ABSTRACT OF PHD THESIS SUBMITTED BY

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MAPPING DOUBLE DUTY ACTIONS TO TARGET THE DUAL BURDEN OF MALNUTRITION

The dual burden of malnutrition (DBM), defined as the co-existence of undernutrition and overnutrition, is an escalating global health concern, particularly in low- and middle-income countries (LMICs). Its rising prevalence, driven by dietary transitions and changing food environments, leads to significant health and economic losses (e.g., increased mortality, morbidities, and disability-adjusted life years (DALYs) that strain healthcare systems. More than one in three individuals suffers from DBM in LMICs, and with the rising prevalence, the present healthcare system is not conducive enough to solve the crisis. Considering these limitations and challenges, preventive approaches underscore the way to address them. This study aimed to develop a novel, cost-effective, and efficient preventive approach, rather than a corrective one, to address DBM, especially in low-resource settings. This study focused on designing a framework for an efficient integrated DBM monitoring system as a preventive approach to solve the issue. The selection of adolescent females as the study group also revolved around the preventive approach to target the DBM, as the adolescent females transitioning to be future mothers, if they gained access to the planned interventions for them, would ultimately hinder the intergenerational cycle of DBM, thus targeting the root of the problem. Hence, the major DBM risk factor assessment and anthropometrics were carried out for adolescent girls to design an integrated DBM monitoring system as a preventive approach and devise solutions to address the issue.

Monitoring major risk factors of DBM discussed in this study paves the way for developing an efficient integrated surveillance system targeting DBM as a preventive measure that can help policy-making or program planning as an effective intervention to target this issue. This study aimed to assess the distribution of Body Mass Index (BMI) for age z score (BAZ) defined nutritional-status categories among adolescent girls, examine significant DBM-related risk factors, and use stakeholder analysis to design an evidence-based framework for an integrated DBM monitoring system. This study also aimed to evaluate Mid-Upper Arm Circumference (MUAC) as an alternative low-cost screening tool in these settings by assessing its diagnostic accuracy and establishing cut-offs for identifying underweight and overweight adolescent girls.

A cross-sectional study was conducted in selected areas of Chhattisgarh and Uttar Pradesh to collect data on risk factors of DBM using a semi-structured questionnaire and anthropometrics (height, weight, and MUAC measurements), along with stakeholder analysis to assess bottlenecks and mitigation factors to target the issue. The World Health Organization (WHO) Anthroplus software was used to convert the height and weight data into BAZ scores to classify the adolescent females into thinness/severe thinness, normal, overweight, and obese categories based on BAZ scores. The regional distribution of these BAZ-defined categories was used to describe the co-existence of undernutrition and overnutrition at the population level. Stepwise regression, Random Forest (RF) analysis, and point-biserial correlation were then used to examine the association between BAZ as the dependent variable and selected demographic, environmental, dietary, and NCD-related risk factors as independent variables. Further analysis was conducted to ascertain the diagnostic accuracy of MUAC using sensitivity, specificity, area under the curve (AUC), and the

Youden Index, and to establish cut-offs corresponding to underweight and overweight categories. The association between BAZ and MUAC was assessed using Pearson's correlation analysis. The Youden Index was used to find the cut-off value of MUAC for underweight and overweight individuals with respect to the BAZ score. For developing the framework, in-depth interviews and focus group discussions were conducted using a semi-structured questionnaire for different stakeholders, i.e., district administration senior officials, Collector and District Magistrate, Anganwadi workers, doctors, block coordinators, researchers, teachers, parents, locals, and adolescents to identify DBM risk factors, designing attributes and mitigation factors.

The Dietary Diversity Score (DDS) variable was found to be the most important for the overall BAZ score at p-value <0.01. Among the variables examined, DDS, processed food, fast food, health-promoting food, inactive hours, toilet facility, hand hygiene, protected water, kitchen garden, and livestock were positively correlated with BAZ score, and physical activity (mild), and diarrhea were negatively correlated with BAZ at p-value <0.01. The correlation between BAZ and MUAC was found to be 0.78, p <0.01. The overall sensitivity, specificity, and AUC of MUAC were observed as 0.89, 0.94, and 0.92, respectively. These findings indicate that MUAC has good diagnostic performance as a low-cost alternative to BAZ-based anthropometric assessment in resource-constrained settings. Accordingly, MUAC may serve as a practical screening alternative to BAZ-based anthropometric assessment among adolescent girls, and MUAC-based classification may support population-level DBM surveillance. The strong correlation between MUAC and BAZ supports the utility of MUAC as a field-friendly substitute for height- and weight-based assessment, thereby reducing technical and financial burden. Similarly, the strong

importance of DDS in the Random Forest analysis and its positive association with BAZ indicate that dietary diversity is an important predictor of nutritional status. The framework designed from the analysis of multi-sectoral stakeholders resulted in an evidence-based, simple, user-centric, adaptable, and holistic integrated DBM monitoring system. The resulting framework was evidence-based, user-centred, adaptable, and structured around inputs, processes, outputs, outcomes, and a feedback loop for continuous improvement. This study identified a cost-effective and efficient screening tool to support population-level DBM monitoring, and stakeholder analysis contributed to the development of a novel integrated DBM monitoring framework. This evidence-driven approach may support preventive action against DBM, reduce health-system burden, and strengthen population-level monitoring in resource-constrained settings.