identification.

Z-SCORE

A z-score provides an idea of how far a data point lies from the mean. Z-scores are a way to compare results to an average population. In the case of the MUAC z-score tape, age-specific data is incorporated into the measurement, providing more sensitive and exact information to the MUAC z-score tape user.

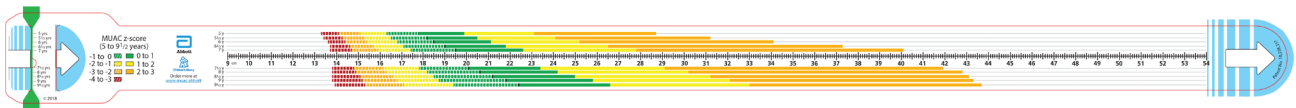


FIGURE 2 – MUAC Z-SCORE TAPE

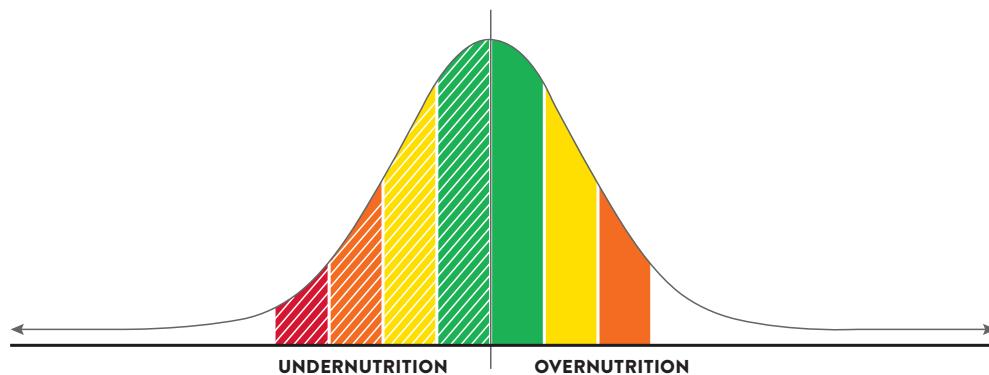


FIGURE 3 – Z-SCORE AND THE POPULATION

MUAC AND MUAC Z-SCORE FUNCTIONALITY

While the original MUAC tape is effective and easy to use, the MUAC z-score tape integrates a population comparison called a z-score, which expands functionality across four categories and further simplifies its use in resource-restricted settings.






	MUAC TAPE 	MUAC Z-SCORE TAPE 	COMMUNITY/HEALTH SYSTEM BENEFITS
FORMS OF MALNUTRITION DETECTABLE	Undernutrition	Undernutrition, overnutrition	Addition of overnutrition provides opportunity to address different varieties of malnutrition and NCD risk
APPLICABLE AGE RANGE	6 months to 59 months	2 months to 18 years	Expands screening population
INFORMATION PROVIDED	Circumference of child's arm (cm)	Circumference of child's arm (cm) and z-score color coding	Provides additional information without reference charts or calculators
SCREENING OVER TIME	Single point-in-time detection of severe malnutrition	Ability to track children through various malnutrition stages	Supports early identification of at-risk children

FIGURE 4 – MUAC FUNCTIONALITY

CURRENT USE: MUAC Z-SCORE IMPLEMENTATION IN COMMUNITIES

The concept of Family MUAC emerged in 2012. It is the idea that community health agents (community health promoters, assistants, peer group educators) and families can learn to use tools, like the MUAC tape, to identify malnutrition among family members in their communities and households. Family MUAC aims to increase access to nutrition screening for children in communities to ensure those at risk of malnutrition are referred to relevant resources and services. As of 2021, 39 countries were implementing this approach.⁴

ABBOTT CENTER FOR MALNUTRITION SOLUTIONS PROGRAMS

The Abbott Center for Malnutrition Solutions is collaborating with others to bring innovative approaches to identify, address and ultimately prevent malnutrition. These programs are integrating the MUAC z-score tape to build capacity and help strengthen the community response around the world.



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BURKINA FASO
KENYA
RWANDA
TANZANIA
ZAMBIA

SOUTH-EAST ASIAN

INDIA

WESTERN PACIFIC

PHILIPPINES

⁴Simplified approaches for the treatment of child wasting. Simplified Approaches. 2021. <https://www.simplifiedapproaches.org>

EVIDENCE-BASED COLLABORATIONS

Several programs integrating the MUAC z-score tape are also incorporating an evidence-based approach to help inform public policies and initiatives that drive long-term impact. These programs include:

Social Sports Schools: Since 2022, the Abbott Center for Malnutrition Solutions (ACMS), in partnership with the Real Madrid Foundation, has employed the MUAC z-score tape as a nutrition screening tool in Real Madrid Foundation's community programs, called Social Sports Schools, across nine countries⁵. Facilitators of the sports and wellness program (sports coaches, social services agents and volunteers) were trained to effectively use the MUAC z-score tape for the nutrition screening of participants between the ages of 5 and 17. Children identified as at risk received referrals to health services. Furthermore, the screening program prompted discussion on malnutrition within the program, among facilitators, coaches, participating children and their families.

ALIMUS Study: The ALIMUS project seeks to determine the impact of home gardening and nutritional counseling on the health of children in Nouna, Burkina Faso, and Siaya, Kenya. The effect of the integrated approach on primary health outcome (height-for-age z-score) is focused on children between the ages of 6 and 24 months. The cluster-randomized control trial trained community health volunteers on the use of the MUAC z-score tape. The community health volunteers conducted nutrition screening, along with nutrition counseling efforts. They also utilized the MUAC z-score tapes at midline and for continuous data collection during 12 months of the study implementation.

Changemaker Project: The Changemaker project employs MUAC z-score tapes as a nutrition assessment tool in a multilayered school-based intervention. Changemaker aims to reduce obesity and its related noncommunicable diseases among adolescents (12 to 15 years of age) in three rapidly urbanizing cities in Burkina Faso, Kenya and Tanzania. The Changemaker project involves training research assistants and school nurses in all three countries on MUAC z-score tape utilization.

Ecuador: In 2022, Abbott initiated partnerships with the municipalities of Cuenca and Manta by donating MUAC z-score tapes and training healthcare professionals and medical brigades on how to use the simple tool to help identify malnutrition risk in children. In 2024, this work was extended to Pichincha and Tungurahua. The partnerships bring new skills and tools related to malnutrition to help the municipalities better respond to critical nutrition needs in their communities and connect those in need to resources in the healthcare system.

⁵Sharn AR, Sorgho R, Sulo S, Molina-Molina E, Rojas Montenegro C, Villa-Real Guno MJ and Abdel-Rahman S (2024) Using mid-upper arm circumference z-score measurement to support youth malnutrition screening as part of a global sports and wellness program and improve access to nutrition care. *Front. Nutr.* 11:1423978. doi: 10.3389/fnut.2024.1423978

RESOURCES

MUAC

- <https://www.unicef.org/supply/simple-tool-detect-severe-malnutrition-mid-upper-arm-circumference-muac-tape>

MUAC Z

- <https://malnutrition.abbott>
- <https://anhi.org/resources/podcasts-and-videos/muac>
- <https://anhi.org/resources/printable/muac-instruction-sheet-for-hcps>



MUAC Z-SCORE TAPE EVIDENCE TO DATE

Children's Mercy Hospital (Kansas City, Missouri, U.S.), with funding from private philanthropic donors and the New England Pediatric Device Consortium, developed a modified insertion tape (depicting z-score ranges) and an electronic z-score tape (calculating precise z-score values) for use in practice. Human-factors testing was performed for the insertion tape with 70 U.S.-based dietitians, and the device was iteratively refined (and retested) until the design and materials were favorably suited to use in a variety of clinical settings.⁶

Lambda, mu, sigma (LMS) values to inform the calculation of MUAC z-scores were estimated for every month of life, from 2 to 222 months, using Centers for Disease Control and Prevention (CDC)/National Health and Nutrition Examination Survey (NHANES) growth reference data (n = 28,995 children). These LMS values were validated using data from two independently conducted studies (n = 1,438 children combined).⁷

With support for larger-scale production of the MUAC z-score tape provided by Hallmark Cards, Inc., the device was rolled out institutionwide at a U.S. hospital in the Midwest. Over 10,000 patients being seen for care in both inpatient and outpatient settings were evaluated to compare the performance of MUAC z-values, age- and sex-standardized body mass index (BMI), and weight-for-height/length z-score (WLZ) values against dietitian-determined nutritional classifications.^{8,9,10}

After testing MUAC z-score tape use (refer to Figure 2) with healthcare providers, testing began in the community setting by those without formal healthcare training. These activities included one study each in community health workers of Guatemala (n = 224 volunteers, n = 1,384 children 5 to 18 years)¹¹ and family members of India¹² (n = 125 parent-child dyads) caring for children at risk for moderate and severe acute malnutrition.

Both studies in Guatemala and India were conducted with a nongovernmental organization partner, Children International, which implemented the MUAC z-score tape organizationwide across 10 sites in eight countries. The MUAC z-score tape was evaluated for its impact and delivery with three different levels of support, in conjunction with deployment: home visits, telephone calls or SMS messaging (n = 1,882 children). Children International continues to use the MUAC z-score tape as part of its programming.¹³

Children's Mercy Hospital owns the rights to the MUAC z-score tape (U.S. Patent No. 10,238,317). It is currently licensed to Abbott, which manufactures and distributes the MUAC z-score tape at cost or through donation. In 2021, the MUAC z-score tape was recognized as a *Fast Company World Changing Ideas* finalist.

⁶Mallory K, Miller MA, Brahmachari R, Mitra N, Abdel-Rahman SM. Leveraging Lean Research Principles to Engage Caregivers to Improve Child Undernutrition: a Case Example in Kolkata, India. December 2020. doi:10.21203/rs.3.rs-130785/v1

⁷Abdel-Rahman SM, Bi C, Thaete K. Updated MUAC reference charts for U.S. children 2 months through 18 years of age. *Nutr Clin Pract.* 2017;32(1):68-76.

⁸Stephens K, Escobar A, Jennison N, Vaughn L, Sullivan R, Abdel-Rahman S; CMH Nutrition Services Z-Score Research Team. Evaluating MUAC z-score as a determinant of nutritional status. *Nutr Clin Pract.* 2018;33:124-132.

⁹Stephens K, Orlick M, Beattie S, Snell A, Munsterman M, Oladitan L, Abdel-Rahman SM. Examining mid-upper arm circumference malnutrition z-score thresholds. *Nutr Clin Pract.* 2020;35:344-352.

¹⁰Wagner J, Ahmu M, Stephens K, Abdel-Rahman S. Longitudinal assessment of mid-upper arm circumference z-scores during nutritional rehabilitation. In preparation.

¹¹Miller M, Mallory K, Escobedo M, Tarot AC, Abdel-Rahman S. Assessing effectiveness of a novel mid-upper arm circumference z-score tape in a community setting in Guatemala. *Arch Public Health.* 2019;77:44. doi.org/10.1186/s13690-019-0370-0

¹²Mallory K, Miller MA, Brahmachari R, Mitra N, Abdel-Rahman SM. Leveraging Lean Research Principles to Engage Caregivers to Improve Child Undernutrition: a Case Example in Kolkata, India. December 2020. doi:10.21203/rs.3.rs-130785/v1

¹³Mukomba M, Mallory K, Brahmachari R, Morse E, Fehlig L, Abdel-Rahman S. Equipping caregivers to track and share their child's progress from home, localizing nutrition interventions through the pandemic and beyond. Presented at: CORE Group Global Health Practitioners Conference; October 3-5, 2022; Bethesda, MD.

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8. Wagner J, Ahmu M, Stephens K, Abdel-Rahman S. Longitudinal assessment of mid-upper arm circumference z-scores during nutritional rehabilitation. In preparation.
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