SCHOOL FEEDING PROGRAM IN ADDIS ABABA, ETHIOPIA: SAFETY AND NUTRITIONAL QUALITY OF MEALS AND PROGRAMMATIC CHALLENGES

A PHD DISSERTATION

BY:

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ADDIS ABABA UNIVERSITY

NOVEMBER, 2024

ADDIS ABABA, ETHIOPIA

School Feeding Program in Addis Ababa, Ethiopia: Safety and Nutritional Quality of Meals and Programmatic Challenges

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Submitted to the Center for Food Science and Nutrition in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Food Science and Nutrition

November, 2024

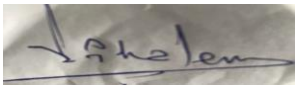
Addis Ababa, Ethiopia

DECLARATION

I, the undersigned, solemnly affirm that the dissertation titled ***" SFP in Addis Ababa, Ethiopia: Safety and Nutritional Quality of Meals and Programmatic Challenges"*** is an exclusive product of my own intellectual endeavor. I declare that it has not been previously submitted for any other degrees at any other academic institution. Moreover, I have acknowledged and diligently attributed all sources of materials utilized in this study, honoring the principles of academic integrity and responsible scholarship.

Yihalem Tamiru Semegn — Signature

Date of submission: November, 2024



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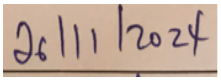
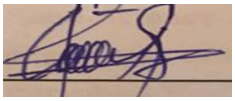
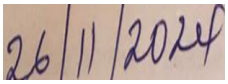
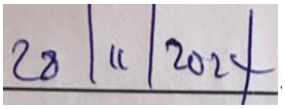
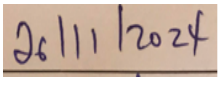
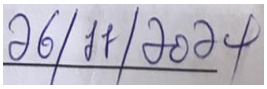
External Examiner Dr.Tafese Bosha (Assoc. Prof.)		
Internal Examiner Dr.Endale Amare (Assoc. Prof.)		
Supervisors Dr. Samson Gebremedhin (Assoc. Prof.)		
Prof.Afework Mulugeta		
Dr. Abebe Ayelign (Assoc. Prof.)		

ACKNOWLEDGEMENTS

First of all, I express my utmost gratitude to my supervisors Dr. Samson Gebremedhin, Prof. Afework Mulugeta, and Dr. Abebe Ayelign for their unwavering dedication as mentors in shaping my academic journey. Their exceptional commitment, invaluable guidance, and meticulous review of my dissertation have propelled me to become an independent researcher. I am profoundly grateful for thier comprehensive feedback, which has significantly elevated the caliber and depth of this study.

Following, I am sincerely grateful to the International Development Research Center (IDRC) Canada Funded project, "Urban agriculture for advancing health food systems in Addis Ababa," for generously providing us with the supplementary data. This invaluable support enabled us to delve into the perceived benefits and challenges of the Addis Ababa SFP from the public primary school students, parents, teachers, and principals' point of view. Additionally, their assistance in covering the expenses associated with data collection on evaluating the microbiological quality of school meals in Addis Ababa is deeply appreciated.

Next, special thanks are extended to the Food Science and Nutrition Research Directorate at the Ethiopian Public Health Institute for granting access to the food microbiology laboratory facilities and providing necessary reagents for the microbial food analysis. Also acknowledge the valuable contributions of Amare Alemu and Kaleab Sebesebe, whose technical expertise greatly supported the successful completion of the food microbiology analysis at the Food Safety and Microbiology Reference laboratory.

I appreciate the Centre for Food Science and Nutrition at AAU for hosting my Ph.D. research and providing invaluable support in obtaining research permissions, including official letters to the relevant authorities.

I extend my heartfelt thanks to the public health and microbiologist professionals who actively contributed to the data collection process, providing invaluable information. Moreover, I acknowledge the support of the Addis Ababa Education Bureau in facilitating the data collection process through support letters and coordination with the sub-city and target schools.

I would like to express my heartfelt gratitude to Dr. Paulos Getachew, the Center Director for Food Science and Nutrition, AAU for his support whenever I needed it. I also want to extend special appreciation to Dr. Samuel Asferaw for his exceptional assistance throughout this journey. Additionally, I acknowledge the valuable contributions of Dr. Mesfin Wogayehu, Dr. Demis Mengist, Honorable Dr. Abebaw Dessalew, Assistant Professor Mekonnen Assefa, and Mr.Yinesu Kassaw your support has been instrumental to my work.

I am grateful to my brother, Dr. Melesse Tamiru, for being a role model in my life; his strength, goal-oriented mindset, and resilient character have inspired me. I also appreciate my brother, Minchil Tamiru, for his moral support, and I thank my little sister, Mignot Getachew, for her presence and strength. Their love and encouragement have significantly contributed to my academic achievements and personal growth.

Finally, I would like to express my heartfelt gratitude to Tigist Abeje for her unwavering support and belief in me. Her presence and dedication have been invaluable pillars of strength throughout my Ph.D. research journey.

DEDICATION

This Ph.D. dissertation paper is a heartfelt tribute to the loving memory of my mother, Wro. Belayenesh Temesegen Getahun. I have accomplished what you always desired to witness. Today, I stand here, successful and filled with profound gratitude, dedicating this achievement to you. Every milestone, every struggle, every victory is a testament to your unwavering love and unwavering belief in me. This is not just my success, but a testament to the legacy you instilled within me. With tears of joy and a heart overflowing with love, I present this accomplishment to you, knowing that your spirit will forever reside within these pages.

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LIST OF ABBREVIATIONS/ACRONYMS

AAU	Addis Ababa University
AOR	Adjusted Odds Ratio
APC	Aerobic Plate Count
BGBB	Brilliant Green Bile Broth
CI	Confidence Interval
CNS	College of Natural and Sciences
COHA	Cost of Hunger in Africa
DDS	Dietary Diversity Score
E. coli	Escherichia Coli
EPHI	Ethiopian Public Health Institute
FAO	Food and Agriculture Organization of the United Nations
FC	Fecal coliforms
FGD	Focus Group Discussion
HACCP	Hazard Analysis and Critical Control Point
HG-SFP	Home Grown School Feeding Program
HPC	Heterotrophic Plate Count
HPLC	HighPressure Liquid Chromatography
IDRC	International Development Research Center
IRB	Institutional Review Board
ISO	International Organization for Standardization
KAP	Knowledge, Attitudes and Practices
KIIs	Key Informant Interviews

NMKL	Nordic-Baltic Committee on Food Analysis
NGO	Non-Governmental Organization
RDA	Recommended Dietary Allowances
RTE	Ready-To-Eat
S. aureus	Staphylococcus aureus
SD	Standard Deviation
SFPs	School Feeding Programs
SNNPR	South Nations Nationalities and Peoples Region
SPSS	Statistical Product and Service Solutions
SSA	Sub-Saharan Africa
STATA	Statistical Software for Data Analysis
TC	Total Coliform
TVC	Total Viable Counts
VRBA	Violet Red Bile Agar
WFP	World Food Program
WHO	World Health Organization

LIST OF PUBLICATIONS

Published Articles

1. Tamiru Y, Ayelign A, Mulugeta A, Reda Z, Gebremedhin S. Dietary quality and nutrient intake assessment in school adolescents: A study in Addis Ababa, Ethiopia. *Clin Nutr Open Sci*. 2024; 55:36-47. https://doi.org/10.1016/j.nutos.2024.03.001
2. Tamiru Y, Ayelign A, Mulugeta A, Jara D, Melaku E, Gebremedhin S. Perceived benefits and challenges of the SFP in Addis Ababa, Ethiopia: A qualitative study. *Journal of Nutr Sci*., (2024), vol. 13, e32; 1-13 https://doi.org/10.1017/jns.2024.42
3. Tamiru, Y., Ayelign, A., Mulugeta, A., & Gebremedhin, S. (2024). Microbiological safety assessment of ready-to-eat cooked foods in the Addis Ababa School Feeding Program, Ethiopia. *Heliyon*,10(18)e38110 https://doi.org/10.1016/j.heliyon.2024.e38110

Submitted Manuscript:

Examine the food safety knowledge, attitudes, and practices of food handlers in the Addis Ababa school feeding program *(Journal of Heliyon).*

ABSTRACT

The implementation of SFPs faces significant challenges, including limited institutional capacity, resource constraints, and inadequate food safety measures. Existing literature highlights a lack of data in these areas, emphasizing the need for comprehensive research to enhance program effectiveness and protect student well-being. In Ethiopia's SFP, issues persist regarding food provision, infrastructure, and administrative concerns related to food quality and hygiene. Previous studies in Addis Ababa which evaluated dietary quality and food safety knowledge among food handlers; however, they were not comprehensive. Therefore, this research aims to fill critical gaps by assessing the dietary quality of school meals, microbiological safety, food safety knowledge among food handlers, and the perceived benefits and challenges of the SFP in Addis Ababa.

A cross-sectional study was conducted involving 293 adolescents from 20 schools. The dietary intake was evaluated via a multiple-pass 24-hour recall method against the RDA. Dietary diversity was measured using a 12-food groups score and analyzed with STATA software. Microbial contamination in RTE and drinking water was assessed collecting samples from 18 primary school kitchens in March and April 2024. This included microbiological analysis for 37 cooked food samples and 18 drinking water samples following ISO and NMKL guidelines. The KAP regarding food safety was evaluated employing structured face-to-face interviews (knowledge with a 29-question questionnaire (70% cutoff), attitudes with a 22-question scale, and practices with a 22-question instrument (scores of 16 or more indicating good practices)). Data were analyzed using descriptive statistics, pairwise correlations, and multiple linear regressions. Additionally, a qualitative phenomenological study was carried out in May 2023 on 98 participants (48 mothers of the students, 20 students, 20 school principals, and 10 experts gathered through key informant interviews and focus group discussions). The qualitative data was transcribed, translated, and thematically analyzed using ATLAS-TI software.

The study highlighted significant nutrient inadequacies of meals provided to adolescents in schools. While school meals contributed a sufficient amount of carbohydrates (74.4%) of the RDA, they fell short in other essential nutrients: energy (34.1%), protein (42.5%), calcium (9.3%), zinc (14.6%), iron (52.9%), vitamin A (14.0%), thiamine (16.7%), vitamin B12 (12.8%), and niacin (3.8%). Moreover, this study assesses the 24-hour DDS of public primary school

adolescents. Key findings reveal that 88.1% achieved adequate dietary diversity (DDS of 5 or higher), with 34.7% scoring 5, 38.5% scoring 6, 13.1% scoring 7, and 2.8% scoring 8. Despite a diverse diet, significant nutrient inadequacies persisted in both the school meals and overall 24-hour dietary intakes.

The microbiological analysis of RTE meal samples indicated an overall acceptable level of quality and safety. However, several concerns were identified. Yeasts and molds exceeded reference standards in 78.4% of the RTE cooked meal samples (>10^2 cfu/ml), while *E. coli* surpassed the acceptable limit in 10.8% of samples (>10^2 cfu/ml), and *S. aureus* counts exceeded limits in 5.4% of samples (10^3 -10^4). Cooked rice showed the highest microbiological counts, particularly for *E. coli* and *S. aureus*. Approximately, 14.4% of the food samples were deemed unsatisfactory, exhibiting contamination from *E. coli, S. aureus*, and *yeasts* and *molds.* Regarding drinking water quality, 23.4% of samples were found to be non-potable, raising concerns about the total *APC, TC,* and *FC.* Notably, 72% of drinking water samples exceeded the *APC* criteria (>100 cfu/ml), 16% surpassed the *TC* standard (>1 cfu/ml), and 5.5% exceeded the *FC* threshold.

The study revealed high levels of knowledge (85.8%), positive attitudes (79.6%), and satisfactory practices 72.3% among food handlers. Key factors influencing these outcomes included education, years of service, and marital status. Education was found to significantly enhance knowledge ($p = 0.004$) and practices ($p < 0.001$). While years of service positively influenced knowledge ($p < 0.001$), it had a negative impact on practices ($p = 0.019$). Marital status also played a role, with significant associations observed in attitudes ($p = 0.046$) and practices ($p = 0.043$). Logistic regression analysis highlighted the importance of specific facilities: having a separate storage area for raw and RTE foods reduced unsatisfactory food safety practices by 55% (AOR = 0.45), while a water facility in the kitchen decreased poor hygiene practices by 46% (AOR = 0.54). Additionally, a hand-washing facility lowered the odds of poor practices by 35% (AOR = 0.65). Notably, food handlers with higher attitude scores had an 81% lower likelihood of exhibiting poor food safety and hygiene practices (AOR = 0.19).

Moreover, a qualitative study shed light on the benefits and challenges of the SFP, showcasing positive impacts on attendance, academic performance, reduced dropout rates, financial relief, improved behavior, and a safer learning environment. However, challenges such as underpaid kitchen workers, operational issues, reduced reading time, increasing food costs, limited market

access, inadequate infrastructure, and growing the intention of dependency were also identified. This study emphasiz the necessity of enhancing nutritional adequacy, ensuring microbiological safety, sustaining food safety knowledge, and addressing program challenges to optimize the SFP in Addis Ababa.

The study underscores the critical need to address nutrient inadequacies among school adolescents by prioritizing menu planning that incorporates nutrient-dense foods and implementing cost-effective strategies utilizing locally sourced options. Implementing nutrition education programs and collaborating with stakeholders on tailored initiatives such as community gardens, partnerships with local farmers, and enhancing the availability of free nutritious meals—are essential for promoting student well-being.

While the microbiological quality of meals served through the Addis Ababa SFP generally meets established standards, some food samples exceeded permissible limits, indicating hygiene challenges that must be addressed through stringent hygiene practices.

Also, food handlers in the program exhibited high knowledge and positive attitudes towards food safety, yet significant gaps in actual practices highlight the need for targeted educational interventions that consider local and cultural influences. Future researches should focus on objective measurements to better understand food safety practices and their implications for public health.

Overall, although the SFP seems to contribute to a safer learning environment and improved educational outcomes, these conclusions may rely more on perception than on measurable evidence. However, urgent action is needed to address critical issues such as underpaid kitchen staff, operational inefficiencies, rising food costs, and inadequate infrastructure. To ensure the program's long-term sustainability, it is essential to implement strategies for reducing workloads, enhancing kitchen infrastructure, adhering to government guidelines, and promoting self-reliance among schools.

Keywords: Knowledge, attitudes, and practices, Adolescents, Dietary intake, Food handlers, Microbial contamination, Microbiological safety, Nutritional quality.

CHAPTER 1: GENERAL INTRODUCTION

1.1 Background

The SFPs, are crucial safety nets globally, providing meals, snacks, or take-home rations, for children, especially in low-income regions, and aiding in the eradication of hunger as per Sustainable Development Goals (SDGs) (Wineman et al., 2022). In Africa, between 2013 to 2019 the SFP beneficiaries increased by 71%, with governments increasingly backing these programs through funding and policies (Gelli & Espejo, 2012; Samsom, 2018; Union, 2021; Wineman et al., 2022). The SFPs are vital during economic crises, supporting vulnerable populations globally, with 388 million students in 161 countries benefiting from school meals (Alderman & Bundy, 2012; Essuman & Bosumtwi-Sam, 2013; Trindade *et al*., 2014; WFP, 2020; Wineman *et al*., 2022; Msimango *et al*., 2023).

Globally, 200 million school-aged children suffer from stunting and underweight, resulting in 2.2 million deaths each year (Assemie *et al.,* 2020). Without intervention, an estimated one billion children could face hunger and experience cognitive and physical impairments by 2020 (Britto & Ulkuer, 2012; Appleby *et al.,* 2019; Assemie *et al.,* 2020). In Sub-Saharan Africa (SSA), school-aged children are especially vulnerable to undernutrition, which impacts cognitive development, academic performance, body size, and work capacity (Britto & Ulkuer, 2012; Engesveen & Shrimpton, 2007; Grantham-mcgregor *et al.,* 2007; Ngo & Serra-Majem, 2018). Poverty is a major contributing factor to malnutrition and hunger, accounting for nearly half of all preschool child deaths globally, particularly in Africa (Groenewald, 2015).

The 2013 Ethiopia Cost of Hunger study highlighted the significant economic impact of undernutrition, causing a loss of around 16.5% of Ethiopia's GDP (A. U. C. *et al.,* 2014). In Ethiopia, high rates of stunting (24%) and wasting (17.7%) are prevalent among children aged 5-14 and 5-19, respectively (Assemie *et al.,* 2020; FAO, 2022; Memirie, 2023). In Addis Ababa specifically, 23% of school children aged 5-14 are stunted, with 4% suffering from anemia (Assemie *et al*., 2020; Memirie, 2023). Micronutrient deficiencies are also widespread, with 24-25.8% experiencing anemia and 10.9% having vitamin A deficiency (Memirie, 2023).

Efforts by organizations like the WFP and the World Bank promote sustainable solutions aligned with the SDGs, emphasizing the community engagement and local resources (B. *et al.,* 2009a,

2018; Chakrabarti *et al.*, 2021; Nations, 2016; Psacharopoulos & Patrinos, 2018; Sitali, 2021; Verguet *et al.*, 2020; WFP, 2013b). The HGSFPs represent this approach by providing locally sourced nutritious meals, enhancing human capital development, and supporting SDGs (B. *et al.*, 2009a, 2018; Chakrabarti *et al.*, 2021; Nations, 2016; Psacharopoulos & Patrinos, 2018; Sitali, 2021; Verguet *et al.*, 2020; WFP, 2019). In Ethiopia, the school feeding program integrates with regional agriculture to address hunger and destigmatize school meals for 26.8 million enrolled children (Mideksa *et al.*, 2024; Nutrition Policy Institute, 2023; Zuercher *et al.*, 2024).

School feeding initiatives yield significant benefits across education, health, nutrition, social protection, and economic development (Pellikka, 2019). These programs enhance academic performance, enrollment, attendance, completion rates, literacy, and mitigate dropout and absenteeism (Agu *et al*., 2023; Aurino *et al*., 2019; Buttenheim *et al*., 2019; Jomaa, *et al*., 2011; Mohammed, 2022; Wang *et al*., 2021; WFP, 2020). Additionally, school feeding promotes female literacy, reduces infant mortality, and tackles social issues like forced/early marriages, child labor, and exploitation, fostering gender parity (WFP, 2020; Jean de Dieu *et al.*, 2023).

The SFPs acts as a comprehensive platform for nutritional, health, and educational interventions, showing positive outcomes in energy intake and micronutrient status (Lamis and Elaine, 2011). However, the effects on physical growth, cognitive performance, and academic achievement may vary among countries. Academic performance in SSA nations, including Ethiopia, often lags significantly behind expectations according to the Africa Student Learning Index (Prentice, 2006; Mingat, 2012; Mideksa *et al.*, 2024).

The Ethiopia's SFPs, initiated in 1994, has expanded its reach and becomes HG-SFP (Change, 2016; AUDA-NEPAD, 2019). The WFP played a pivotal role in implementing the HG-SFP worldwide. By collaborating with local governments, communities, and farmers, the WFP has facilitated the establishment and expansion of these programs. Through capacity-building initiatives, technical assistance, and knowledge sharing, the WFP has helped communities develop sustainable food systems that support local economies and enhance food security (FAO, 2018). By leveraging its expertise in logistics and supply chain management, the WFP has ensured the smooth sourcing and distribution of locally produced food to schools participating in these programs. This integrated approach not only promotes the health and well-being of

students, but also fosters community resilience and economic empowerment, aligning with the WFP's mission to eradicate hunger and malnutrition globally (FAO, 2018).

Initiatives like the 'Yenat Weg' program by NGOs and local authorities have been instrumental in providing meals to vulnerable students in Addis Ababa (WFP, 2018a). In 2019, the Addis Ababa City Administration launched a comprehensive SFPs, offering two daily meals to around 360,000 primary school students to ensure equitable access to education (Abebe & Ashenafi, 2021). However, there remains limited information on the quality and safety of school meals, as well as the perceived benefits and challenges within the Addis Ababa SFPs (Consulting, 2021).

In low- and middle-income countries (LMICs), limited access to nutritious foods leads to insufficient dietary diversity and micronutrient deficiencies in school-age children (Ochola & Masibo, 2014; FAO, 2019b). Unhealthy Western-style eating habits exacerbate these deficiencies, resulting in inadequate energy and nutrient intake (Ochola & Masibo, 2014). School meals should provide at least one-third of the recommended daily energy, protein, and nutrient requirements (Ayogu *et al.,* 2018). Establishing safe and comprehensive SFPs is essential for ensuring food and nutrition security for disadvantaged school-age children (Cohen *et al.,* 2021). Nutritious meals play a vital role in the growth and well-being of school-age children and adolescents, with a full-day meal meeting 60-75% of daily requirements (FAO, 2019b; WFP, 2017b). Limited access to nutritious foods in LMICs, like Ethiopia, significantly contributes to an inadequate dietary diversity and micronutrient deficiencies among school-age children (Ochola & Masibo, 2014; FAO, 2019b). Unhealthy eating patterns have been shown to worsen these deficiencies, underscoring the importance of ensuring that school meals offer a variety of nutrients to meet children's daily needs (Ochola & Masibo, 2014; FAO, 2019b).

The impact of SFPs on students' health and nutrition varies. Some studies showed positive effects on body mass index (BMI), body fat, and hemoglobin levels (Zenebe *et al*., 2018; Mulugeta & Asres, 2020; Ayehu & Sahile, 2021; Mekuria *et al*., 2021), while others report no significant impact on stunting, thinness, weight, and hemoglobin levels (Mekuria *et al.,* 2021; Desalegn *et al.,* 2022a; Destaw *et al.,* 2022b). Concerns exist that caloric and nutritional contributions from school meals may not meet recommended levels (Destaw *et al.,* 2022b), emphasizing the need for a thorough assessment of meal adequacy. Ensuring the nutritional needs of school-age children are met requires school meals to provide a substantial portion of

daily energy and nutrient requirements for growth and well-being (WHO, 2006b; Ayogu *et al.*, 2018; FAO, 2019b).

However, deficiencies in Addis Ababa's current SFPs have been noted, with meals falling short of recommended energy and nutrient levels (Destaw *et al.,* 2022b), and lacking essential food items critical for a balanced diet, potentially leading to energy deficits among children (WFP, 2017b; Destaw *et al.,* 2022b). Moreover, these meals do not meet two-thirds of the required intake for adolescents, particularly lacking in fat and phosphorus (McKinley, 2005; Tan *et al.,* 2014; Gregorič *et al.*, 2015; Destaw *et al.,* 2022b).

Ensuring food safety in SFP is also crucial to safeguard consumers, particularly vulnerable groups like children with developing immune systems (Scallan *et al.,* 2011; Dora-Liyana *et al.,* 2018; Global Alliance for Improved Nutrition, 2022). Research highlights the importance of monitoring food safety practices, training food handlers on hygiene, and assessing microbial indicators to uphold meal safety for schoolchildren (Ann & Druff, 2012; Munthali *et al*., 2014; Nagla *et al*., 2014; Mgqibandaba *et al*., 2020). Inadequate food safety practices in mass catering, including SFP, can trigger foodborne illness outbreaks (Ann & Druff, 2012; Munthali *et al.,* 2014). Microbial indicators are essential for overseeing food safety and hygiene practices in the food industry (Lues & Van Tonder, 2007; Moore & Griffith, 2002; Woh *et al.,* 2017). Addressing food safety issues and implementing proper safety measures are vital to reduce foodborne diseases among susceptible children (Ann & Druff, 2012; Nagla *et al.,* 2014; Ababio *et al.,* 2016; Cruz, 2020; Kamboj *et al.,* 2020).

Inadequate food safety knowledge results in unsafe practices and cross-contamination among handlers in food service (Jianu & Chiş, 2012; Martins *et al.,* 2012; Afolaranmi *et al.,* 2015; McGill *et al.,* 2015). Strict supervision and adherence to safety protocols are essential in large-scale food preparation to mitigate the risk of foodborne infections and outbreaks (Mgqibandaba *et al.,* 2020). Understanding the dietary quality, microbial safety, handlers' knowledge, and stakeholder perceptions is vital for safe SFPs. However, gaps persist in ensuring food safety, with reports of contaminants (Ababio *et al.,* 2016; Cruz, 2020). Improving food safety knowledge and practices among handlers is critical to prevent illnesses and ensure meal safety (Ababio *et al.,* 2016; Cruz, 2020). On the other hand, research on stakeholders' perspectives regarding program effectiveness and improvement was limited.

Therefore, this research focused on evaluating the SFPs in Addis Ababa, Ethiopia by assessing the dietary quality of meals, evaluating the microbiological safety, examining food handlers' knowledge and practices, and exploring the perceived benefits and challenges from multiple stakeholder perspectives, including students, parents, teachers, and principals. This study also aimed to address the gaps in understanding stakeholders' perspectives on the effectiveness and improvement of SFPs. The findings of this evaluation provide valuable insights to policymakers, implementers, and stakeholders, facilitating evidence-based decision-making and the improvement of the program's safety, quality, and effectiveness.

1.2 Statement of the Problem

The Addis Ababa SFPs encounter challenges in maintaining meal quality and safety for public primary school students, crucial for their well-being (Desalegn *et al.,* 2022b). Advocates emphasize benefits like hunger alleviation and improved attendance, while critics raise concerns about superficial solutions to malnutrition and stigmatization (Kristjansson *et al*., 2007a).

Ensuring the safety of food served in SFPs is crucial to shield students from foodborne illnesses. Fundamental aspects such as appropriate food handling during preparation and storage, the personal hygiene standards of food handlers, and water used in cooking and cleaning are indispensable for upholding food safety standards. Consequently, it is imperative to assess the food safety knowledge, attitudes, and behaviors of food handlers in school kitchens. Enhancing comprehension and addressing these elements are pivotal for enhancing the overall implementation and effectiveness of school feeding initiatives, ultimately championing the well-being and health of students. Through a focus on enhancing operational understanding and effectiveness, this research endeavors to offer insights that can elevate the impact, sustainability, and overall success of SFPs in Addis Ababa (Gordon, 2010; Oostindjer *et al.,* 2017; Cohen *et al.,* 2021; Liu *et al.,* 2021), ultimately fostering healthier learning environments and empowering students for a brighter future.

Despite the significant investments from donors and national governments in both developed and developing countries, comprehensive research and evaluations of SFPs were lacking (Chai *et al.,* 2007; Lee *et al.,* 2009; Payne-Palacio & Theis, 2016b). Most existing assessments by non-governmental organizations focus primarily on educational outcomes (Kristjansson *et al.,* 2007b; Change, 2016). Recent studies have highlighted challenges in implementing SFPs in Ethiopia (Mideksa *et al.,* 2024), while research on their effectiveness often narrowly examines nutritional or educational impacts, neglecting holistic assessments (Wang *et al.,* 2021). Ongoing debates about the effectiveness and evaluation methods of these programs persist (Gertler *et al*., 2016), with challenges in connecting hunger to academic performance requiring further methodological exploration (Tomlinson, 2007b). Although SFPs can improve enrollment and attendance, they may not address the root causes of malnutrition and hunger, with evidence suggesting limited impacts on academic achievement (Dheressa, 2011).

The SFPs are essential for providing nutrition to children from low-income backgrounds, sparking debates on their effectiveness and assessment methods (Gordon, 2010; Gertler *et al*., 2016; Cohen, *et al*., 2021; Liu *et al*., 2021). Advocates stress hunger alleviation and enhanced school attendance, while critics voice concerns about stigma and the limited impact on addressing malnutrition (Kristjansson *et al*., 2007a;). Rigorous research, especially for vulnerable children in Ethiopia, is crucial for informed decision-making on program design, implementation, and funding (Yabanci, 2005; Tomlinson, 2007b), with locally implemented initiatives facing challenges that require further investigation to address local issues and explore long-term effects (Poppe *et al.,* 2017; Aregawi, 2012; Desalegn *et al.,* 2022b; Mohammed *et al.,* 2023b).

The SFPs in Ethiopia present varied findings, emphasizing the requirement for further research to grasp their effects on health and education outcomes (Dheressa, 2011). While some studies show positive impacts, others indicate no significant changes in metrics like enrollment and academic performance (Dheressa, 2011; Aregawi, 2012; Mohammed, 2018; Mekuria *et al*., 2021; Desalegn *et al*., 2022a; Mideksa *et al*., 2024). Discrepancies in study findings on enrollment and academic performance can arise from several factors. Variations in research design, sample size, and population demographics can lead to different outcomes. Challenges such as food quality and financial limitations contribute to differing outcomes, emphasizing the necessity for deeper insights into the effects on nutrition and academics in Ethiopian programs (Dheressa, 2011; Mideksa *et al.,* 2024). In regions like the Sidama in Southern Ethiopia, programs have demonstrated increasing effectiveness, enhancing attendance, academic performance, and reducing dropout rates over time (Desalegn *et al.,* 2021). Similarly, in Addis Ababa, school meal initiatives were linked to improved educational outcomes, particularly benefiting female students by enhancing academic achievements and increasing enrollment rates (Destaw *et al.,* 2022a).

Research gaps persist on understanding the impact of school meals on dietary intake in developing nations like Ethiopia, with limited focus on adolescent dietary intake and the need to evaluate dietary and nutrient intake due to prevalent unhealthy eating habits (Ochola & Masibo, 2014; Au *et al.,* 2018). Effective SFPs necessitate insights on intervention timing, addressing dietary gaps, ensuring food safety, and considering stakeholders' perspectives (Marzano &

Balzaretti, 2013; Ochola & Masibo, 2014; American, 2017; Silva, 2022). Conflicting research findings on the influence of school meal consumption on diet quality underscore the necessity of precise data for targeted health and nutrition interventions (Hanson & Olson, 2013). The nutritional composition and serving sizes of school meals significantly influence the quality and quantity of nutrients acquired by students, emphasizing the importance of accurate dietary intake information for guiding tailored health and nutritional interventions for children and adolescents (American, 2017).

However, a research gap exists concerning school meal consumption and its effects on overall dietary intake, particularly in countries like Ethiopia (Ochola & Masibo, 2014; Au *et al.*, 2018). Evaluating the dietary and nutrient intake of school-aged children and adolescents is vital for assessing their nutritional well-being (Ochola & Masibo, 2014). Some studies demonstrate positive correlations between school meal consumption and diet quality, while conflicting findings suggest a lack of consensus (Clark & Fox, 2009; Hanson & Olson, 2013; Cohen *et al.*, 2014; Au *et al.*, 2016; Kinderknecht *et al.*, 2020).

Ensuring the safety and nutritional value of school meals is essential for protecting children from microbial risks and promoting their health (Petruzzelli *et al.*, 2018). Contamination of food and water can contribute to the transmission of microbial diseases, emphasizing the importance of maintaining proper hygiene during food preparation and handling (Nkere *et al.*, 2011; Solomon & Oguoma, 2017). Challenges and research gaps hinder effective implementation, including issues related to water quality and inconsistent data on large-scale school meal programs (Marzano & Balzaretti, 2013; Global Child Nutrition Foundation (GCNF), 2022).

Addressing food safety in Ethiopia necessitates meticulous consideration of various factors such as dietary quality, food safety protocols, food handler expertise, and stakeholder perspectives (Ayalew *et al.*, 2013; Stephen *et al.*, 2018; Global Alliance for Improved Nutrition, 2022).. Inadequate implementation of safety measures in school meal programs presents significant challenges to food safety, jeopardizing the well-being of children and adolescents (Chai *et al.*, 2007; Dag, 2020; Kortei *et al.*, 2020). Governments and stakeholders prioritize ensuring safe food due to its profound impact on health, growth, development, and educational outcomes, underscoring the need for improved coordination and stricter regulations at the federal level

(Chai *et al*., 2007; Ayalew *et al*., 2013; Ababio *et al*., 2016; Dag, 2020; Kortei *et al*., 2020; Global Alliance for Improved Nutrition, 2022).

The research aims to fill critical gaps in the Addis Ababa SFPs by assessing the dietary and microbiological quality of meals, evaluating food safety practices among handlers, and exploring stakeholder perspectives. By analyzing nutritional and microbiological aspects, assessing food handlers' safety knowledge, and gathering viewpoints from students, parents, teachers, and principals, the study seeks to enhance program understanding and effectiveness.

Ethiopia's SFP faces challenges in responsibilities, finances, and organization (Rongen *et al.*, 2023). Issues span food quality, resources, stakeholder collaboration, and late deliveries due to procurement processes (Haile & Ali, 2019; Mideksa *et al.*, 2024) (Desalegn *et al.*, 2022b). Ensuring clean water, timely rations, and program infrastructure is problematic (Desalegn *et al.*, 2022b). Financial constraints and food quality persist as barriers (Mideksa *et al.*, 2024). Persistent obstacles include inflation, storage inadequacies, rising costs, bureaucracy, lack of support, and reluctance to change (Azubuike & Mbah, 2019; Mossmann *et al.*, 2017).

Closing these gaps could significantly improve the quality, safety, and impact of the Addis Ababa SFPs, potentially leading to tailored interventions that address hunger, enhance educational outcomes, and ensure student well-being. In light of the program's significant impact, persistent challenges call for in-depth research, targeted interventions, and increased collaboration among stakeholders to prioritize student welfare and pave the way for a brighter future for generations to come. This study is focused on evaluating the dietary and microbiological quality, examining food safety practices, and understanding stakeholder perspectives within the Addis Ababa SFPs.

1.3 Research Questions

Based on the statement of the research problem discussed above, the present study addressed the following research questions:

1. Do the school meals delivered through the SFP in Addis Ababa fulfill the expected dietary quality?
2. Do the school meals delivered through the SFP in Addis Ababa fulfill the expected microbial safety standards?
3. Is the level of food safety knowledge, attitudes, and practices (KAP) among food handlers involved in the SFP in Addis Ababa optimal?
4. What are the perceptions of parents, students, teachers, and government principals regarding the perceived benefits and challenges of SFP in Addis Ababa?

1.4 Objective

1.4.1 General Objective

The study aimed to assess the quality and safety of school meals and explore the perceived benefits and programmatic challenges of the school feeding program in Addis Ababa.

1.4.2 Specific Objectives

1. To assess the dietary quality of meals provided through school feeding program in Addis Ababa.
2. To evaluate the microbiological quality of meals of the school feeding program in Addis Ababa.
3. To examine the food safety knowledge, attitudes, and practices of food handlers in school feeding program in Addis Ababa.
4. To explore the perceived benefits and challenges of school feeding program in Addis Ababa

1.5 Significance of the Study

The significance of this research study is paramount for the SFPs in public primary schools in Addis Ababa, focusing on assessing dietary and microbiological quality of meals to meet nutritional standards and uphold food safety. Additionally, it examines food safety practices among handlers to enhance meal safety and reduce contamination risks. Furthermore, the study explores stakeholder perspectives including students, parents, teachers, and principals to understand the perceived benefits and challenges of the SFP, aiming to inform improvements, shape policies, and enhance program effectiveness for the well-being of students in Addis Ababa.

The comprehensive evaluation of dietary quality within the framework of the SFPs not only serves as a crucial assessment, but also as a catalyst for improvement. This meticulous examination aims to identify and address any shortcomings in the nutritional content and balance of meals provided to students. By pinpointing areas of inadequacy and proposing actionable enhancements, this study strives to guarantee that students receive meals that are not only filling but also nutritionally sound, supporting their overall health, growth, and cognitive development. The significance of this research lies in its potential to revolutionize the meal offerings within the SFPs, ensuring that students are not only fed, but are nourished in a manner that optimally supports their well-being and academic performance.

Simultaneously, the scrutiny of the microbiological quality of school meals represents a critical component in the realm of student safety and well-being. By delving into the intricacies of potential contamination sources and the presence of harmful microorganisms, this study plays a pivotal role in fortifying the food safety protocols embedded within the SFPs. Through the identification and mitigation of risks associated with foodborne illnesses, this research contributes significantly to safeguarding the health and welfare of students. The assurance of safe and hygienic meal provisions not only fosters a conducive learning environment but also instills confidence in the community regarding the integrity of the feeding programs, ultimately prioritizing the well-being of the students they serve.

Examining food safety knowledge, attitudes, and practices among SFPs food handlers is essential for overall meal safety. This analysis informs the development of strategies to bolster meal safety by identifying areas for improvement and enhancing food handling practices. By evaluating food

safety knowledge and adherence to practices, the study aims to identify training needs and support mechanisms for food handlers, ultimately reducing the risk of food contamination.

Investigating the perceived benefits and challenges of the Addis Ababa SFPs from multiple stakeholder viewpoints is highly significant. This qualitative assessment provides a comprehensive understanding of the program's impact and areas needing improvement. By capturing stakeholders' voices and experiences, the study can highlight program strengths, address challenges, and shape policies and interventions to better align with stakeholder needs.

The significance of this study lies in its thorough evaluation of the SFPs in Addis Ababa, offering valuable insights into meal quality, food safety, and stakeholder perspectives. The findings and recommendations have the potential to shape national policy decisions, promoting the establishment of effective and safe SFPs. This research serves as a crucial resource for the public, donors, academia, policymakers, and stakeholders, facilitating informed decision-making and supporting evidence-based improvements in SFPs across the country.

CHAPTER 2: LITERATURE REVIEW

3.1 History of School Feeding

3.1.1 Global Perspective

The SFPs have a long history, beginning in 1790 when Benjamin Thompson initiated a program in Munich, Germany, providing schooling and meals to hungry children in exchange for part-time work (Yendaw & Dayour, 2015; Tagoe, 2018; Dapo-famodu, 2021). Throughout the 1800s, the idea spread across Europe, with France establishing a school lunch program for disadvantaged children in 1867 (Kidanemariam, 2019). During the mid-1800s, the Children's Aid Society of New York and the Starr Center Association of Philadelphia provided lunches in the United States (Bundy *et al.*, 2012).

In 1906, the UK government prioritized school meals (Bundy *et al.*, 2012). School meals had become widespread in high-income countries by the 19th century (Dapo-famodu, 2021). The Netherlands formalized a national program in 1900 (Kidanemariam, 2019). In Brazil, the School Nutrition and Food Security Program was introduced in 1945 after World War II, adopting a decentralized approach with local school meals councils (Swartz, 2009; WFP, 2009). Brazil also recognized the right to food and emphasized socioeconomic entitlements in their Constitution since 2010 (Lesley *et al*., 2016). The SFPs gained global significance post-war, being integrated into food assistance, disaster relief, and development initiatives (Kidanemariam, 2019).

India also has a long history of state-funded school food programs, often with external aid (Yunusa, 2012). In the early 1940s, South Africa implemented a program providing free milk and complete meals to students (Tomlinson, 2007b) and as well addresses past inequalities, guided by post-apartheid policies (Lesley *et al*., 2016).

Chile has a 60-year history of SFPs, progressing from fortified powdered milk to providing fresh, affordable food items. In Ghana, school feeding began in the 1950s with take-home rations for Catholic schools, aiming to improve nutrition and enrollment rates. Kenya's school milk program started in 1979, but ended due to cost constraints, leading to a partnership with the UN WFP in 1980 (Lesley *et al*., 2016).

In the early twentieth century, SFPs were recognized as a means to achieve more than just short-term hunger relief for schoolchildren. They became viewed as a strategy to accomplish social and agricultural objectives (Dapo-famodu, 2021). The perspective on school feeding underwent a significant shift in the twentieth century, considering it a tool for social change and development goals, particularly in response to the food, fuel, and financial crises of 2008. This transformation reshaped global thinking regarding school feeding. Today, government-supported SFPs exist in some form in almost all countries worldwide (World Bank, 2018; Dapo-famodu, 2021)

3.1.2 School Feeding Program in Ethiopia

In Ethiopia, the WFP-sponsored SFP began as a pilot project in 1994 in the Tigray Region, providing hot meals to 250,000 children in 40 schools in conflict-affected areas (Change, 2016; Gallenbacher, 2018; Xie & Brownell, 2020). In 2008, the WFP provided school meals to 915 schools, benefiting 482,000 children. Each child received a food ration consisting of 150 grams of corn-soya blend (CSB), 6 grams of fortified vegetable oil, and 3 grams of iodized salt. These meals were provided as cooked meals on every school day (Poppe *et al.,* 2017).

The program expanded to include chronically food insecure districts in Afar, Amhara, Oromia, SNNPR, Somali, and Tigray, prioritizing districts with low enrollment and high gender disparity. It further extended to other vulnerable areas, such as pastoralist regions and chronically food-deficient highland districts, to promote school attendance (Poppe *et al.,* 2017). Over time, the program's coverage increased, benefiting over a million children in drought-affected areas by 2019. Ethiopia's national nutrition program (NNP) recognizes HG-SFP as a crucial intervention for addressing malnutrition (Desalegn *et al.,* 2022b).

In 2016, the HG-SFP transitioned from being WFP-led to a government-owned initiative and was renamed the Students Feeding Agency through legislation in 2020 (Xie & Brownell, 2020). The Ethiopian government has implemented various programs and strategies to address the nutritional needs of school-age children, including the Ethiopia School Meal Initiative (ESMI), which provides meals to 3,000 students and promotes milk production through school-owned cows (Consulting, 2021).

The HG-SFP is now part of Ethiopia's educational development strategy. It aims to combat hunger and food insecurity among school children (Destaw *et al.,* 2022a). The program is

implemented in various regions, with different models such as government-led in Addis Ababa, donor-led in Afar and Somali, and community-led in Oromia region (Demoze and Alex, 2023).

The HG-SFPs is a program that provides domestically produced and purchased food for school feeding. The WFP focuses on integrating SFPs with local agricultural production to support local farmers, households, and small businesses. The HG-SFP also offer culturally relevant and indigenous food to school children (WFP, 2017a).

3.1.3 The School Feeding Program in Addis Ababa

The Addis Ababa School Feeding Program initiative aims to combat hunger in public elementary schools while simultaneously improving both nutritional and educational outcomes. This program serves as a cornerstone in advancing food and nutrition security, particularly benefiting disadvantaged schoolchildren and bolstering the overall sustainability of the food system. Through the provision of essential meals, it lightens the financial load on marginalized families who face challenges in affording nourishing food for their children.

The government-owned SFP began in Addis Ababa in 2019 (Destaw *et al.*, 2022a), following pilot phases in the SNNP and Oromia regions from 2012 to 2014. It later expanded to all regional states and Dire Dawa city administration (Memirie, 2023). (Memirie Solomon, 2023). Transitioning from traditional methods, the program shifted to HG-SFP (Drake *et al.*, 2020). While previous programs mainly addressed hunger by serving purchased meals, HG-SFP aims for broader impacts, including enhancing food security, education, social protection, poverty reduction, household food security, and rural agricultural development (Bundy *et al.*,2017; Drake *et al.*,2020; WFP, 2020).

In 2022/23, the government-sponsored SFP benefited over 6 million school children, with Oromia having the highest number of beneficiaries over 5 million, followed by Addis Ababa with over 700,000. Addis Ababa City administration allocated 75.5 million USD for the program during that academic year (Memirie, 2023). The SFP in Addis Ababa provides breakfast and lunch to pre-primary and primary students in grades 1-8, following a specific meal menu (Ababa *et al*., 2021; Memirie, 2023). The program, funded by the city administration, serves two meals per school day and has been replicated in other regions. To ensure sustainability, a school feeding agency was established to manage the program effectively (Ababa *et al.*, 2021).

3.2 Socioeconomic Impacts and Potential of School Feeding Program

School meals programs are now prioritized by governments due to their multifaceted benefits. These programs not only contribute to education but also provide crucial support to vulnerable families. Nutritionally balanced school meals, combined with nutrition education and health measures, enhance child development, reduce hunger, and yield short- and long-term advantages. Integrating local food production into school meals programs supports local producers, economies, and long-term food security (WFP, 2017b).

The SFPs combat child hunger, boost school attendance, decrease absenteeism, and enhance cognitive abilities. They improve health and nutrition outcomes for schools and households, incorporating nutrition education and behavioral change interventions for students and communities. Moreover, these programs generate job opportunities in meal preparation for both women and men (WFP, 2013c; Drake *et al.,* 2017).

Investing in education is crucial for economic growth, with higher returns compared to physical capital investments (AFRICA, 2014). The SFP not only contribute to improved health, education, and productivity in adulthood, but they also positively impact local agricultural production, stimulate market development, and alleviate household expenses, especially during crises when take-home rations are provided (Bundy *et al.*, 2012).

Evaluations conducted by WFP country offices have demonstrated the positive outcomes of SFPs, including improvements in education, nutrition, health, school management, household outcomes, and the School Meal Safety Net. Successful HGSFP initiatives have shown positive results in school enrollment, attendance, cognitive skills, and economic benefits (WFP, 2013c Drake *et al.,* 2017). These programs generate long-term economic returns, with an estimated USD 3 to 10 return for every USD 1 investment in health, education, and productivity during adulthood (African Union Commission, *et al.,* 2014b).

Community participation is a crucial aspect of strong and sustainable SFPs, with local ownership and contributions being key factors. However, effective coordination, accountability, and sustainability require strong policy support. Successful programs are those that align with community needs and engage in local agricultural production for greater economic benefit (WFP, 2013c; Drake *et al.,* 2017). Despite the importance of SFPs, empirical studies often suffer

from methodological shortcomings and weak quality, leading to biased findings (Adelman *et al.*, 2008).

3.2.1 Impact of School Feeding Program on Nutritional and Educational Outcomes

The SFPs enhance attendance, cognitive abilities, and learning with nutritious meals, along with deworming and micronutrient provision. They improve children's nutritional status and educational outcomes, fostering attentiveness, engagement, and better behavior in class (Bundy *et al.*, 2006).

Global studies reveal improved test scores, attendance, and study skills, with trials showing increased enrollment and reduced dropouts (Ahmed, 2004; Matrices *et al*., 2008). These programs benefit school enrollment, attendance, cognitive skills, and community economics, also boosting smallholder farmers' productivity through SFPs (WFP, 2013d; Drake *et al.*, 2017).

The impact of school meals on performance varies with food type, ration size, and program duration, showing significant effects in low-participation areas and among initially malnourished children (Adelman *et al.*, 2008).

Nutritional interventions, particularly providing meals in the morning, have demonstrated improvements in cognitive function and school attendance (Acham *et al.*, 2012; Alderman *et al.*, 2012; Hochfeld *et al.*, 2016). A systematic review and meta-analysis of SFPs in low- and middle-income countries revealed positive effects on growth, weight gain, and school attendance. Compared to control groups, SFPs resulted in significant increases in height, weight, and the percentage of school days attended (Wang *et al.*, 2021).

3.3 Dietary Quality of Meals Provided through the School Feeding Program

3.3.1 Nutritional Contributions and Adequacy of School Meals

During primary school years, children undergo significant mental, physical, and behavioral growth, making proper nutrition essential for their healthy development. Adequate energy from carbohydrates, along with essential nutrients such as proteins, vitamins, and minerals, is crucial for metabolism and disease prevention (Wiseman, 2003). Poor nutrition during childhood can have long-term negative consequences (Dewey & Begum, 2011; Ampaabeng & Tan, 2013; Soliman *et al.*, 2021). To ensure a healthy childhood, children should receive a nutritious diet

that meets recommended dietary requirements, including sufficient protein, carbohydrates, fats, vitamins, and minerals. The RDA is commonly used as a reference for necessary nutrient intake (Wiseman, 2003).

Research conducted in Addis Ababa revealed that school meals contributed around one-third of the RDA for proteins and carbohydrates, but fell short for fat, failing to meet the two-thirds (60%-75%) requirement for adolescents (Destaw *et al.,* 2022b). Similar findings were observed in school meals in Nigeria, Ghana, and Spain, where fat content was less than one-third of the daily requirement, despite including sources rich in oleic, linoleic, and palmitic acids (Tan *et al*., 2014; Agbozo *et al.,* 2018; Ayogu *et al.,* 2018; Lavall *et al.,* 2020).

Regarding dietary fiber, the study found that early adolescents received adequate servings from school meals, while older children did not, likely due to the composition of meals, particularly the presence of fiber-rich cereals like wheat and Teff (Destaw *et al.,* 2022b). Adequate fiber intake is essential for waste removal and preventing physiological problems; however, a study in Slovenia reported that school meals did not meet minimum dietary fiber requirements (Gregorič *et al.,* 2015).

In terms of specific nutrients, thiamine levels in school meals met nearly two-thirds of the requirement for younger children but fell short for adolescents. Riboflavin contributions were also below two-thirds of the daily requirement, potentially due to the absence of riboflavin-rich foods (Destaw *et al.,* 2022b; Tugault-Lafleur & Black, 2020). Niacin content was extremely low, primarily because niacin-rich foods were missing. Although iron levels met recommendations—similar to findings in Ghana but different from those in Nigeria (Destaw *et al.,* 2022b), but different from those in Nigeria (Ayogu *et al.,* 2018). The calcium content of school meals in Addis Ababa was in line with the RDA for early adolescents (Destaw *et al.,* 2022b) but fell below the daily RDA for late adolescents, consistent with findings in Nigeria (Ayogu *et al.,* 2018).

Efforts are underway to enhance the nutritional adequacy of school meals through well-designed SFPs that have introduced programs for micronutrient fortification and the provision of nutritious foods aligned with RDAs. Linking these programs with local food production has also proven beneficial for both rural economies and the nutritional quality of the meals provided (WFP, 2013d; Drake *et al*., 2017).

Increasing food and nutrient consumption among school-aged children can lead to significant benefits, including improved weight, reduced susceptibility to infection, and enhanced cognitive development. Even when fortified meals do not meet energy requirements, they can improve micronutrient intake. Children with low energy or micronutrient intake during early childhood can experience notable improvements in physical and mental growth in a short time frame (Adelman *et al*., 2008).

Randomized trials have demonstrated the potential of SFPs to address energy deficiencies, showing that these programs can increase daily energy consumption in children whose intake was previously inadequate. Iron fortification and deworming initiatives have shown positive interactions in improving nutritional outcomes, and participation in Feed for Education (FFE) programs has been linked to gains in physical growth (Adelman *et al*., 2008).

Furthermore, studies show varying results regarding the nutritional composition of school meals across different regions. In Ghana, SFP participants had higher energy and nutrient intakes, lower prevalence of anemia, and higher hemoglobin concentrations compared to non-participants (Abizari *et al*., 2014). In the United States, school lunches were associated with better overall diet quality than lunches brought from home (Au *et al*., 2016). However, in Portugal, the average energy and carbohydrate contents of school lunches did not meet reference values, although protein content exceeded recommendations. Total fat and saturated fatty acid levels were within guidelines, but salt and dietary fiber content exceeded recommended limits (Nogueira *et al*., 2021). These findings highlight the ongoing need for continuous monitoring and improvement of the nutritional content of school meals to better support children's health and development.

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2021). These findings highlight the ongoing need for continuous monitoring and improvement of the nutritional content of school meals to better support children's health and development.

3.4 Microbiological Quality of School Meals and Drinking Water Served to Students in the School Feeding program

3.4.1 Faecal Contamination and Foodborne Pathogens

The presence of faecal contamination in food and water poses a significant risk for transmitting gastrointestinal pathogens (Oluwapelumi *et al.,* 2020). Coliform bacteria, including enteric pathogens like Salmonellae and Shigellae, are commonly found in the intestines of humans and animals. The detection of coliforms in food and water indicates faecal contamination, which increases the likelihood of exposure to pathogens and the development of diseases such as diarrhoea and typhoid fever (Nkere *et al.*, 2011; Oluwapelumi *et al.,* 2020).

Faecal indicator organisms, like E. coli, are frequently identified in food samples, serving as indicators of potential faecal contamination and poor hygiene practices. Staphylococcus aureus, another common foodborne pathogen, can produce toxins that cause food poisoning. Understanding the growth conditions and routes of transmission for these pathogens is essential for ensuring food safety. In particular, inadequate personal hygiene, especially among food handlers, significantly contributes to food contamination. Additionally, improper storage conditions can create an environment that fosters the multiplication of pathogens in food, reaching infective levels (Oluwapelumi *et al.*, 2020).

3.4.2 Microbial Indicators for Evaluating the Safety of Drinking Water

The microbial safety of drinking water is primarily assessed based on the risk of enteric diseases. Testing for every potential enteric pathogen is impractical, so the evaluation of microbial safety relies on detecting indicators of faecal pollution (Leclerc *et al.,* 2001). Microbial indicators of faecal pollution are organisms that are abundant in human or animal faeces. Their presence suggests possible contamination of the water source or distribution system with faecal matter, indicating the potential presence of enteric pathogens. These microbial indicators themselves are generally not human pathogens (Verhille, 2013).

Four main indicators are commonly used to assess the microbial safety of drinking water: Heterotrophic Plate Counts (HPC), *TC, FC,* and *E. coli* (Leclerc *et al.*, 2001; Verhille, 2013).

The HPC refers to colony counts of heterotrophic bacteria, which provide an estimate of the overall load of aerobic and facultative anaerobic bacteria in a water sample. The HPC is also known as Standard Plate Count (SPC), *APC*, or *TPC* (Leclerc *et al.,* 2001; Verhille, 2013). The total coliform group consists of various bacteria primarily found in the environment, while the fecal coliform group is a subset of the total coliform group predominantly found in faeces. *E. coli* belongs to the fecal coliform group and is specifically associated with the intestinal tract of warm-blooded animals (Verhille, 2013).

3.4.3 Microbiological Quality Assessment and Handling Practices in Food and Water

Consuming food contaminated with pathogens or bacterial toxins poses health risks to individuals (Tan, Lee, *et al*., 2013; Woh *et al.,* 2017). Food handlers play a significant role in transmitting microbiological agents to food, either through contact with human body parts or cross-contamination between different food items (Malhotra *et al.,* 2008; Woh *et al.,* 2017). Poor personal hygiene and frequent contact of hands with raw food, faeces, nose, skin, or genital regions can heavily contaminate hands with enteric pathogens (Chua *et al.,* 2015; Woh *et al.,* 2017). Furthermore, improper handling and unhygienic practices during food preparation contribute to food contamination by pathogens, leading to illnesses among consumers (Woh *et al.,* 2017).

The microbiological quality assessment of food and water provides insights into the level of microbial contamination. Bacterial counts in prepared food and water serve as indicators of the hygiene practices adopted by food handlers. Contamination of food and water can contribute to the transmission of microbial diseases, emphasizing the importance of maintaining proper hygiene during food preparation and handling (Nkere *et al.,* 2011; Solomon & Oguoma, 2017).

The study conducted on the bacteriological quality and food safety of a Brazilian school food program found no presence of Salmonella or Listeria monocytogenes in the samples analyzed. However, coliforms were detected in 52.9% of the samples, while Escherichia coli and Staphylococcus aureus were present in 1.5% and 32.4% of the samples, respectively (Nagla *et al.,* 2014).

3.5 Food Safety Knowledge, Attitudes, and Practices of Food Handlers Participating in the School Feeding Program

Food safety is a pressing public health issue in Ethiopia, as well as in other developing countries. Lack of knowledge and poor food handling practices have been identified as major contributors to foodborne diseases and diarrheal-related morbidity. Historically, food safety has received insufficient attention from governments and the general public, leading to outbreaks of foodborne diseases associated with unsanitary conditions in catering establishments (Abate *et al.,* 2017; Birke & Zawide, 2019; Bulto *et al.,* 2022).

In Malaysia, a study revealed a positive correlation between knowledge, attitudes, and practices among food handlers. Participants demonstrated good knowledge scores in personal hygiene and foodborne diseases, along with positive attitudes and good practices. However, a significant percentage of respondents had never received food safety training, resulting in insufficient knowledge in certain areas (Abdullah Sani & Siow, 2014).

Similar findings were observed in Addis Ababa, Ethiopia, where a study found that a majority of food handlers had good knowledge, attitudes, and practices regarding food safety. Factors such as training, age, work experience, education level, and employment status were associated with better attitudes and practices (Fekadu *et al.,* 2024).

In Ghana, food handlers exhibited good knowledge of hygienic practices, particularly in handwashing. However, there were knowledge gaps regarding specific foodborne pathogens, with notable percentages unaware of Salmonella and hepatitis A as foodborne pathogen. Nonetheless, a majority recognized other diseases transmitted through food (Akabanda *et al*., 2017c). The significance of experience and training in improving knowledge, attitudes, and practices among food handlers was highlighted in a study conducted in school kitchens in Espírito Santo, Brazil (da Vitória *et al*., 2021).

At Kotebe Metropolitan University in Addis Ababa, Ethiopia, food handlers in the student cafeteria consistently demonstrated good knowledge and practice of food safety, including proper handwashing, washing of vegetables and fruits, and wearing appropriate safety clothing (Bulto *et al.,* 2022).

Similar concerns were observed in Accra, Ghana, where food handlers in institutional food service establishments exhibited negative attitudes towards food safety and inadequate knowledge and practices (Abate *et al.,* 2017).

In Hulu Langat district, Malaysia, inadequate hand hygiene knowledge was found among food handlers, particularly concerning RTE foods and proper handwashing methods. However, there was a slight positive correlation between hand hygiene knowledge and self-reported practices (Siew *et al*., 2013).

Overall, training has been shown to have a positive impact on food safety knowledge among food handlers, emphasizing the importance of periodic recertification. Higher education levels were associated with greater knowledge, and food handlers demonstrated high levels of knowledge in surface and utensil hygiene as well as food storage practices. Language barriers and training methodologies were identified as potential factors influencing food safety knowledge (Jianu & Chiş, 2012; Martins *et al.,* 2012; Panchal *et al.,* 2012)

Food handlers in Accra, Ghana's institutional food service establishments exhibited negative attitudes towards food safety and inadequate knowledge of contamination sources, cross-contamination, appropriate food holding temperatures, and poor practices like multiple freeze-thaw cycles and infrequent handwashing after coughing or sneezing (Kunadu *et al.,* 2016).

Similarly, a study conducted in Slovenia revealed inadequate knowledge among food handlers regarding microbiological hazards, correct hot holding temperatures, organoleptic methods for detecting food contamination, and risks associated with handling food while experiencing health issues (Jevšnik *et al.,* 2008).

Storing food in the danger zone was identified as a significant knowledge gap in safe food handling practices in Accra, Ghana (Kunadu *et al.,* 2016). Factors such as low participation in food training programs, low educational levels, and language barriers were associated with poor knowledge levels (Onyeneho & Hedberg, 2013; Woh *et al.,* 2016).

Mishandling and neglecting hygiene measures by food handlers can lead to the transmission of various pathogens, including Hepatitis A, noroviruses, typhoidal Salmonella, Staphylococcus aureus, and Shigella spp, through their hands, cuts or sores, mouth, skin, and hair (Sharif *et al.,* 2013). Additionally, food handlers may shed foodborne pathogens like E. coli O157:H7 and non-

typhoidal Salmonella during the infectious or recovery period following gastrointestinal illness (Gonçalves *et al.,* 2013).

3.5.1 Food Safety Handling Measures in School Feeding Program

Ensuring food safety in SFPs is a significant challenge, particularly in resource-constrained settings (Fotopoulos *et al.,* 2011; Jomaa *et al.,* 2011). These programs, designed to address poverty and hunger, often face limitations that hinder the implementation of proper food safety systems (Baş *et al.,* 2006; Fotopoulos *et al.,* 2011). The large-scale food handling involved in SFPs increases the risk of contamination, leading to outbreaks of foodborne illnesses (Akabanda, Hlortsi, & Owusu-kwarteng, 2017a). Cross-contamination during food preparation is a common cause of food poisoning in schools, emphasizing the critical need for proper food handling procedures (Sanlier & Konaklioglu, 2012a; July *et al*., 2017). Reports of foodborne disease outbreaks in schools, such as in Brazil and South Africa, further highlight the importance of ensuring food safety in school meals (Santana *et al.,* 2009; Akabanda *et al.,* 2017a).

Research conducted in South Africa revealed concerning findings regarding food handlers' knowledge and practices in SFPs (July *et al*., 2016a). There were significant gaps in their understanding of food safety measures. For instance, a majority of food preparation facilities lacked a HACCP program, and food handlers were often unaware of HACCP. Inadequate practices, such as improper cutting board washing procedures and failure to sanitize utensils after handling raw meat, were also observed (July *et al*., 2016a).

Studies conducted in Ethiopia, including in Jimma and Bahir Dar, have identified issues such as inadequate waste management, poor personal hygiene among food handlers, and unsatisfactory sanitary conditions in catering establishments (Mendedo *et al.,* 2017; Neme *et al.,* 2017). Assessments of food handlers' personal hygiene revealed deficiencies in adhering to proper practices (Legesse *et al.,* 2017; Neme *et al.,* 2017).

Factors linked to low levels of food safety practices among food handlers include age, marital status, years of service, monthly income, food hygiene and safety training, attitude, and knowledge depth (Tessema *et al.,* 2014; T Mekasha, 2016; Legesse *et al.,* 2017; Mendedo *et al.,* 2017; Chekol *et al.,* 2019a). In Jigjiga Town, inadequate food hygiene practices were found among meat handlers, with their knowledge and safety practices falling below acceptable levels

(Tegegne *et al.*, 2017b). Similarly, a study at a student cafeteria in Addis Ababa University documented poor food handling practices (Meleko, 2015). These findings emphasize the importance of targeted interventions and training programs to improve food safety practices among food handlers in various settings.

It is important to recognize the impact of food safety on children, as they are particularly vulnerable. Previous studies primarily focused on educational performance and enrollment in SFPs, with limited attention to cognitive development and nutrition (Adelman *et al*., 2008; Steven *et al*., 2018). However, the World Bank estimates that unsafe food costs low- and middle-income economies approximately USD 110 billion annually in reduced productivity, illness, disability, and medical expenses (Steven *et al*., 2018).. To address these challenges, stronger regulatory frameworks, behavior change interventions, and an inclusive approach involving all stakeholders in the food chain are recommended (Steven *et al*., 2018).

Despite extensive studies on educational and nutritional outcomes, there is a lack of specific research on food safety in SFPs (Adelman *et al.*, 2008). Moreover, there is a need for studies assessing food safety awareness, knowledge, attitude, and practices among food handlers in primary schools in Addis Ababa.

Ensuring food safety in SFPs is crucial but challenging. Limitations in resource-constrained settings hinder the implementation of proper food safety systems. Cross-contamination and inadequate practices pose risks to children's health. Addressing these risks, improving food handlers' knowledge and practices, and strengthening regulatory frameworks are essential for enhancing food safety in school meals. Further research is needed to fill the gaps in understanding and improve food safety practices in SFPs.

3.5.2 Foodborne Pathogens and Food Safety Practices

Food handling practices play a crucial role in preventing foodborne illnesses caused by pathogens and spoilage microorganisms (Tegegne *et al.*, 2017a; Chekol *et al.*, 2019a). Contaminated food is responsible for millions of cases of foodborne infections worldwide (Minis-, 2009; Sanlier, 2012). The prevalence and diversity of foodborne diseases have been on the rise (Tessi *et al.*, 2002).

Following proper practices at every stage of the food production process, including production, processing, storage, handling, and preparation, is essential for ensuring food safety (Sanlier, 2012; Ayelign, 2017). Inadequate agricultural methods, poor sanitation, lack of preventive measures in food processing, chemical misuse, contaminated inputs, and improper storage and handling can compromise food safety. Good hygiene practices and the implementation of food safety management principles, such as the HACCP system, are crucial (Santana *et al.*, 2009). Prerequisite programs like good manufacturing practices (GMP), standard operating procedures (SOP), and employee hygiene practices further enhance the effectiveness of the HACCP plan (Santana *et al.*, 2009).

Foodborne diseases occur when contaminated or unsafe foods and beverages are consumed, posing risks to human health (Grace, 2015). These hazards can be classified into three types: biological hazards (viruses, bacteria, protozoa, molds, and parasites), chemical hazards (industrial chemicals, natural compounds, phycotoxins, mycotoxins, and hazardous metals), and physical hazards (stones, metal or glass fragments, nanomaterials, and radionuclides) (Grace, 2015). By implementing rigorous food safety practices and addressing these various hazards, the risk of foodborne illnesses can be significantly reduced, ensuring the safety of the food consumed by individuals.

3.5.3 Factors Affecting Food Safety Practices in School Feeding Program

Food safety practices among food handlers in SFPs play a critical role in preventing foodborne disease outbreaks. However, research indicates that many food handlers in various food service establishments lack essential food safety competencies, such as temperature management, personal hygiene, and cross-contamination prevention (July *et al*., 2016b). Poor personal hygiene practices, inadequate cooking, unsafe food sources, contaminated equipment, and improper food storage are identified as major causes of foodborne disease outbreaks (Sanlier & Konaklioglu, 2012b; Del Portal & Karras, 2013; July *et al*., 2017).

Studies examining food-handling practices in school foodservice have identified areas of concern, particularly regarding inadequate safety measures during food preparation (Barbara, 2018). The knowledge, attitudes, and practices of food handlers significantly influence the occurrence of food poisoning incidents (Lazou *et al.*, 2012). Positive attitudes, behavior, and education among food handlers are strongly linked to maintaining safe food handling practices

(Akabanda *et al.*,2017a). Poor personal hygiene, including inadequate handwashing, significantly contributes to the transmission of foodborne illnesses (Strohbehn *et al.,* 2008).

Proper handwashing is essential in school settings to reduce disease transmission from hands to food and surfaces (Green *et al.,* 2006). Food handlers play a vital role in preventing foodborne illness outbreaks in schools, and their adherence to good hand hygiene practices is crucial (July J Sibanyoni *et al*., 2017). Neglecting handwashing can increase the risk of cross-contamination and the spread of harmful bacteria (Mutalib *et al.,* 2012; Tan *et al.,* 2013).

Studies conducted in Ethiopia have highlighted inadequate management of liquid waste and refuse, poor personal hygiene practices among food handlers, and subpar sanitary conditions in public catering establishments (Tessema *et al.,* 2014). Factors such as age, marital status, years of service, monthly income, training, attitude, and depth of knowledge have been associated with low levels of food safety practices (Tessema *et al.,* 2014; Legesse *et al.,* 2017; Mendedo *et al.,* 2017; Abdisa & Fekadu, 2018; Gizaw *et al.,* 2018; Chekol *et al.,* 2019c). Targeted interventions and improved training programs are needed to enhance food safety practices among food handlers (Meleko, 2015; Tegegne *et al.,* 2017b).

Training programs are crucial for enhancing food handler knowledge, but it is important to recognize that knowledge alone does not always translate into behavioral changes (Ansari-Lari *et al.,* 2010a; Soares *et al.,* 2012a). Emphasizing food safety during the preparation and distribution of school meals is particularly important to protect vulnerable children with weakened immune systems (Soares *et al*., 2012a; Aisha *et al*., 2016; Fung *et al*., 2018).

3.5.4 Ensuring Food Safety in School Feeding Program

Ensuring Ensuring food safety is critical for SFPs, as contaminated food can lead to widespread illness among students and staff (Soares *et al*., 2012a; Afzan *et al*., 2013; Aisha *et al*., 2016). Schools are particularly susceptible to foodborne disease outbreaks due to the large number of children and close physical contact. The microbiological quality of school meals is closely linked to food safety and hygiene practices (Rosmawati *et al.,* 2014).

Children are vulnerable to foodborne illnesses, making proper food safety practices even more crucial (Caturla *et al.,* 2012). Food safety involves handling, storing, and preparing food in a way that minimizes the risk of contamination from physical, chemical, or biological sources.

Implementing appropriate food safety measures can prevent or eliminate the presence of disease-causing organisms. Ensuring food safety in school catering is of paramount importance due to the large quantity of meals served to a large number of students daily (Osaili *et al.*, 2013).

To address food safety issues, the World Bank recommends preventive measures, improved regulatory frameworks, behavior change initiatives, and an inclusive approach involving all stakeholders (Jaffee, *et al.,* 2019). The Food for Education (FFE) program has developed a comprehensive manual that provides guidelines for ensuring food safety within SFPs (WFP, 2017b).

3.6 Perceived Benefits and Challenges of the School Feeding Program

The implementation of SFPs faces challenges related to insufficient institutional capacity, limited resources, and inadequate food safety measures (WFP, 2013b). In Ghana, many schools lack proper kitchen structures, safe water access, cooking facilities, and sanitation facilities, while food handlers receive no training in hygiene and nutrition (Gyapong, 2014; Atta & Jacob, 2015). Similarly, in South Africa, challenges include the lack of kitchen and dining facilities, inadequate training for food handlers, poor sanitation, limited access to safe water, and issues with food quality and safety (WFP, 2013d; July *et al*., 2016a; July , 2017).

Insufficient resources contribute to cross-contamination, food poisoning, and illnesses, affecting children's health and learning abilities (Wilcock *et al.*, 2011; Liz Martins & Rocha, 2014). In the Netherlands, a study showed overall satisfaction with school lunch arrangements among children and parents, but variations in implementing food policies were observed (Rongen *et al.*, 2023). Teachers highlighted time constraints for lunch consumption, while children emphasized the importance of choice and expressed a positive attitude towards school lunches (Rongen *et al.*, 2023). Concerns were raised about program responsibility, financial implications, and organizational aspects (Rongen *et al.*, 2023).

Persistent challenges such as food price inflation, insufficient storage facilities, escalating costs, bureaucratic obstacles, lack of technical support, and reluctance to adapt pose significant barriers to the success of school feeding programs. Moreover, leveraging school farms is viewed as a promising strategy to bolster SFPs (Mossmann *et al.*, 2017; Azubuike & Mbah, 2019).

The SFPs face effectiveness and sustainability challenges due to inadequate resources, unpredictable funding, and the need for improved supervision and resource management. While students appreciate improved food accessibility, concerns arise about declining quality, quantity, and increased waste (Liu *et al.*, 2021).

Implementing Universal School Meal policies encounters challenges such as product availability, staffing shortages, logistics, and administrative burdens (Gordon, 2010). Studies in Brazil and Zambia reveal low program adherence, implementation irregularities, lack of nutritionists, inadequate infrastructure, insufficient cook training, and limited food and nutritional education efforts (RochaI *et al.*, 2018; Sitali, 2021).

In Zambia's Ndola District, challenges include limited parental involvement, inadequate water supply, labor and storage facility issues, insufficient food quantity, unclean food preparation areas, short meal-serving time, and negative parental attitudes. The parents and teachers believed school meals boosted enrollment, while students emphasized the role of meals in providing energy and focus, enhancing afternoon engagement (Mary and Mbewe, 2018). Universal school meal programs in the United States have been associated with increased household incomes, especially benefiting lower-income families with children (Cohen *et al*., 2021). Similarly, in Armenia, the School Feeding Program has demonstrated significant welfare enhancements for those in extreme poverty or facing strong social aversion to inequality, underscoring its social protection impact (Bakhshinyan *et al.*, 2019).

In Osun State, Nigeria, the SFP did not significantly improve academic performance or reduce dropout rates despite high awareness among participants (Olawale *et al*., 2022). In the UPE schools of Ssembabule District, Uganda, challenges include poverty, negative parental attitudes, insufficient budgets, water and storage shortages, lack of government support, delayed funds, and cases of embezzlement (Hadijah, 2022). Implementing SFPs faces challenges such as political interference, operational costs, limited community involvement, and exclusion of certain schools (Bundy *et al*., 2012; Essuman & Bosumtwi-Sam, 2013; Langsten, 2017).

Both, Uganda and Kenya encounter challenges with meal quality, water scarcity, inadequate infrastructure, and poverty (Ann & Mwangi, 2019; Fungo, 2023). Ghana, Ethiopia, and South Africa experience challenges including delayed funding, procurement issues, overcrowded classrooms, inadequate facilities, and food safety concerns (Sanlier, 2012; Sulemana *et al.*,

2013b; Mafugu, 2021; Desalegn *et al.,* 2022b). Addressing these challenges, including improving community involvement, infrastructure, funding, and food safety practices, is crucial for successful program implementation (Memirie, 2023; Mideksa *et al.,* 2024).

In Ethiopia's SFP, challenges persist in food provision, infrastructure, and administration, including issues with food quality, hygiene, and limited resources (Haile & Ali, 2019; Mideksa *et al.,* 2024). The Ethiopian Somali Regional State has seen positive impacts on education with improved enrollment, attendance, motivation, concentration, and academic achievement, but challenges remain in demand-supply balance, stakeholder collaboration, food distribution management, and program structure (Haile & Ali, 2019).

Late delivery of food to schools is a significant issue attributed to lack of experience, standard milling facilities, and bureaucratic procurement procedures (Desalegn *et al.,* 2022b). Similar challenges have been observed in Ghana, Jigjiga zone, and Southern Ethiopia (Dheressa, 2011; Aregawi, 2012; Sulemana *et al.,* 2013a). The SFP in the Sidama Region of Southern Ethiopia, has significantly improved class attendance and academic performance. Despite these benefits, challenges remain in ensuring clean water provision, addressing ration delivery delays, maintaining food quality standards, improving program infrastructure, and providing adequate sanitation and hygiene training (Desalegn *et al.,* 2022b).

Research conducted in Ethiopia emphasizes the positive social impact of school feeding programs. These initiatives foster a sense of community, enhance children's social behavior, and provide economic benefits through income transfers, job opportunities, and support to local economies (Grantham-McGregor, 2005).

However, financial constraints and issues with food quality continue to pose obstacles to the overall success of school meal programs in Ethiopia. Overcoming these challenges is essential for maximizing the potential benefits these programs can offer to students and communities (Mideksa *et al.,* 2024).

In South Africa, the School Feeding Program has become a crucial income source for local women cooperatives. This finding underscores the program's significance in not only meeting children's nutritional needs but also in empowering local women through economic opportunities and community engagement (Beesley & Ballard, 2013).

3.6.1 Programmatic Challenges in Ensuring Year-round Nutritional Support within Academic Calendar Gaps

Challenges of the SFPs implemented in all pre and primary public primary schools by the Ethiopian government, specifically through the Addis Ababa School Feeding Agency, arise from the program's limited coverage throughout the academic year. The Ethiopian academic calendar typically spans from mid-September to late June, comprising approximately 170 school meal days. This leaves students without meals for about 100 days, including weekends and holidays, creating gaps in nutritional support. The Addis Ababa SFPs primarily operates on weekdays, failing to provide year-round sustenance (Destaw, 2021).

Extending the program to encompass the entire year is essential to address this challenge and ensure continuous nutritional assistance for students, kitchen staff, and parents. Broadening the coverage to include breaks is pivotal for fostering long-term human development among students (Destaw, 2021). Meal provisions during academic breaks play a vital role in sustaining students' well-being throughout their educational journey. While SFPs primarily target hunger within schools (Drake *et al.*, 2020; WFP, 2020), it is imperative to also consider providing meals at home during academic breaks.

Offering meals during weekends, holidays, breaks, and vacations can significantly enhance food security for students, bridging gaps in nutritional support and potentially boosting income for women cooperatives involved in food production. Drawing insights from initiatives like weekend feeding programs in the United States (Fiese *et al.*, 2020), which specifically target food-insecure children to alleviate food insecurity, can inform strategies to enhance the effectiveness and reach of the SFPs in Ethiopia.

3.7 Conceptual Framework

The conceptual framework presented a comprehensive analysis of the school feeding program in public primary schools in Addis Ababa, Ethiopia, delving into various crucial aspects. Through a multidimensional approach, the study assessed the dietary quality and nutrient intake of meals, scrutinized the microbiological safety of the food, examined food handlers' knowledge and practices, and explored stakeholders' perceptions of the program's benefits and challenges.

By centering on outcomes like dietary quality, nutrient intake, microbial safety, and food safety practices, the research aimed to shed light on areas necessitating improvement within the program. Intermediate outcomes such as dietary diversity, adherence to safety standards, reduction in microbial contamination, and food safety knowledge were pivotal in comprehending the mechanisms influencing the overall efficacy of the school feeding initiative.

Furthermore, the study delved into factors like menu planning, food preparation methods, hygiene practices, stakeholder engagement, and demographic characteristics to offer actionable insights for enhancing the program's impact. This comprehensive approach aimed to contribute valuable knowledge to the scientific community, guiding evidence-based policies and interventions to promote food safety, nutritional health, and overall well-being among school children participating in such feeding programs.

The framework, illustrated in Figure 2.1, provides a structured and meaningful blueprint for evaluating the Addis Ababa SFPs and their impact on public primary schools. It outlines four specific objectives focusing on dietary quality, microbiological safety, food handler practices, and stakeholders' perspectives. By systematically investigating these elements and their interconnections, the framework supports evidence-based decision-making and the enhancement of SFPs, establishing a robust groundwork for understanding and improving the program's dynamics and impact on the target population.

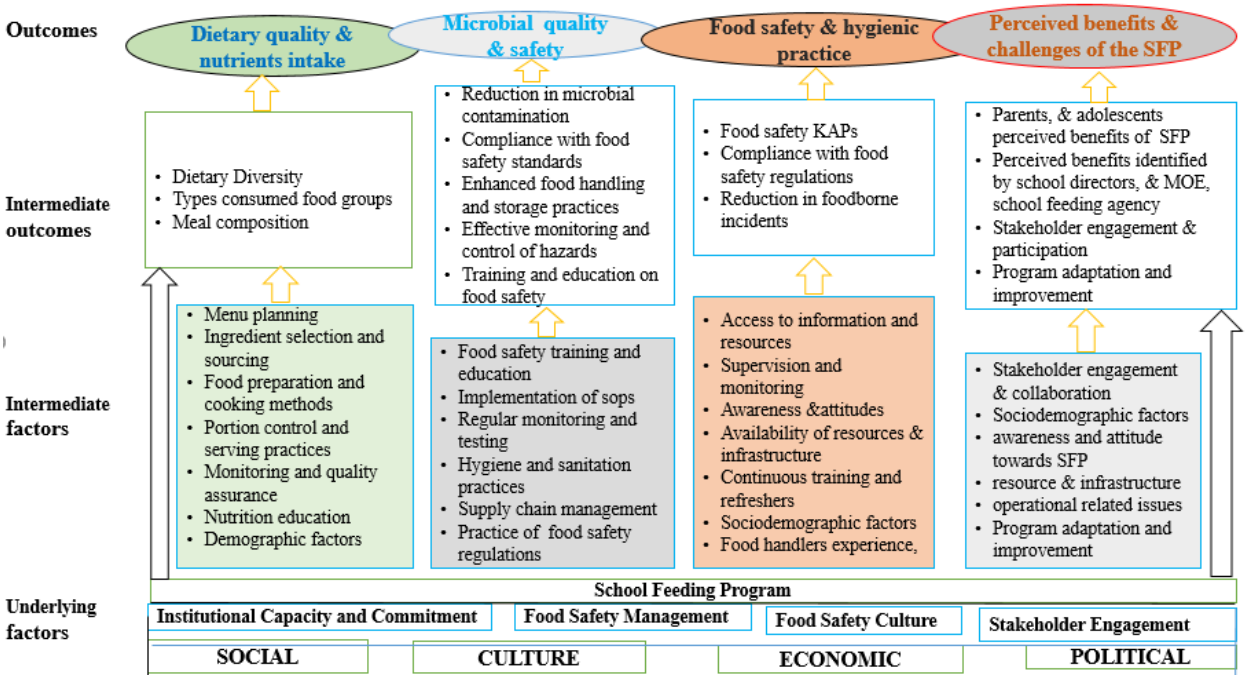

Figure 1: Conceptual framework of food safety, dietary and microbial quality of meals served by the SFP in Addis Ababa, Ethiopia

The conceptual framework has been developed based on an extensive review of relevant literature from various sources, resulting in an original design (Adelman *et al.*, 2008; Drake *et al.*, 2017)

CHAPTER 3: DIETARY QUALITY AND NUTRIENT INTAKE ASSESSMENT IN SCHOOL ADOLESCENTS: A STUDY IN ADDIS ABABA, ETHIOPIA

Clinical Nutrition Open Science 55 (2024) 36–47

Contents lists available at ScienceDirect

Clinical Nutrition Open Science

journal homepage:
www.clinicalnutritionopenscience.com

Original Article

Dietary quality and nutrient intake assessment in school adolescents: A study in Addis Ababa, Ethiopia

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3.1 Abstract

Background: In regions with food insecurity challenges, school meals play a crucial role as the primary source of nutrition for many students. This research aims to assess the dietary quality and contribution of school meals to energy and nutrient needs of school adolescents in Addis Ababa, Ethiopia.

Methods: A school-based cross-sectional study was conducted on a total of 293 adolescents were selected from 20 selected schools. A multiple-pass 24-hour recall was method employed to collect the dietary intake data from adolescents. Then, the nutrient intake was compared to RDA. The school meals below two-thirds of the RDA serving as an indicator were categorized a of sub-optimal quality. The dietary diversity was assessed with a12-food group score using STATA software.

Results: The study revealed an inadequate nutrition in school meals for adolescents. While school meals provided an adequate contribution of carbohydrates (74.4% of the RDA), the contribution for other nutrients was low: energy (34.1%), protein (42.5%), calcium (9.3%), zinc (14.6%), iron (52.9%), vitamin A (14.0%), thiamine (16.7%), vitamin B12 (12.8%), and niacin (3.8%). Also, the study revealed a high prevalence of inadequate intakes of priority nutrients among school adolescents, including protein (57.5%), carbohydrates (25.6%), calcium (90.7%), zinc (85.4%), iron (47.1%), vitamin A RAE (86.0%), vitamin C (86.0%), thiamine (83.3%), vitamin B12 (90.2%), and niacin (96.2%). Despite high dietary diversity, key nutrient inadequacies persisted in both school meals and overall 24-hour meals.

Conclusions: Nutrient inadequacies in school adolescents necessitate prioritizing menu planning with nutrient-dense foods, implementing cost-effective strategies with locally sourced options, establishing nutrition education programs, and collaborating with stakeholders on tailored initiatives like community gardens, local farmer partnerships, and subsidized/free nutritious meals to address deficiencies and promote well-being.

Keywords: dietary diversity, dietary quality, micronutrients, school meals

3.2 Introduction

Approximately 180 million school-age children experience malnutrition, with 1 billion at high risk of food insecurity (*School Meals and Food Systems: Rethinking the Consequences for Climate, Environment, Biodiversity and Food Sovereignty*, 2023). Adolescence (ages 10-19) in developing countries, like Ethiopia, is critical due to prevalent poor-quality diets (Ross *et al.*, 2020; Chacón *et al.*, 2021), that increase vulnerability to malnutrition and its adverse effects on education, growth, and development.

Adolescents are vulnerable to nutrient deficiencies, delayed sexual maturation, stunted growth, and negative health outcomes due to rapid growth, changing dietary patterns, and developmental changes (Christian & Smith, 2018; Nicholaus *et al.*, 2020; FAO, 2021). Micronutrient deficiencies, particularly iron insufficiency, have significant global health implications during this period (Black *et al*., 2013; Bailey *et al*., 2015; Nicholaus *et al*., 2020).

Adolescents have higher nutrient needs as they achieve significant physical milestones (Hannah Ritchie, 2002), and may have an opportunity to catch up in height if they experienced stunted growth earlier in childhood (Black *et al*., 2013; Nithya & Bhavani, 2018).

HG-SFPs impact underprivileged school-aged children, providing safe and nutritious meals that enhance food and nutrition security (Cohen *et al*., 2021; Drake *et al*., 2017). These initiatives reach around 418 million children globally, improving school enrollment, attendance, academic achievement, cognitive development, and reducing dropout rates. SFPs promote equity by ensuring access to quality nutrition and education fostering inclusivity (*School Meals and Food Systems: Rethinking the Consequences for Climate, Environment, Biodiversity and Food Sovereignty*, 2023).

Adolescents undergo significant physiological, cognitive, and psychosocial changes (Destaw *et al*., 2021), posing challenges for nutritional interventions. The importance of addressing adolescent nutrition to break the intergenerational cycle of growth failure is insufficiently addressed in Ethiopia (Wassie *et al.*, 2015). Assessing diet quality is crucial for understanding food security and the relationship between micro- and macronutrients (Analysis, 2019).

The Ethiopian government has implemented a national school feeding policy to promote equitable education access and integrate local agriculture (National School Feeding Policy Draft,

2019). In Addis Ababa, a dedicated school feeding agency ensures sustainable program implementation. Since February 2019, the city has launched a large-scale program providing two meals per school day to address child hunger (Destaw *et al*., 2021; MoE, 2020).

The school meal programs are designed to complement home-cooked meals, aiming to provide at least one-third of the Recommended Nutrient Intake (RNI), specifically 30%, and to fulfill 60-75% of daily energy and nutrient requirements (WHO, 2006b; Destaw *et al.*, 2022b; WFP, 2017b; FAO, 2019a). However, there is limited data on the dietary quality and adequacy of Homegrown SFPs in Ethiopia compared to other countries (Gregorič *et al*., 2015; Agbozo *et al*., 2018; Ayogu *et al*., 2018; Claire *et al*., 2020).

This study assesses the dietary quality of school meals in Addis Ababa, Ethiopia, and their effectiveness in meeting the nutritional needs of school-aged adolescents. The results will provide valuable insights for policymakers and stakeholders, helping to enhance nutrient intake through SFPs.

3.3 Materials and Methods

3.3.1 Study Setting and Design

A cross-sectional study was conducted among school adolescents in Addis Ababa in April 2023, focusing on 20 public primary schools in five sub-cities (MoE, 2022). Addis Ababa is a diverse and significant city projected to exceed 5 million in population by 2036 (Weldeghebrael, 2021). It has a city-wide SFPs, serving around 638,857 students in 264 public primary schools (MoE, 2022). The city faces socio-economic challenges, including high unemployment, poverty, and food insecurity (Berhe *et al*., 2017).

3.3.2 Sampling Procedure

Researchers used a multi-stage sampling approach in the study. Five sub-cities out of eleven in Addis Ababa were randomly chosen. An equal number of schools (four primary schools) were then selected randomly from each sub-city. An equal sized study participants from grades 6 and 7 were chosen through simple random sampling.

3.3.3 Sample Size Determination

The sample size of the study participants was determined based on the literature (Oakland, 1953), using a formula that considers the standard deviation (SD) of the outcome variable (σ) and the desired margin of error (E) with a significance level (α) of 0.05. The literature (Destaw et al., 2022b; Oakland, 1953) provided a standard deviation value of 34.0 for food energy gained from school meals. By applying the formula based on the mean of a continuous outcome variable in a single population, a sample size of 294 participants was determined for the study.

Using the formula $n = \left(\frac{z\sigma}{\epsilon}\right)^2$ where

z = 1.96 (z-score for a 95% confidence level)

σ = 34.0 (standard deviation), and

ϵ = 5 (margin of error of 5 units)

$$n = \left(\frac{1.96*34.0}{5}\right)^2 = 177.64$$

The total sample size calculated is approximately 177.64. By adding 10% of 178 (18), the final sample size is 196 participants. Multiplying 196 by a design effect of 1.5 yields a sample size of 294 participants.

3.3.4 Strategies in Maximizing Sample Size

To ensure a robust and meaningful study, we employed strategies to maximize the sample size and gather valuable data. These included extensive participant recruitment efforts and clear data collection procedures. We collaborated closely with schools and authorities, conducting information sessions to encourage participation and address concerns. Rigorous data collection protocols were implemented, with comprehensive training to minimize biases. Regular data monitoring and verification maintained data integrity.

Despite challenges like incomplete reporting, we promptly addressed issues, reviewing and verifying data while following up with participants for missing information. We believe the collected data still provide valuable insights, contributing to scientific understanding and expanding knowledge in the field. Overall, our diligent efforts in maximizing the sample size and

ensuring data quality enhance the validity and reliability of our study, increasing its impact and relevance.

3.1.1 Source Population

All adolescents in Addis Ababa public primary schools who are beneficiaries of the SFPs.

3.1.2 Study Population

Adolescents attending the selected public primary schools during the study period and who are beneficiaries of the SFPs.

3.1.3 Dietary Assessment and Data Collection

The study used the 24-hour recall method, specifically the adapted multiple-pass technique by Gibson and Ferguson. This structured approach, known as the "four passes," was employed to collect detailed information on food type and quantity (Gibson, 1989). The study utilized the multiple-pass 24-hour recall method for precise and comprehensive dietary data collection at school and their home. In Pass 1, participants listed all foods and drinks consumed throughout the day, including night-time intake. Pass 2 obtained detailed descriptions of listed foods and drinks, including preparation method, source, state, and presentation state. In Pass 3, portion sizes were estimated, with 3A focusing on individual portions, 3B addressing mixed dishes, and 3C collecting mixed dish recipes. Portion size estimation methods (PSEM), including direct weight measurement, standard unit sizes, and proxy weight estimation using the PSEM aids like playdough, water, rice, or maize flour, were utilized. Pass 4 reviewed the data to ensure accuracy and identify errors. The multiple-pass 24-hour recall method provided precise and systematic information on participants' dietary intake, including food and drink types, portion sizes, and recipe details.

Figure 3. 1 Dietary scales used for 24-hour dietary intake assessment

Figure 3. 2 Proxy weight estimation methods (PSEM) for portion size using playdough (g)

Figure 3. 3: Implementation of the four passes technique for collecting 24-Hour dietary intake

The study employed the multiple-pass 24-hour recall method, where participants listed all foods and drinks consumed, followed by detailed descriptions. Portion sizes were estimated using various techniques, and data were verified for accuracy. Data collection involved students recalling food items and drinks, including portion sizes, with guidance from data collectors.

3.1.4 Measuring Individual Dietary Diversity Score (IDDS) for Adolescents

The IDDS for adolescents was determined by assessing their consumption of 12 food groups, following Food and Agriculture Organization guidelines (Gina Kennedy, Terri Ballard, 2013; Horsey *et al.*, 2019). Each food group was assigned a score of 1, with a maximum score of 12. The DDS was calculated by summing the number of distinct food groups consumed within a 24-hour recall period. Scores were categorized as low (less than 5 food groups), medium (5-6 food groups), and high (7-12 food groups). This classification facilitates the analysis of dietary

patterns and identifies individuals with varying levels of dietary diversity (Khamis *et al.,* 2021; Mbwana *et al.*, 2016).

3.1.5 Quality Assurance

In order to ensure data accuracy, reliability and quality, the supervisors, and data collectors received comprehensive training on the use of ODK, interview skills, and 24-hour recall interviews involving multiple personnel enhanced data reliability. A pre-test was conducted with 5% of school adolescents at primary schools not selected for the study, which helped refine the tools based on their feedback. Rigorous oversight included daily reviews, immediate error corrections, and secure data storage with privacy measures. The ODK data capture tool facilitated logical data entry and maintained data quality, while supervisors verified form completeness to ensure data integrity throughout the process.

In the methods section, standardizing the dietary recall assessment among data collectors, especially for multiple passes, was crucial for ensuring data consistency and reliability. To achieve this, all data collectors underwent comprehensive training on the dietary recall methodology, covering the multiple pass approach, probing techniques, portion size estimation, and data recording procedures.

During the 24-hour dietary quality assessment, we adhered to the EPHI standard operating procedure and protocol. A detailed protocol was developed, outlining the specific steps for each pass of the assessment, including standardized prompts, questions, and guidelines for reference. Practice sessions were conducted to allow data collectors to simulate the assessment process, ensuring practical application of the standardized protocol and clarification of any uncertainties. Experienced supervisors oversaw data collection, providing feedback to maintain adherence to the protocol and address deviations promptly. Incorporating consistency checks, periodic data reviews, and inter-rater reliability assessments helped identify and rectify discrepancies. A feedback mechanism allowed data collectors to report challenges, and regular refresher training sessions reinforced the standardized procedures, facilitating consistent and accurate implementation of the multiple pass dietary recall assessment method throughout the study.

3.1.6 Data Management and Analysis

A rigorous data management process ensured accurate and complete data. Diets were checked for completeness before coding, and a thorough verification process minimized errors. The FAO categorization guide was utilized to classify food items into standardized groups (Gina Kennedy, FAO & 360, 2016; Horsey *et al.,* 2019; Ayal *et al.* 2022). The classification enabled systematic analysis of dietary patterns, nutrient intake, dietary quality, and nutrient contributions. The study examined 12 food groups, assessing consumption as either adequate or inadequate based on the number of groups consumed. This assessment provided insights into food group variety, adequacy, and dietary patterns (Yeneabat *et al.,* 2019). The study compared macro- and micronutrient intake data with reference values using the Ethiopia-specific Food Composition Table (FCT). Descriptive statistics were analyzed using STATA software (version 16.0) to assess socio-demographic characteristics and summarize nutrient intake. Intake was compared with RDAs to identify potential deficiencies or excesses in nutrient intake.

3.1.7 Ethical Standards Disclosure

The IRB of the College of Natural and Computational Sciences (CNS IRB), Addis Ababa University, with Ref. No. CNCSDO/623/15/2023, approved all procedures involving research study participants by the Declaration of Helsinki. The Addis Ababa Education Bureau also granted permission for the study. To reach out to the parents of participating students, an invitation was sent by the school director, asking them to come to the school for an informational meeting. During this meeting, parents were provided with details about the research, and written informed consent was obtained before the study commenced. Additionally, students actively participated in the study and provided their own assent. Strict privacy measures were implemented during the data management process to protect the rights and confidentiality of all participants.

3.2 Results

3.2.1 Socio-demographic characteristics

The response rate was 99.66%. The findings showed that 40.96% of the students were female, and 59.04% were male. The majority of the students (84.63%) were aged 10 to 14. Among the household heads, 60.75% were male, and 39.25% were female. The study found that 70.31% of the household heads were married, while 14.33% were divorced, 11.26% were deceased, and 4.10% were unmarried. In terms of education, 8.19% of the household heads were illiterate, 39.25% had completed primary school, 23.55% had completed secondary school, and 29.01% had education at a college level or above. In terms of occupation, 26.3% of the household heads were employed, and 73.7% were unemployed. Family income analysis revealed that 16.38% had a monthly income below 2000 Ethiopian Birr, 34.13% had an income between 2000 and 5000, and 49.49% had an income above 5000 **(Table 3.1).**

Table 3. 1 Socio-demographic Characteristics of the study participants in SFP of Addis Ababa, Ethiopia, 2023 (n = 293)

Variable	Frequency(N)	Percentage (%)
Sex of adolescence		
Female	120	40.96
Male	173	59.04
Age of adolescence		
10 to 14 years old	248	84.63
15 to 19 years old	45	15.37
Sex of the household head		
Female	115	39.25
Male	178	60.75
Marital status of the household head		

Married	206	70.31
Divorced	42	14.33
Widowed	33	11.26
Single	12	4.10
Educational status of the household head		
Illiterate	24	8.19
Primary school	115	39.25
Secondary school	69	23.55
College and above	85	29.01
Household head occupation		
Employed	77	26.3
Unemployed	216	73.7
Family monthly income (ETB)		
<2000	48	16.38
2000-5000	100	34.13
>5000	145	49.49

3.2.2 Food Group Consumption by School Adolescents

The research investigated the eating habits of schoolchildren in terms of food group consumption. Cereals emerged as the most frequently consumed food group, with a rate of 89.1%. Following cereals, oils, and condiments were also popular, with consumption rates of 87.4% and 88.1%, respectively. On the other hand, fish and egg products were the least consumed, with rates of 0.7% and 1.7%, respectively. Milk, meat products, and fruits were also consumed in relatively small quantities, with rates of 4.4%, 5.5%, and 7.5%, respectively **(Figure 3.4).**

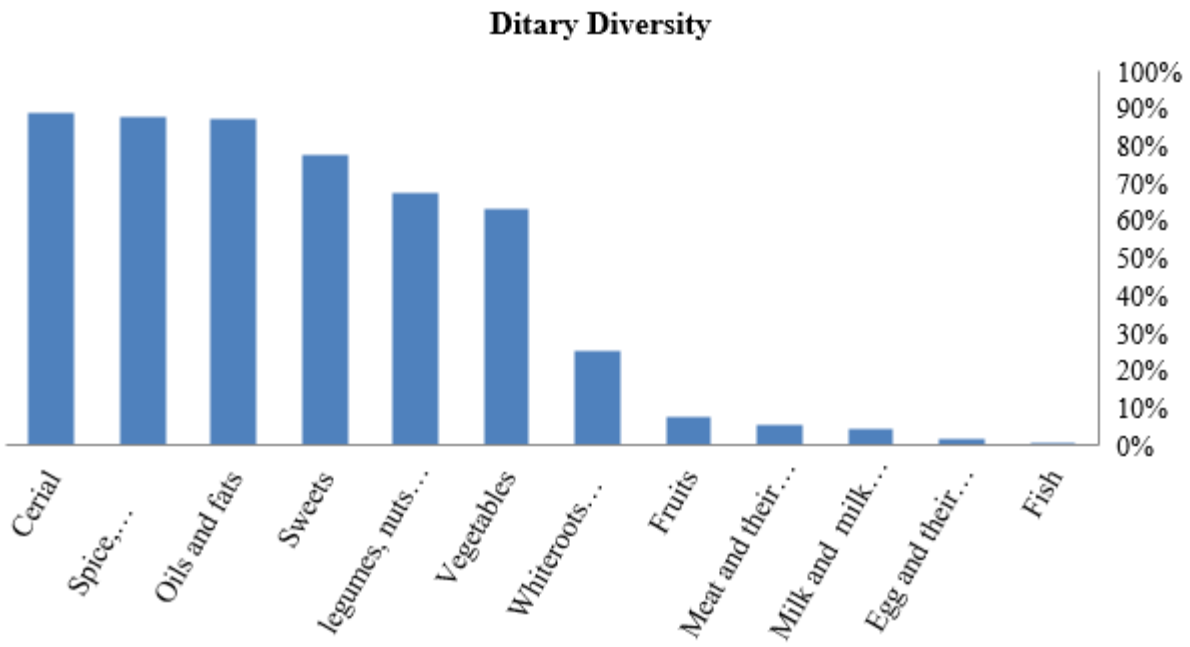

Figure 3. 4 Food groups consumed in the previous 24 hours by public primary school adolescents from Addis Ababa, Ethiopia, 2023

3.2.3 Individual Dietary Diversity Score (IDDS) of 24-hour Meals Among School Adolescents

Table 3.2 presents the IDDS of 24-hour meals among public primary school adolescents. The analysis shows that the majority had adequate dietary diversity, with 89% meeting the criterion for sufficient diversity (DDS scores of 5 or above). Notably, 34.7% achieved a score of 5, while 38.5%, 13.1%, and 2.8% scored 6, 7, and 8, respectively, indicating high levels of dietary diversity. However, 11% had low or inadequate DDS below five. Overall, the findings highlight a high proportion of adolescents consuming a diverse range of food groups.

Table 3. 2 Individual dietary diversity score of public primary school adolescents in Addis Ababa, Ethiopia (2023)

Minimum Dietary Diversity	Frequency (N)	Percentage (%)
3	4	1.4
4	29	9.6
5	102	34.7
6	112	38.5
7	38	13.1
8	8	2.8
Total	293	100

3.2.4 Percentage Contributions of School Meals to the Recommended Daily Allowance

Table 3.3. Displays mean values ± standard deviations (SD) and the percentage of RDA contributed by school meals for various nutrients. Protein intake from school meals is also notable, covering 42.5% of the RDA. Carbohydrate intake from school meals is substantial, accounting for 74.4% of the RDA. However, there are deficiencies in certain nutrients. Calcium intake from school meals is inadequate, meeting only 9.3% of the RDA. Zinc intake is also insufficient, contributing 14.6% of the RDA. On the other hand, iron intake is relatively better, meeting 52.9% of the RDA. Sodium intake from school meals falls below the recommended levels, providing 23.2% of the RDA. Similarly, vitamin A-RAE, vitamin C, thiamine, vitamin B12, and niacin intakes from school meals are below the recommended levels, contributing 14.0%, 14.0%, 16.7%, 9.8%, and 3.8% of the RDAs, respectively.

Table 3. 3: Nutritional contribution of school meals to RDA among study participating adolesecnts in Addis Ababa, in April 2023, (n=293)

Variable	Mean ± SD	RDA	% of the daily recommended intake contributed by meals at school
Energy (kcal)	750.1 ± 50.3	2200	34.1
Protein, g	18.7 ± 3.2	44	42.5
Carbohydrate, g	189.2 ± 12.6	254	74.4
Calcium, mg	120.8 ± 25.1	1300	9.3
Zinc, mg	2.2 ± 1.5	14.0	14.6
Iron, mg	7.9 ± 3.1	15	52.9
Sodium, mg	92.8 ± 18.4	400	23.2
Vitamin-A-RAE, µg	56.0 ± 7.6	400	14.0
Vitamin-C, µg	5.6 ± 2.1	40	14.0
Thiamine, µg	0.2 ± 0.4	1.2	16.7
Vitamin-B12, µg	0.2 ± 0.6	2.4	9.8
Niacin, µg	0.6 ± 2.4	16	3.8

RDA: *recommended daily allowance* (Caswell *et al.*, 2015; FAO & World Health Organization, 1998; Ryan-harshman & Aldoori, 2006)**.**

3.2.5 Nutritional Adequacy of Diet

The analysis in **Figure 3. 5 s**hows mixed results in terms of the nutritional adequacy of the 24-hour meals. Energy intake is inadequate, meeting only 36.5% of the recommended level. Protein and fat adequacy are moderate, at 46.1% and 54.6%, respectively. Carbohydrates and fiber meet recommended levels at 86.7% and 84%, respectively, while iron adequacy is high at 92.5%. However, the adequacy of several nutrients is notably low, including phosphorus (23.2%), zinc (3.4%), beta-carotene (30.4%), thiamine (16%), niacin (7.8%), vitamin B12 (14.7%), and vitamin C (37.5%). In summary, the meals are insufficient in energy, protein, phosphorus, zinc, beta-carotene, thiamine, niacin, vitamin B12, and vitamin C. Although carbohydrates, fiber, and iron are adequately provided, there is substantial room for improvement to meet the recommended nutrient intake for a well-balanced diet.

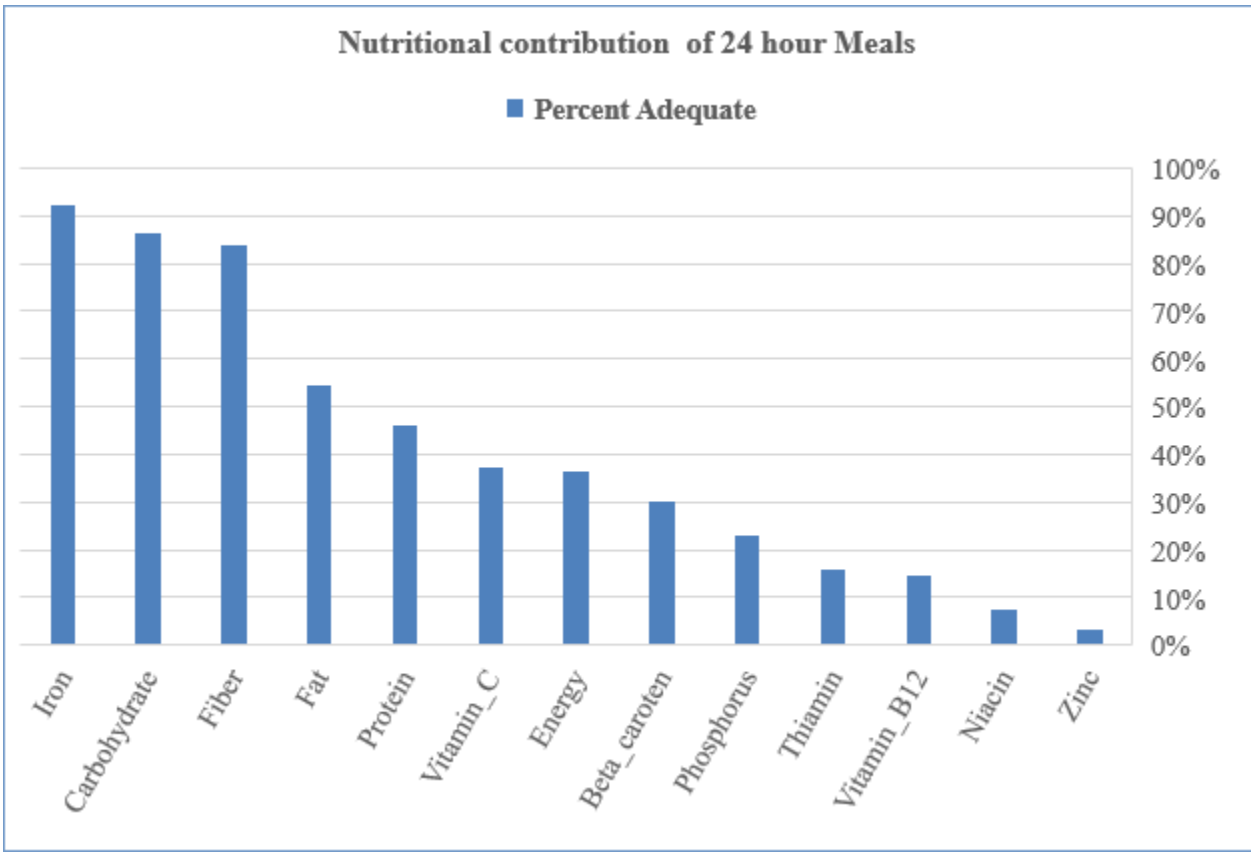

Figure 3. 5 Nutrient adequacy levels of macro and micro nutrients in the 24-Hour meals among study participating adolescents in Addis Ababa, in April 2023, (n=293)

3.3 Discussion

The Addis Ababa SFPs initially focused on economically disadvantaged school-aged children to address hunger. However, since February 2019, the program has expanded to include all public pre-primary and primary schools in the city (Destaw *et al*., 2021; MoE, 2020). The study revealed that the examined school meals in the SFP fell short of meeting the recommended daily energy and nutrient requirements set by the WFP. The WFP guidelines recommend that a comprehensive school meal scheme should ideally provide 60% to 75% of children's energy and nutrient needs (WFP, 2017b).

This study emphasizes the absence of dietary diversity in school meals, excluding key food groups such as fruits, vegetables, meat, fish, poultry, and milk. Similar findings were observed in Ethiopian school meals (Destaw *et al.,* 2022b). Addis Ababa SFP school children from impoverished backgrounds may lack access to a well-rounded diet at home, leading to potential deficiencies in energy and vital nutrients. In contrast, school meals in other countries show greater dietary diversity. For example, in Ghana, meals include energy-rich staples, some vegetables, and fish, with limited dairy and fruits (Agbozo *et al.,* 2018).

This study revealed that school adolescents predominantly consumed diets rich in cereals (89.1%), spices, condiments, and beverages (88.1%), and oils (fats) (87.4%). However, a smaller percentage of participants consumed foods like milk, fruit, eggs, meat, and fish, aligning with previous research conducted in Meshenti and Dembia, North-West Ethiopia (Ayal *et al.,* 2022; Gonete *et al.,* 2020). The studies conducted have shown that a significant number of participants had limited or rare consumption of specific food groups. However, it was found that cereals were consumed daily by a substantial proportion of participants, with rates of 99.8% and 64% in the respective studies (Ayal *et al.,* 2022; Gonete *et al.,* 2020). Similar findings were observed in studies conducted in the Solomon Islands, where 94% of participants reported consuming cereals, and in Zambia, where a high percentage of participants (99.4%) reported cereal consumption (Caswell *et al.,* 2015; Horsey *et al.,* 2019). These findings indicate a consistent pattern of regular cereal consumption among the participants in multiple study locations.

The school meals in this study met 84.0% of the daily fiber requirement, mainly due to the inclusion of fiber-rich cereals such as wheat and teff, commonly prepared as injera or firfir. These findings are consistent with a previous study conducted in Ethiopia (Destaw *et al.,* 2022b),

contrasting with results from Slovenia where school meals fell short of the minimum dietary fiber requirement (Gregorič *et al.,* 2015). However, the 24-hour meals consumed by adolescents in this study were found to be nutritionally inadequate.

Only 30.4% of the meals offered adequate intake of beta-carotene, which is essential for vision and immune function. Furthermore, vitamin B12 intake was insufficient in 14.7% of the meals, indicating a concerning inadequacy. The absence of fruits and vegetables, such as papaya, carrots, and dark-green leafy vegetables, in the school meals may account for the low levels of beta-carotene and B-vitamins. Notably, none of these foods were included in the meals served.

The mean dietary diversity score for the 24-hour meals in this study was 5.6 (SD±0.96), consistent with a similar study among Ethiopian adolescent girls (Wassie *et al.,* 2015). However, it exceeded the score found in a study among secondary school students in East Amhara, Woldia (Endalifer *et al.,* 2021). The implementation of the SFP likely contributed to a greater variety of food options, resulting in the disparity in scores.

In terms of dietary diversity, 88.1% of participants in this study achieved adequacy, which is higher than proportions reported in studies on pregnant women in Arba Minch and at the household level in Borena, Oromia region, Ethiopia (19%) (Delil *et al.,* 2021; Aliyo *et al.,* 2022). However, it is similar to studies conducted on women of reproductive age in the Oromia region (81.9%) and adolescent girls in northwest Ethiopia (75.4%) (Birru *et al.*, 2018; Merga *et al.,* 2022).

The disparity in the mean DDS can be attributed to participant characteristics. Our study had a lower mean DDS compared to a study conducted in Iran, which reported a mean DDS of 6.81 (Vakili *et al.,* 2013). Among our participants, 11.95% were found to consume inadequately diversified meals. Specifically, 12.4% of males and 11.3% of females had lower DDS. These percentages were lower than those reported in the study done at Woldia study (49.1%) (Endalifer *et al.,* 2021), and the study conducted in Iran (21.3%) (Vakili *et al.,* 2013). The SFP has a positive impact on dietary diversity, but improvements are needed for consistent optimal diversity.

The analysis of the nutritional adequacy of the adolescents' 24-hour meals revealed sufficient intake of carbohydrates (86.7%) and iron (92.5%). However, a significant proportion of

participants had inadequate intake of zinc (96.6%), vitamin B12 (85.3%), thiamine (84.0%), and niacin (92.3%). While the intake of carbohydrates and iron was deemed sufficient for the majority of participants, the inadequacy of key nutrients such as zinc, vitamin B12, thiamine, and niacin is concerning. A high proportion of adolescents were found to have insufficient intake of these vital nutrients, which can have significant implications. Deficiencies in zinc may impact immune function and growth, while inadequate levels of vitamin B12, thiamine, and niacin can affect energy levels, cognitive function, and overall health.

These findings are consistent with a previous study conducted in Ethiopia (Ayal *et al.,* 2022). The study suggests that school meals contribute one-third of the recommended nutrient intake (RNI) for daily energy and protein requirements (WFP, 2017b). However, their contribution to calcium, zinc, sodium, vitamin A-RAE, vitamin C, thiamine, vitamin B12, and niacin falls below one-third of the daily requirements (WFP, 2017b). These deficiencies can significantly impact various aspects of their development and well-being. Insufficient energy and protein intake can lead to developmental delays, hindered growth, and poor mental development. Inadequate levels of zinc, vitamin, and calcium, may result in frequent illnesses, compromised immune function, and suboptimal school performance.

While global iron intake among adolescents is typically insufficient (Biesalski Hans & Jana, 2018), in this study, the iron intake from school meals met the daily recommended requirements, providing nearly two-thirds of the daily requirement for adolescents (WFP, 2017b). This aligns with previous studies conducted in Ethiopia (Destaw *et al.,* 2022b), and Ghana (Agbozo *et al.,* 2018), but contrasts with findings in Nigeria (Ayogu *et al.,* 2018). The inclusion of iron-rich Injera and/or Firfir made from Teff in the school meals may have contributed to the observed higher iron intake.

3.4 Limitations of the Study

A limitation of this study is the absence of a direct examination of the interplay between school meal provisions, nutritional adequacy, household head's income, and educational attainment. While the research focused on evaluating dietary quality and nutrient consumption among school adolescents, it did not investigate the specific effects of school meals on meeting their nutritional needs or how household income and educational levels might influence their nutrition sufficiency. Future research should explore these relationships to gain a more comprehensive

understanding of the factors influencing adolescents' dietary quality and nutrient intake. Additionally, potential limitations include reliance on self-reported data, which may be prone to memory biases, measurement and social desirability biases that could impact the accuracy of the findings.

3.5 Conclusion

The study revealed nutrient inadequacy in school adolescents, despite their DDS is high and sufficient energy intake from school meals. To address this, prioritize menu planning with nutrient-dense foods like dairy, lean meats, fruits, and vegetables. Implement cost-effective strategies using locally sourced, affordable food items. Establish comprehensive nutrition education programs to raise awareness of balanced diets and the benefits of nutrient-rich foods among students and families. Collaborate with school administrators, policymakers, healthcare professionals, and community organizations to develop tailored strategies, including community gardens, partnerships with local farmers, and programs for subsidized or free nutritious meals. These measures will effectively address nutrient deficiencies and promote the well-being of school-age adolescents. Collaboration among stakeholders is crucial for substantial impact. Implement strategies like fortifying micronutrients and improving school meal quality. Strong partnerships and innovation can bridge nutrient gaps and unlock the potential of our adolescents. However, current SFPs fall short of meeting the nutritional needs of deprived adolescents. Urgently prioritize diversified school meal offerings, including animal products, fruits, and vegetables. By implementing these transformative measures, we can enhance the energy and nutrient content of meals, empowering students with improved health outcomes and the opportunity to thrive.

CHAPTER 4: ASSESSMENT OF MICROBIOLOGICAL QUALITY OF SCHOOL MEALS IN THE ADDIS ABABA HOMEGROWN SCHOOL FEEDING PROGRAMS

4.1 Abstract

Background: Ensuring the microbiological safety and quality of school meals and drinking water is vital for the well-being of students in SFP. Therefore, this study aimed to assess the microbiological safety assessment of RTE cooked foods in the SFP in Addis Ababa, Ethiopia.

Methods: This investigation assessed microbial contamination indicators in RTE school meals and drinking water in the Addis Ababa SFP, Ethiopia. Samples were collected from 18 primary school kitchens in March and April 2024. Microbiological analysis was performed on 37 cooked food samples and 18 drinking water samples using ISO and NMKL guidelines.

Results: The microbiological investigation of RTE prepared meal samples revealed an overall acceptable level of quality and safety. However, concerns were identified. For instance, yeasts and molds surpassed reference standards in 78.4 % of samples (>10^2 cfu/ml), *E. coli* exceeded standards in 10.8 % of samples (>10^2 cfu/ml), and *S. aureus* counts exceeded limits in 5.4 % of samples (10^3 -10^4). Cooked rice the highest microbiological counts, especially of *E.coli* and *S.aureus*. Approximately 14.4 % of food samples were unsatisfactory, showing contamination from *E. coli*, *S. aureus*, and yeasts and molds. Regarding drinking water, the non-potable percentage in drinking water was 23.4 %, raising concerns about *APC* microbial count, *TC*, and *FC*. In particular, 72 % of the drinking water samples surpassed the *APC* criteria (>100 cfu/ml), 16 % exceeded the *TC* standard (>1 cfu/ml), and 5.5 % exceeded the *FC* threshold.

Conclusions: The microbiological quality of meals served through the Addis Ababa SFP generally met established standards. However, some food samples exceeded the permitted limits, indicating hygiene difficulties. Therefore, stringent premises and personal hygiene measures must be implemented to safeguard their safety and well-being of the school children.

Keywords: Drinking water quality, Food safety, Microbiological quality, School feeding program

4.2 Introduction

The SFPs play a vital role in national social protection systems globally, offering anticipated benefits such as enhancing educational capabilities, addressing hunger, reducing malnutrition, improving school attendance, academic performance, and promoting gender equity in education (Bank, 2012; WFP, 2013a; Mohammed *et al.*, 2023a). These programs, often viewed as government support initiatives, significantly impact both education and children's health (Nagla *et al.*, 2014), emerging as crucial strategies in many countries to aid socially vulnerable individuals amidst economic hardships (Nagla *et al.*, 2014).

The global presence of foodborne pathogens in RTE foods poses significant health risks, particularly in LMICs where these foods are prevalent. Inadequate hygiene practices among vendors in these regions heighten the risk of microbial contamination, necessitating improved food safety regulations and practices to safeguard public health (De Voglia *et al.*, 2014; Adeleke *et al.*, 2020; Sabuj *et al.*, 2020). RTE foods, widely consumed by school-aged children and the working class in LMICs, significantly impact dietary intake. A decade-long study on the microbiological safety of RTE foods in LMICs emphasizes their critical role as essential dietary sources, despite risks arising from poor hygiene, poverty, limited health knowledge, and lax regulations (Adeleke *et al.*, 2020).

Contaminated drinking water is a critical global health issue, leading to severe illnesses and fatalities, especially in developing regions, where poor water quality not only hampers economic progress but also jeopardizes the lives of millions (Wolde, 2022). Approximately 40 % of the African population lacks access to improved water supply and sanitation (Sallam, 2012). The global safety of drinking water is compromised by contaminants from various sources, underscoring the pivotal role of microbiological standards in ensuring pathogen-free and unpolluted water (Wolde, 2022). While access to clean water is prevalent in Europe and North America, many developing nations struggle with inadequate water and sanitation infrastructure, resulting in widespread waterborne infections (Cabral, 2010; Wolde, 2022). The scarcity of safe drinking water correlates closely with increased morbidity and mortality from diseases associated with poor sanitation practices (Dunn *et al.*, 2014; Wolde, 2022).

Despite the widespread implementation of SFPs globally, coverage varies significantly, with disparities between high-income and low-income countries (Cohen *et al.*, 2023). Ensuring food

safety remains a global challenge, affecting both developed and developing nations, with significant impact on public health and economic progress (Ayalew *et al.*, 2013). Ethiopia faces challenges in its food safety system, including gaps in legal frameworks, surveillance, laboratory services, and coordination among food safety organizations (Ayalew *et al.*, 2013).

The QSAE plays a crucial role in ensuring food safety through certification, inspection, and testing, following international standards (Ayalew *et al.,* 2013). However, Ethiopia's food safety system faces hurdles due to a less developed food infrastructure, population growth, resource constraints, and hygiene challenges (Ayalew *et al.,* 2013), key obstacles include surveillance of foodborne diseases, coordination among food safety entities, laboratory services, and fostering public-private partnerships (Ayalew *et al.*, 2013).

Ethiopia's SFP, operational for over 30 years, is expanding and integrating with regional agricultural production (Mideksa *et al.,* 2024). The government is actively transforming the agricultural sector and SFP through effective policies (Mideksa *et al.,* 2024). With 26.8 million school-age children enrolled in pre-primary and primary education, Ethiopia launched a large-scale SFP in Addis Ababa in February 2019 to combat hunger (Solomon, 2023). This program aims to destigmatize school meals (Zuercher *et al.,* 2024). In the academic year 2022/23, government-sponsored SFPs benefited over 6 million schoolchildren, with the number of beneficiaries in Addis Ababa city administration (over 700,000) (Memirie Solomon, 2023). Moreover, the program has created employment opportunities for 10,120 mothers involved in food supply, cooking, and serving (MoE, 2022; Xie & Brownell, 2020). However, ensuring the microbiological quality and safety of meals is critical to prevent foodborne illnesses among students. Despite this, concerns have been raised regarding food safety, encompassing ingredient quality, food items, and the hygienic conditions during meal preparation for students (Green *et al.*, 2007a).

The microbiological quality of food reflects its microbial contamination level, with higher contamination indicating poor food storage and handling practices that increase disease transmission risks (Oguoma & Agusi, 2013; I. E. *et al.,* 2014). Bacterial counts in prepared food and water are crucial for assessing food safety and quality, shedding light on the hygiene standards maintained by food handlers during food preparation. Food and water are commonly recognized as vehicles for microbial disease transmission, including those induced by coliforms

(Nkere *et al.,* 2011; I. E. *et al.,* 2014). Recent concerns underscore the risks of microbial contamination in RTE meals, especially prevalent in high-volume settings like SFPs. The involvement of multiple individuals in large-scale food preparation (Annor & Baiden, 2011; Idris Ali & Immanuel, 2017), as seen in SFPs, increases the likelihood of contamination in the final product (Idris Ali & Immanuel, 2017).

Food contamination risks are heightened in large-scale cooking settings, leading to foodborne diseases with significant health and economic impacts, particularly in developing nations (Annor & Baiden, 2011; Idris Ali & Immanuel, 2017). RTE foods a common carrier of foodborne illnesses, contributes significantly to global outbreaks due to potential microbial contamination, posing grave health risks (De Voglia *et al.,* 2014; Sabuj *et al.,* 2020). Also, poor hygiene practices during food preparation are key contributors to the prevalence of foodborne diseases (Al Mamun *et al.,* 2013).Unintended contamination in food processes can trigger foodborne disease outbreaks, significantly impacting consumer health and national economies, especially in developing regions(Idris Ali & Immanuel, 2017; Compaore *et al.,* 2022). Annually, there are an estimated 582 million cases and 420,000 fatalities globally, with Africa bearing a major burden (Ngueugang *et al.,* 2021). Microbial food contamination is a critical public health issue (Kortei *et al.,* 2020). Approximately 45% of foodborne outbreaks are linked to educational settings (Marilyn B. Lee & Greig, 2010; Nagla *et al.,* 2014; Niehaus *et al.,* 2011). In the Republic of Korea, 47% of foodborne disease cases were associated with schools, while Japan reported 11,826 cases and 12 deaths from E. coli O157:H7 infections in schools in early 1996 (Ababio *et al.,* 2016; Cruz, 2020). Brazil saw 11.6% of reported cases in 2005 linked to school catering services (Ababio *et al.,* 2016; Cruz, 2020). An outbreak in South Wales in 2005 affected 157 schoolchildren due to contaminated sliced meats (Ababio *et al.,* 2016; Cruz, 2020), and France reported 544 adolescents affected by Salmonella in 2010 (Ababio *et al.,* 2016; Cruz, 2020). Instances of foodborne illnesses have also been documented in Egypt, Cambodia, and India, where many children fell ill after consuming school meals (Ababio *et al.,* 2016; Cruz, 2020).

Globally, 884 million people lack access to safe drinking water, with Bangladesh facing significant challenges (Shaibur *et al.,* 2019). In Africa, 40% of the population struggles with inadequate water supply and sanitation. Research in Lesotho, Addis Ababa, Dire Dawa, Jimma, and North Gondar found widespread bacterial contamination in water sources, indicating serious

hygiene and quality issues (Admassu *et al.*, 2005; A. Solomon *et al.*, 2011; Sallam, 2012; Amenu *et al.*, 2013; Gwimbi *et al.*, 2019; Wolde *et al.*, 2020). Persistent waterborne diseases stem from microbial pollutants, necessitating improved water safety protocols (José Figueras & Borrego, 2010; Wolde *et al.*, 2020). Contaminants, arising from fecal matter and infrastructural deficiencies, pose threats to piped water systems (Wolde *et al.*, 2020).

Children, especially those within educational institutions, are notably vulnerable to severe health complications induced by pathogenic bacteria present in tainted food sources (Gerba, 2009; Marilyn B. Lee & Greig, 2010). The assurance of food safety stands as a pivotal endeavor in shielding individuals from illnesses and associated hazards, given the fundamental role that food plays in human health (Kumari *et al.*, 2019). Nevertheless, the school setting poses unique challenges concerning disease transmission, with the potential for pathogenic microorganisms to contaminate food and water sources (Taulo *et al.*, 2009; Marilyn B. Lee & Greig, 2010; Groenewald, 2014).

The assessment of microbiological quality is essential to uphold safety standards for student meals. Microbiological contamination serves as a critical parameter that demands scrutiny to guarantee the safety of food prepared within catering systems (Petruzzelli *et al.*, 2018). Despite the presence of regulatory frameworks, school catering services frequently struggle to meet the required safety protocols during meal preparation. The oversight of specific sanitation guidelines across different phases of food handling jeopardizes the safety of students' meals (Santana *et al.*, 2009).

Previous studies have emphasized the importance of monitoring and assessing the microbiological quality of RTE foods in SFPs to identify potential risks and prevent foodborne outbreaks. Risk factors such as cross-contamination, improper storage, inadequate cooking, and poor cleaning procedures have been identified as critical (Marzano & Balzaretti, 2013; Petruzzelli *et al.*, 2018). Several school-related outbreaks have been associated with food contamination resulting from unwell (Quiroz *et al.*, 2000; Daniels *et al.*, 2002) or or unhygienic food handlers (Chua *et al.*, 2015; Woh *et al.*, 2017).

Indicator microorganisms play a crucial role in routine food safety evaluations by assessing hygiene practices in food establishments (Lues & Van Tonder, 2007). They are essential for detecting and quantifying food contamination, with key indicators *TVC*, *TC*, *E. coli*, and *S.*

aureus (Lues & Van Tonder, 2007; Buchanan & Oni, 2012). The *APC* measures the overall microbial load in a food sample. Total coliforms indicate general hygiene and potential pathogen presence. *E.coli* signifies fecal contamination and potential pathogenicity. *S. aureus* can produce toxins causing foodborne illness and is linked to poor food handling and hygiene. Additionally, although yeast and molds are not direct safety indicators, they are monitored for their effects on food quality and spoilage.

Given that food provides an optimal environment for microbial proliferation, the risk of spoilage and foodborne illnesses is heightened (Compaore *et al.*, 2022). Institutions like school cafeterias, which cater to large populations, face increased susceptibility to foodborne illnesses due to the extensive scale of food preparation, thereby escalating the potential for contamination (Payne-Palacio & Theis, 2016a; Dag, 2020).

In Addis Ababa, school kitchens involved in the SFP provide meals such as bread, rice, and injera with lentil-based sauce, typically served without reheating. However, there is limited information on the microbial safety of these offerings. This study evaluates the microbial safety and quality of meals and drinking water in the SFP, aiming to enhance food safety protocols and protect student well-being by identifying areas for improvement.

4.3 Methods and Materials

4.3.1 Study Area

Addis Ababa, the country's largest city, has significant political, economic, and symbolic importance (Weldeghebrael, 2021). By 2036, its population is projected to exceed 5 million, according to the central statistical agency (Weldeghebrael, 2021).The city government launched a large-scale school feeding program in Addis Ababa in February 2019 to combat hunger (Solomon, 2023). Currently, the school feeding program is implemented in all 264 public primary schools across 11 sub-cities, benefiting approximately 700,000 students (Solomon, 2023). The Addis Ababa SFP offered two school meals per day, comprising breakfast and lunch, throughout the week (Ethiopia: Food-Based Dietary Guidelines, 2022).

4.3.2 Study Design and Period

A school based cross-sectional study design was used to undertake this research work from March to April 15, 2024 in Addis Ababa, Ethiopia.

4.3.3 Inclusion and Exclusion Criteria

The study included RTE foods such as injera with sauces, rice, and bread regularly consumed by students in the school feeding program were included. Food samples that were inaccessible during the data collection process and any leftover foods from the selected sample were excluded from the study.

4.3.4 Sample Size Determination

To ensure comprehensive analysis and representative results, by the principle of rule of thumb (15-30%) in the study area around eighteen public primary schools have been selected where the large number of students serve and cooked foods were presented in large. A structured sampling approach was employed. Three distinct types of food samples, including injera with sauce, rice, and bread, were collected per school due to their frequent consumption by students as part of the school feeding program. From each of the eighteen selected public primary schools, a maximum of three food types comprising two cooked food samples and one drinking water sample were gathered based on their availability. These samples underwent meticulous laboratory analysis to assess their microbiological quality and safety.

4.3.5 Sample collection and handling procedures for food samples

In this study, 55 samples were collected for analysis, comprising RTE cooked food samples (n= 37) and drinking water samples (n=18). The RTE cooked food samples were further classified into three groups: 16 samples of injera with lentil sauce, 14 samples of rice, and 7 samples of bread. The collection took place from March to April 15, 2024, at selected public primary schools. Sampling occurred on weekdays between 11:30 a.m. and 12:30 p.m., coinciding with designated serving times and based on availability. Approximately 100 g of each food type was aseptically collected on each sampling day. The samples were placed in sterilized plastic stomacher bags, which were labeled with unique codes, subject names, and food types. The bags were securely sealed and stored below 4°C in a cooler with ice.

		
Figure 4. 1 Autoclave bag used for collection of cooked food samples	**Figure 4. 2** Ice box for collection of cooked food samples and drinking water	**Figure 4. 3** Sterile bottle for collecting drinking water

4.3.6 Microbiological Indicators and Quality Criteria for Food Safety

4.3.6.1 Microbiological Indicators for Food Safety

In this study, we employed common microbiological indicators to assess food safety in the SFP in Addis Ababa. The indicators assessed included *APC*, *TC*, *E.coli,* and *S. aureus.*

4.3.7 Microbiological Analysis Parameters and Quality Criteria for Cooked Foods

We followed Codex Alimentarius recommendations for cooked foods to determine the analysis parameters for each sample group. These parameters included *APC, TC, E.coli, S.aureus,* yeast, and molds. To conduct the microbial analysis, we homogenized 25 grams of each food sample with 225 ml of sterile buffered peptone water using a Bag Mixer for two minutes at speed 6. Serial dilutions were prepared using sterile buffered peptone water, and duplicate plates were made for each sample at each dilution following ISO 6887–1:2017 standard methods. Microbial counts were reported as CFU/ml. We assessed a total of 55 food samples, consisting of 37 food samples and 18 drinking water samples, to evaluate the microbiological quality and safety of RTE foods. This analysis involved detecting microbial indicators and pathogens, including *APC, TC, E.coli, S. aureus,* yeast, and molds.

Quality criteria were defined for each parameter to evaluate the microbiological quality. The criteria included *APC* $<10^6$ cfu/ml, *TC* $<10^2$ cfu/ml, *FC* $<10^2$ cfu/ml, *E. coli* < 3 cfu/ml, *S. aureus* $<10^2$ cfu/ml, and yeasts and molds < 10^2 cfu/ml., additionally specific microbial parameters for

water were evaluated, including *APC* < 100 cfu/ml, *TC* < 1 cfu/ml, *FC* < 1 cfu/ml, and *E. coli* < 1 cfu/ml. These criteria were tailored to each food item and its preparation processes **(Table 4.1).**

Table 4. 1 Reference standards for microbiological quality of RTE food and drinking water.

Standards limit for RTE cooked food samples			
	Satisfactory	Marginal	Unsatisfactory
Indicator organisms	Guideline limit (cfu/ml) for RTE food		
APC	$<10^6$ cfu/ml	10^6-10^7 cfu/ml	$\geq 10^7$ cfu/ml
TC	$<10^2$ cfu/ml	10^2-10^4 cfu/ml	$\geq 10^4$ cfu/ml
FC	$<10^2$ cfu/ml	10^2-10^4 cfu/ml	$\geq 10^4$ cfu/ml
E. coli	<3 cfu/ml	3-100 cfu/ml	≥ 100 cfu/ml
Staphylococcus count	$<10^2$ cfu/ml	10^2-10^3 cfu/ml	10^3-10^4 cfu/ml
Yeast and mold count	$< 10^2$ cfu/ml		$>10^2$ cfu/ml
Standards limit (cfu/ml) for drinking water samples			
Indicator organisms	Potable		Not-potable
APC	< 100cfu/ml		>100cfu/ml
TC	< 1cfu/ml		≥ 1 cfu/ml
FC	< 1 cfu/ml		≥ 1 cfu/ml
E. coli	< 1 cfu/ml		≥ 1 cfu/ml

Source: *Centre for Food Safety, 2014; ESA, 2013; Ethiopian Standards Agency, 2019; Food Standards Australia New Zealand, 2022; Latchumaya et al., 2021; New, 2001; NSW Food Authority, 2009*

4.3.8 Sample Processing and Preparation for Analysis

Aseptically, 25 g of foods were weighed into sterile stomacher bags, blended with 225 ml BPW, and homogenized in stomacher for 2 min. Tenfold dilutions of homogenate were carried out with sterile peptone water (0.1%; model 400, Seward Medical, London, UK) (Wei *et al.*, 2006; Khater *et al.*, 2013; Laure Wounang Ngueugang *et al.*, 2021). The analysis was performed on the same day as sample collection to ensure timely and accurate results.

4.3.9 Aerobic Plate Count Determination

Aerobic viable cells were counted using plate count agar (PCA, Difco Co., Detroit, MI, USA) and an automatic spiral plater (Spiral system, Model DU2, Cincinnati, OH, USA). The agar plates were incubated at 37°C for 48 hours. After incubation, visible colonies were counted. Plates with colony counts ranging from 25 to 250 were selected for *APC* enumeration. The APC was calculated using the dilution factor and colony counts, and the results were expressed as CFU/mL or CFU/g (Wei *et al.,* 2006).

4.3.10 Enumeration of *E. coli* and *Coliform*

Chromocult coliform agar (CCA, Merck Co., Darmstsdt, Germany) was used to enumerate *E. coli* and *coliform* following the manufacturer's instructions (Finney *et al.,* 2003). Dilutions were plated and incubated at 37ºC for 24-48 hours. Purplish red colonies were identified as coliform, while blue colonies were identified as *E. coli* (NMKL, 2006a; Wei *et al.,* 2006)

4.3.11 Enumeration of S. aureus

A 0.1 ml volume of the sample was spread evenly on Mannitol Salt Agar obtained from (HiMedia Laboratories Pvt. Ltd in Mumbai, India). The agar plates were incubated at 37°C for 48 hours to allow colony formation (Wei *et al.,* 2006). The *S. aureus* count was determined by observing typical colonies on the plates and conducting a positive coagulase test. Typical black colonies were further confirmed using rabbit plasma medium, which detects the presence of coagulase, an enzyme responsible for clot formation. The combination of enumeration on Mannitol Salt Agar and the positive coagulase test provided the *S. aureus* count (Bano *et al.,* 2020).

4.3.12 Enumeration of Total Coliforms

One milliliter of the food homogenate from each dilution was transferred to sterile Petri dishes. Then, 5 ml of molten Tryptone Soya Agar obtained from (HiMedia Laboratories plc in Mumbai, India) (kept at 45°C) was poured into each dish. The dishes were incubated at 37°C for 48 hours, followed by further incubation at 35°C ± 0.5°C for 24-48 hours with the agar plates inverted (NMKL, 2006a).

4.3.13 Confirmation of Total Coliforms

Selected colonies were inoculated into Brilliant Green Bile Broth obtained from (Oxoid LTD in Basingstoke, Hampshire, England). The broth was incubated at 37°C for 48 hours, and positive coliform results were determined by examining gas production and turbidity after incubation (NMKL, 2006a).

4.3.14 Enumeration of Yeast and Mold

A 0.1 ml portion of the food homogenate was spread onto Rose-Bengal chloramphenicol Agar obtained from (Micromix Pvt. Ltd in Verna, India). The agar plates were incubated at 25°C for 5 days. Yeasts were identified by their creamy and white appearance, while molds were distinguished by their velvety texture and various colors (Spencer & Spencer, 2001).

4.3.15 Sampling of drinking water

Water samples (n=18) were collected from each selected school from March and April 15, 2024. The tap outlets were disinfected with 80% alcohol, followed by the addition of 0.5ml of sodium thiosulphate solution in the sterilized bottle to neutralize residual chlorine. Before sampling, the water was allowed to run for approximately 3 minutes. About 250 ml of water were aseptically collected in sterilized plastic bottles. The samples were transported with ice container to the EPHI food microbiology laboratory for analysis. The indicators analyzed included coliforms, *E. coli*, and aerobic mesophilic bacteria. Results were expressed as CFU/ml of water, and the samples were analyzed on the same day as collection.

4.3.16 Aerobic Plate Count

One milliliter of the water sample was pipetted into each dish, ensuring thorough mixing for homogeneity. Standard plate count agar was melted and poured into each dish, covering the entire surface. The dishes were left undisturbed for 15 minutes to allow the agar to solidify. Inverted petri dishes were sealed in a plastic bag to create an appropriate incubation environment and placed in an incubator set at 35 ± 0.5 °C for 48 ± 3 hours. After incubation, visible colonies on the solidified agar were counted using a colony counter. The colony counts were recorded, and the *APC* was calculated based on the number of colonies and the dilution factor. The results were compared to regulatory guidelines or established standards for drinking water quality (Malik et al., 2020).

4.3.17 Determining coliform and fecal coliform using membrane filtration

Microbiological analyses were performed using the membrane filtration technique according to ISO protocols, for the detection of *E.coli*. Water samples of 250 ml each were filtered through a pore size of 0.45 µm and 47 mm in diameter for all organisms. The membranes were placed in each Petri dish filled with a specific medium. The filters were placed on Tryptone Soya Agar plates for *TC* detection and Violet Red Bile Agar plates for thermotolerant *E. coli* detection (Gerba, 2015). Incubation of the plates occurred at specific temperatures for 48 hours: 37°C for Tryptone Soya Agar plates and 44°C for Violet Red Bile Agar plates. After incubation, the plates were examined for characteristic coliform colonies. Representative colonies were selected and inoculated into brilliant green lactose bile broth, followed by incubation at 37°C for 48 hours to assess gas production and confirm the presence of *coliform* bacteria. Positive tubes were transferred to EC broth and subjected to the indole test after incubating at 44.5°C for 48 hours to confirm suspected *E. coli* (Gerba, 2015).

For specific *E. coli* detection, water samples from positive EC broth tubes were inoculated into nutrient broths and incubated at 44.5°C for 24 hours to promote *E. coli* growth. The broths were then subjected to the indole test. Colony counting was performed using the pour plate method, visually counting colonies on agar plates to calculate the total viable count (TVC). Positive coliform detection was indicated by gas production and lactose fermentation within the designated incubation period. Confirmation was achieved by transferring samples to Brilliant Green Bile Broth agar plates and observing the growth of typical coliform colonies (Bano *et al.*, 2020; Malik et al., 2020; NMKL, 2006a, 2006c, 2006b; Nordic Committee on Food Analysis, 2006).

4.3.18 Description of bacteriological loads of the sample

To determine the bacteriological loads of the sample, the colonies on each plate were counted using a colony counter. The results were described as colony forming units per milliliter (CFU/ml) using the following formula (Laure Wounang Ngueugang *et al.*, 2021).

$$CFU/ml = \frac{number\ of\ colonies\ x\ dilution\ factors}{volume\ of\ the\ sample}$$

4.3.19 Data Management and Quality Control

To ensure data management and maintain quality control throughout the study, a standardized format was implemented for sample collection. This format included essential details such as sample type, location, date and time of collection, collector names, and the number of samples taken. All laboratory materials used for analysis underwent a thorough cleaning process, including washing, rinsing, and sterilization, to preserve sample integrity and eliminate potential contaminants. Qualified professionals, including public health and microbiology experts, were trained in proper sample collection procedures during an orientation session. The collected samples were stored in aseptic conditions in ice chests or chilled cooler bags and transported to the food microbial laboratory at the Ethiopian Public Health Institute. Before analysis, media for sample testing was prepared according to manufacturer instructions, and its sterility was confirmed through overnight incubation. Stringent quality control measures were implemented for each batch of samples to ensure accurate and reliable results.

Tests were run with positive and negative controls for the whole quality of the study under the whole supervision of culture media, reagents and samples were run with positive and negative controls.

4.3.20 Statistical Analysis

Descriptive statistics, including frequencies, percentages, and other relevant measures, were used to summarize and analyze the data regarding microorganisms. The collected data were entered into an Excel spreadsheet, and the statistical software STATA version 16 was utilized for the analysis.

4.3.21 Ethical Approval

This study was reviewed and approved (IRB/04/2015/2023) by the Institutional Review Board of the college of natural and computational sciences, Addis Ababa University (CNS–IRB). Additionally, permission was obtained from city government of Addis Ababa education bureau to the collection of food and water samples, the directors of all selected public primary schools provided their consent. Confidentiality measures were strictly adhered to, ensuring the protection of all collected sample information.

4.4 Results

4.4.1 Microbiological quality assessment of injera with sauces, rice, and bread served to students

The microbiological quality assessment was conducted on three food items, namely injera with sauces, rice, and bread, which were served to students, and the findings are presented in **Fig. 4.4.** The findings revealed important insights into the microbial safety of these food items. In terms of *APC*, all three food items met the satisfactory criteria. Injera with sauces had a count of 18, rice had a count of 14, and bread had a count of 6. These results indicate that the microbial load in the food items was within acceptable limits and did not pose a significant risk to the students' health.

The evaluation of *TC* bacteria showed that injera with sauces and rice maintained satisfactory levels, with counts of 12 and 8, respectively. However, bread had marginal results with a count of 5. Although the counts in bread were slightly higher than the desired level, they still did not exceed the threshold for unsatisfactory results. Overall, there were no unsatisfactory results for *TC* in any of the food items. Similarly, the assessment of *FC* revealed satisfactory levels in injera with sauces (count of 14) and rice (count of 8), while bread showed marginal levels with a count of 4. Although the marginal result in bread suggests a slightly higher presence of *FC*, it did not reach an unsatisfactory level. None of the food items recorded unsatisfactory results for *FC*. *Yeast* and *molds*, which can impact the quality and shelf life of food, were found to be satisfactory in injera with sauces (count of 4) and rice (count of 3). However, both food items had unsatisfactory results for yeast and molds, with injera with sauces having a count of 14 and rice having a count of 11. Bread also showed marginal results with a count of 2, but no unsatisfactory result was observed.

This findings suggest that the food items, particularly injera with sauces and rice, may have had some issues with yeast and mold contamination, requiring attention to maintain their quality. Regarding *S. aureus*, a bacterium associated with foodborne illnesses, injera with sauces, rice, and bread all had satisfactory counts of 16, 12, and 5, respectively. However, there was one marginal result in each food item, with injera with sauces and rice having a count of 1, and bread having a count of 1. Two unsatisfactory results were recorded for *S. aureus* in injera with sauces

and rice. These marginal and unsatisfactory results indicate the need for improved hygiene practices during food preparation to prevent the growth of *S. aureus*.

Lastly, the presence of *E. coli*, a common indicator of *FC*, was evaluated. It was found to be absent in injera with sauces, rice, and bread, with counts of 17, 12, and 5, respectively. However, four unsatisfactory results were observed for *E. coli* in rice (two), injera with sauces, and bread (one each), indicating the presence of *E. coli* in four samples. These findings highlight the importance of strict sanitary measures to prevent fecal contamination during the preparation and handling of food items.

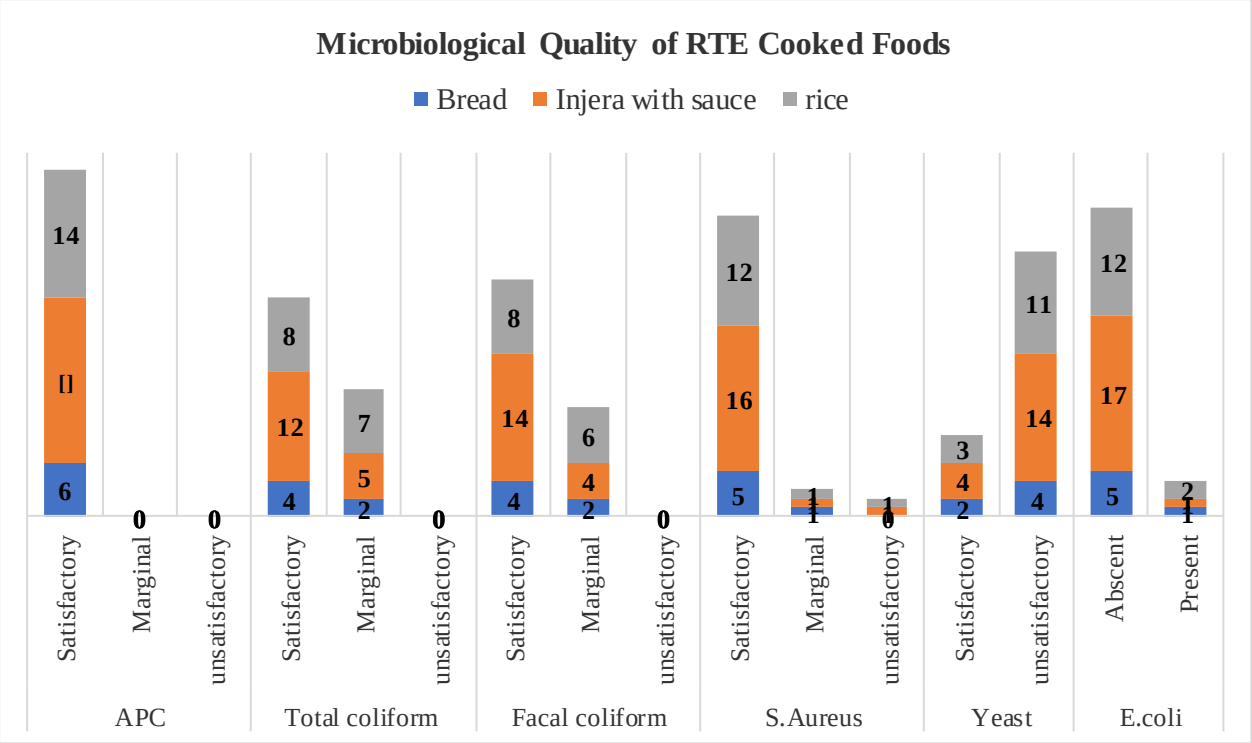

Figure 4. 4 Microbiological assessment of RTE cooked meals served to students in public primary schools as part of the Addis Ababa SFP, Ethiopia (n= 37)

4.4.2 Microbial safety evaluation of RTE cooked foods samples

The microbial quality assessment was conducted based on different indicator microorganisms, and the results are summarized in **Table 4.2**. The table provides insights into the levels of various microorganisms, helping to evaluate the overall safety and quality of the samples. In terms of the *APC*, all 37 samples tested fell within the satisfactory range, with less than $<10^6$ cfu/ml. This indicates that the microbial load in the samples was within acceptable limits, indicating good microbial quality.

For both *TC* and *FC*, the majority of the samples (64.9% and 70.3% respectively) showed satisfactory levels, with $<10^2$ cfu/ml. However, a portion of the samples (35.1% for *TC* and 29.7% for *FC*) fell into the marginal range, indicating a slightly elevated microbial presence. No samples exceeded the unsatisfactory threshold, which is positive in terms of microbial safety.

Evaluation of *E. coli* levels revealed that 89.5 % of samples exhibited satisfactory counts below<3 cfu/ml, with none falling within the marginal range (3–100 cfu/ml). However, it is worth noting that 10.8 % of the samples exceeded the unsatisfactory threshold, indicating a higher presence of *E. coli* in those samples. Likewise, for *S. aureus*, the majority of samples (89.2 %) displayed satisfactory levels below $<10^2$ cfu/ml. A small percentage of samples (5.4 %) resided in the marginal range (10^2-10^3 cfu/ml), and another 5.4 % of the samples were in the unsatisfactory range (10^3 -10^4 cfu/ml). These findings underscore the necessity for enhanced control measures to uphold sample microbial safety.

In terms of yeasts and molds, only 21.6 % of the samples had satisfactory levels below $<10^2$ cfu/ml. Conversely, the bulk of samples (78.4 %) surpassed the unsatisfactory threshold, signaling a notable presence of yeasts and molds. This outcome suggests potential apprehensions regarding food quality and spoilage, emphasizing the imperative for heightened control measures to curb the proliferation of yeasts and molds in the samples.

Table 4. 2 Microbial safety evaluation of RTE cooked foods samples in the Addis Ababa SFP, Ethiopia (March to April 2024) (n = 37).

Indicator organisms	Microbial quality			
	Food samples examined (n=37)	Satisfactory	Marginal	Unsatisfactory
		In % and CFU/ml	In % and CFU/ml	In % and CFU/ml
APC	37	100 ($<10^6$)	0.0 (10^6-10^7)	0.0 ($\geq 10^7$)
TC	37	64.9 ($<10^2$)	35.1 (10^2 -10^4)	0.0 ($\geq$ -10^4)
FC	37	70.3 ($<10^2$)	29.7 (10^2-10^4)	0.0 ($\geq$ 10^4)
E. coli	37	89.5 (<3)	0.0 (3-100)	10.8 ($>10^2$)
S. aureus	37	89.2 ($<10^2$)	5.4 (10^2-10^3)	5.4 (10^3 -10^4)
Yeasts and *molds*	37	21.6 ($<10^2$)	-	78.4 ($>10^2$)

4.4.3 Overall microbial quality in school meal samples served in the SFP

In analyzing the overall quality of the samples, a comprehensive assessment was conducted across multiple parameters. The satisfactory category emerged as the dominant classification, encompassing approximately 68.7 % of the samples. Notably, high ratings were observed for the *APC* (100 %), *TC* (64.9 %), *FC* (70.3 %), *E. coli* (89.5 %), *S. aureus* (89.2 %), and yeasts and molds (21.6%). Conversely, the marginal category accounted for approximately 16.9 % of the samples, unveiling nuanced concerns primarily in *TC* (35.1 %), FC (29.7 %), and *S. aureus* (5.4 %). Within the "unsatisfactory" category, comprising about14.4 % of the samples, specific issues surfaced in parameters such as *E. coli* (10.8 %), *S. aureus* (5.4 %), and yeasts and molds (78.4 %). Referring to the pie chart in **Fig. 4.5.**, the segmented categories provide insights into the distribution of microbial quality levels, offering a detailed understanding of the safety and quality of the school meal samples within the program.

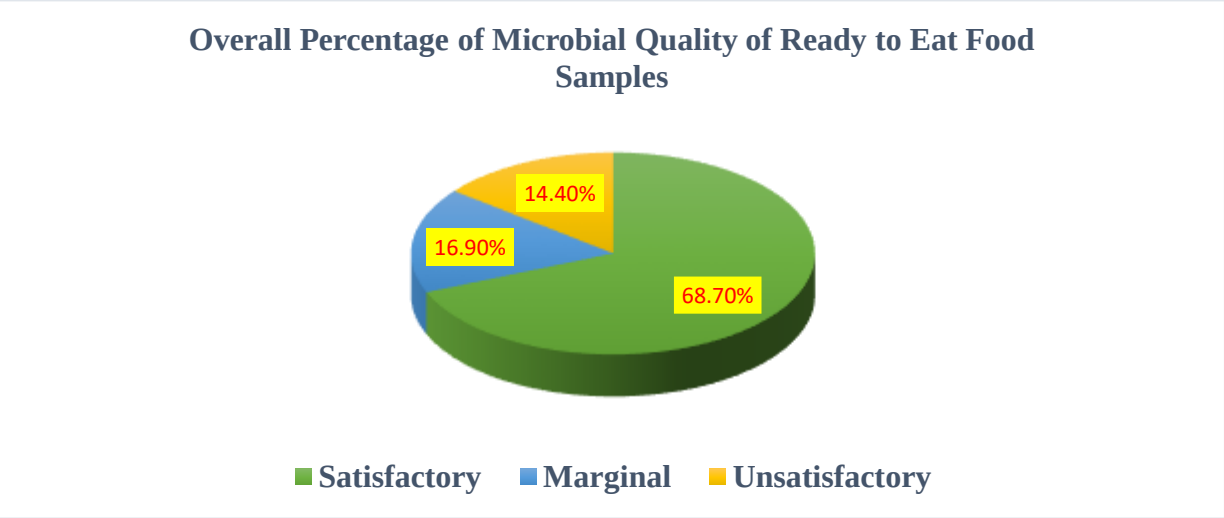

Figure 4. 5 Comprehensive assessment of microbial quality in school meal offerings within the Addis Ababa SFP, Ethiopia (March to April 2024) (n= 37).

4.4.4 Microbial quality assessment of drinking water samples

Table 4. 3 outlines the findings from the evaluation of 18 drinking water samples designated for student consumption. The analysis focused on key parameters including *APC*, *TC*, *FC*, and *E. coli*. In the assessment, 28.8 % met the acceptable limit for *APC* (<100 cfu/ml), while the majority, constituting 72.2 % of the samples, surpassed this limit (>100 cfu/ml). Concerning *TC*, 84 % of the samples demonstrated counts below the permissible level (<1 cfu/ml), while 16 % exceeded this threshold (>1 cfu/ml) (<1 cfu/ml).

Regarding *FC* counts, a small fraction of samples 5.5 % exceeded the recommended limit (>1 cfu/ml), with the vast majority 94.5 % falling below this threshold (<1 cfu/ml). Noteworthy is the absence of *E. coli* in all samples, with every test yielding negative results and all samples remaining well below the stipulated limit (<1 cfu/ml).

Table 4. 3 Microbial quality assessment of drinking water samples served to students in the Addis Ababa SFP, Ethiopia (March to April 2024) (n = 18).

Indicator organism	Microbial quality of water		
	Drinking water samples (n=18)	Potable (In % and cfu/ml)	Not potable (In % and cfu/ml)
APC	18	28.8% (<100)	72.2% (>100)
TC	18	84% (<1)	16% (>1)
FC	18	94.5 % (<1)	5.5 % (>1)
E.coli	18	100% (<1)	0.0% (>1)

4.4.5 Assessment of potability and contamination in drinking water samples

The investigation revealed that a majority of the drinking water samples, approximately 76.6 %, adhered to potable water standards, signifying commendable microbial quality within acceptable limits. Conversely, 23.4 % of the samples exhibited non-potable characteristics pointing to elevated levels of microbial contamination, rendering them unsuitable for consumption.

The visual depiction in the accompanying pie chart, as illustrated in **Fig. 4.6**., succinctly presents these proportions, offering a clear overview of the distribution between potable and non-potable samples. Addressing the issue of non-potable water highlights the crucial imperative to enhance water quality measures, thereby ensuring the provision of safe and clean drinking water for students.

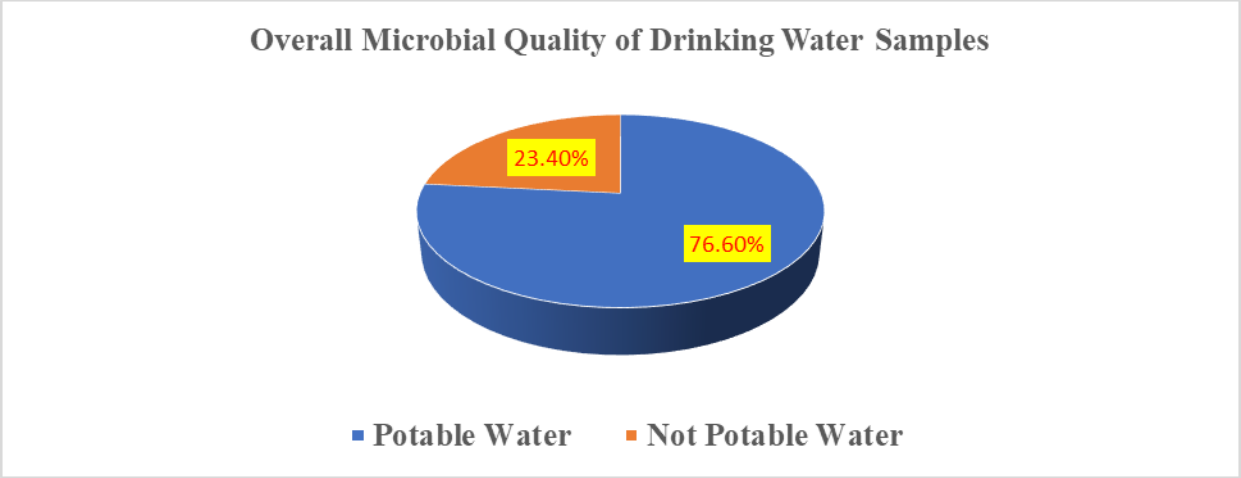

Figure 4. 6 Evaluation of microbial quality in potable and non-potable drinking water samples within public primary schools of the Addis Ababa SFP, Ethiopia (March to April 2024) (n = 18).

4.4.6 Variability in microbial contamination levels of water and food samples

The examination of microbial contamination levels in water and food samples unveiled substantial variability across multiple parameters, reflecting diverse concentrations present in the samples. Summary statistics offer valuable insights into the breadth and fluctuations in microbial counts within the dataset.

The average count of aerobic microorganisms, captured by the *APC* metric, stood at 1745.7, indicating a typical concentration observed in the samples. However, the wide range from 0 to 8320 suggests substantial variations in microbial counts among the samples, showcasing notable deviations from the average and underscoring the heterogeneity in contamination levels.

Serving as indicators of water quality, *TC* exhibited an average count of 1437.255. The wide range from 8 to 10000 indicates a significant variation in *TC* concentrations across the samples. This variability underscores the diverse levels of microbial contamination present in the dataset, indicating differences in water quality among the samples.

Specifically utilized to detect fecal contamination in water, *FC* showcased an average count of 371.273. With a high standard deviation of 1434.809 and a range spanning from 5 to 8500, the dataset reveals significant fluctuations in *FC* levels, indicating varying degrees of contamination observed within the samples.

S. aureus, a bacterium associated with infections, exhibited an average count of 196.579. The range from 0 to 4600 indicate a considerable variation in the presence of this bacterium across the samples. This finding highlights the need for proper monitoring and control measures to ensure the safety in food samples.

Observations for yeasts and molds revealed an average count of 2320.541. With a wide standard deviation of 5129.028 and a range extending from 0 to 30000, the dataset underscores substantial variability in fungal levels within the samples, underscoring the critical importance of vigilance and management in mitigating fungal contamination in food samples.

Table 4. 4 Summary statistics of microbial contamination levels in drinking water and food samples within the Addis Ababa SFP, Ethiopia (March to April 2024) (n = 55).

Variable	**Obs**	**Mean**	**Std. Dev**	**Min**	**Max**
APC	55	1745.75	2304.902	0	8320
T C	55	1437.255	3242.069	8	10000
F C	55	371.273	1434.809	5	8500
S. aureus	37	196.579	792.411	0	4600
Yeasts and molds	37	2320.541	5129.028	0	30000

4.5 Discussion

The investigation into the microbiological quality of RTE cooked meal samples in the Addis Ababa SFP revealed an overall satisfactory level of quality and safety, aligning with findings from previous studies (Tessi *et al.,* 2002). However, notable concerns emerged as yeasts and molds exceeded reference standards in 78.4 % of samples (>10^2 cfu/ml), *E. coli* surpassed limits in 10.8% of samples (>10^2 cfu/ml), and *S. aureus* counts exceeded acceptable thresholds in 5.4% of samples (10^3 -10^4), indicating potential risks associated with these pathogens. Cooked rice displayed the highest microbial counts, particularly for *E.coli* and *S. aureus*, corroborating the trend observed in other studies (DH *et al.,* 2008). Approximately 14.4 % of the food samples were deemed unsatisfactory due to contamination from *E. coli, S. aureus*, yeasts, and molds, echoing concerns raised in similar research (Guadu *et al.,* 2016).

Comparing these findings with studies from different regions sheds light on both similarities and differences in RTE food safety practices. For instance, research in Benin City and Bangladesh highlighted similar challenges with microbial contamination in RTE foods, emphasizing the need for improved food safety measures across diverse settings (Wogu *et al.,* 2011; Jahan *et al.,* 2018). Studies in Bangladesh and India further underscored varying levels of microbial contamination in fast foods, with findings indicating potential health risks posed by pathogens like *E. coli* and Staphylococcus spp (Idris Ali & Immanuel, 2017; Sabuj *et al.,* 2020).

The analysis of RTE cooked foods distributed to schools in Argentina and street-vended RTE food in Amravati City, India, revealed comparable concerns regarding microbial contamination, especially concerning pathogens like *E. coli,* and *S. aureus* (Tessi *et al.,* 2002; DH *et al.,* 2008). These findings resonate with the current study's observations and emphasize the widespread nature of microbial risks associated with RTE foods in different contexts.

In the present investigation, *S. aureus* was detected in 5.4 % of food samples, contrasting with studies from Argentina and Brazil where no *S. aureus* was found, highlighting potential variations in microbial contamination levels across regions (Tessi *et al.,* 2002; Santana *et al.,* 2009). Similarly, concerning levels of *E. coli* were observed in approximately 10.8 % of samples, aligning with previous reports and emphasizing the critical role of stringent food safety practices in preventing microbial contamination and associated health risks (Nagla *et al.,* 2014; Petruzzelli *et al.,* 2018).

Studies conducted in various regions, such as Gondar, Ethiopia, and the University of Port Harcourt, Nigeria, further underscore the global challenge of bacterial contamination in street-vended foods, with findings revealing the presence of pathogens like *TC, S. aureus*, and Salmonella species, reinforcing the need for enhanced food safety measures worldwide (Guadu *et al.*, 2016; Odu & Assor, 2013).

Moreover, research on street-vended foods in Jigjiga City, Eastern Ethiopia, highlighted a high contamination rate of 72 % with prevalent isolates being *E. coli* and *S. aureus,* particularly in foods like 'Sambusa' and 'Pasta (Nagla *et al.*, 2014). A study in Gondar town, Northwest Ethiopia, found that out of 72 street-vended food samples analyzed, 44 were contaminated with *S. aureus* and *E. coli*, with varying levels of contamination across different food items (Amare *et al.*, 2019; Teferi, 2020). These findings are consistent with a study in Jimma Town, Southwestern Ethiopia, where S. aureus was present in 29.38 % of food samples, predominantly in 'firfir', and another study in Gondar, Ethiopia, which reported contamination rates of 64.3 % with pathogenic bacteria, including *E. coli* and *S. aureus* (Endris *et al.*, 2013; Reda *et al.*, 2017).

The presence of even a small number of *E. coli* in food samples is concerning due to the potential for severe foodborne illnesses associated with certain strains (Tambekar *et al.*, 2011). The detection of *E. coli* in RTE foods underscores issues of contamination during food handling and processing, emphasizing the critical need for enhanced hygiene practices and proper cooking techniques to minimize risks.

Our study's findings underscore a significant concern regarding the microbial quality and safety of food samples, particularly in relation to yeasts and molds. A notable proportion of the samples (78.4 %) were deemed unsatisfactory due to elevated levels of these microorganisms. This contamination rate exceeds the results of a comparable study conducted in Burkina Faso, where only 24.75 % of samples exhibited contamination by *yeasts* and *molds* (Compaore *et al.*, 2022).

Yeasts and molds serve as indicators of food quality (Tortorello, 2003), and their presence in food samples not only signifies compromised quality but also poses substantial health risks, especially among school-age children. Molds have the potential to produce mycotoxins, harmful substances with adverse effects on human health. Consequently, immediate attention and remedial action are imperative upon their detection in food samples.

The occurrence of yeasts and molds in heat-treated foods can be attributed to various factors, including inadequate cooking, postprocessing contamination, cross-contamination, or the utilization of substandard raw materials. Moreover, the absence of adequate protection from ambient conditions can contribute to food spoilage and the proliferation of these microorganisms.

The assessment of drinking water within the scope of the current school-based study unveiled alarming levels of non-potability, with 23.4 % of samples failing to meet safety standards. Notably, 72 % of the samples exceeded the acceptable *APC* count (>100 cfu/ml), 16 % surpassed the *TC* limit (>1 cfu/ml), and 5.5 % exceeded the *FC* threshold (Tessi *et al.,* 2002). This finding resonates with similar studies in Ethiopia and other sub-Saharan regions, where sources such as taps, reservoirs, springs, and wells commonly exhibit microbial contaminants, indicating a pervasive issue that transcends individual study locations (Shaibur *et al.,* 2019; Wolde et al., 2020). Investigations in diverse regions have shed light on the challenges surrounding drinking water quality. For instance, research in the rural villages of the Mohale Basin in Lesotho revealed high levels of pollution in drinking water, with *E. coli* detected in 78 % of unprotected water sources and 60 % of protected sources, alongside signs of open defecation in 59 % of samples, underscoring sanitation and hygiene challenges in such settings (Gwimbi *et al.,* 2019; Wolde *et al.,* 2020).

In the current study, the analysis of drinking water samples highlighted substantial contamination levels, with notable percentages testing positive for *APC, TC,* and *FC,* indicative of unsatisfactory conditions (Tessi *et al.,* 2002). This contrasts with findings from studies in Argentina and Italy, where lower levels of contamination were reported, emphasizing regional disparities in water quality and contamination sources (Tessi *et al.,* 2002; Marzano & Balzaretti, 2013)

Regional variations in water quality were further underscored by research findings from Peshawar, Jaipur, Karnataka, Bhilai, and Tabuk, indicating varying percentages of drinking water samples contaminated with coliforms (Ali *et al.,* 2013; Aly & Elbadawy, 2017; Singh *et al.,* 2014). These discrepancies emphasize the necessity for tailored assessments and targeted interventions to address microbial contamination effectively.

The absence of *E. coli* in the drinking water samples from the current study aligns with findings from Argentina but differs from reports in Assam, India, Peshawar, Pakistan, and Bo, Sierra Leone, where substantial proportions of samples were contaminated with *E. coli* (Borah *et al*., 2010; Ali *et al*., 2013; Jimmy *et al*., 2013). Compliance with WHO guidelines stipulating non-detectable levels of *TC* bacteria in 100 ml samples further underscores the critical need for stringent water quality standards (Wolde *et al.,* 2020).

Comparing research outcomes from different regions, such as Saudi Arabia, India, Pakistan, and Sierra Leone, reveals varying contamination rates with *coliforms* and *E. coli* in drinking water samples, highlighting global challenges with microbial contamination in water sources (Sh AlOtaibi, 2009; Borah *et al.,* 2010; Ali *et al.,* 2013; Jimmy *et al.,* 2013). Studies focusing on municipal drinking water quality in Addis Ababa City, Ethiopia, and other regions within the country underscore the presence of bacterial indicators in public taps, protected wells, and water lines, reflecting the broader concern of water quality and safety (Admassu *et al.,* 2005; Solomon *et al.,* 2011; Amenu *et al.,* 2013; Wolde *et al.,* 2020)

Challenges in ensuring the quality and safety of drinking water persist due to contaminants stemming from both man-made and natural sources. Microorganisms present in drinking water, often due to fecal contamination and microbial growth within distribution systems, pose significant public health risks, underscoring the importance of robust water quality management practices (José Figueras & Borrego, 2010; Wolde *et al.,* 2020).

It is critical to acknowledge the constraints inherent in this study. Initially, the focus on indicator microorganisms serves to highlight unsanitary conditions or potential health hazards. However, the mere presence of these indicators does not confirm the existence of specific pathogens, necessitating further inquiry for precise identification and quantification. Moreover, the study's narrow focus on a limited number of schools may impede the extrapolation of results to encompass all public primary schools in the city. The research underscores the significance of ongoing surveillance to safeguard consumers against foodborne illnesses and food poisoning by ensuring the microbiological safety of RTE foods. This is particularly vital for the well-being of primary school students, who may not always prioritize their dietary choices. While emphasizing the need for nutritious and safe food, the study's limitations, such as the incomplete characterization of all bacterial and fungal isolates, could potentially underestimate the actual

extent of food contamination. Additionally, the absence of investigations into parasites, and the practices of food handlers hampers a comprehensive understanding of the factors influencing the microbiological quality of RTE foods.

4.6 Conclusions

The findings underscore the pressing need for immediate action to address microbial safety challenges within the Addis Ababa SFPs. While most samples adhered to acceptable standards, the presence of heightened levels of *E. coli*, *S. aureus*, and yeasts/molds emphasizes critical areas of concern. Elevating hygiene standards during food preparation and enforcing stringent control measures are paramount to ensure student safety and well-being.

Moreover, comprehensive interventions are essential to combat microbial contaminants in drinking water, mandating improved hygiene practices, safeguarding water sources, and implementing regular monitoring protocols. Prioritizing the microbial safety of food and water is indispensable for effectively safeguarding the health and welfare of students enrolled in the Addis Ababa SFP. The novel findings presented in this study not only highlight the existing challenges but also underscore the urgency and importance of implementing proactive measures to enhance food and water safety protocols within SFP. This study contributes valuable insights that can guide future research and policy initiatives aimed at ensuring the optimal health outcomes for school children.

CHAPTER 5: ASSESSING FOOD SAFETY KNOWLEDGE, ATTITUDES, AND PRACTICES OF FOOD HANDLERS IN SELECTED PRIMARY SCHOOLS IN ADDIS ABABA

5.1 Abstract

Background: In school food services, especially in developing nations like Ethiopia, ensuring student health through food safety is crucial. Effective food safety practices prevent foodborne illnesses, which can impact children's health and academic performance. Therefore, this study investigated the knowledge, attitudes, and practices of food handlers in the SFP in Addis Ababa, Ethiopia.

Methods: A cross-sectional study was conducted from April to May 2023, involving 632 food handlers from 20 randomly selected schools in Addis Ababa. All food handlers involved in food service operations at each selected school participated in the study. Data were collected through face-to-face interviews using structured questionnaires to assess knowledge, attitudes, and practices regarding food safety. Knowledge was assessed using a 29-question Food Safety Knowledge Questionnaire, scored on a 100-point scale, with a cutoff of 70% indicating "good knowledge." Attitudes were evaluated with a 22-question Food Safety Attitudes Questionnaire, categorizing scores as favorable or unfavorable; participants scoring 15 or fewer were deemed to have an "unfavorable" attitude, while those scoring 16 or more were classified as having a "favorable" attitude. Practices were measured using a separate 22-question Food Handling Practices Questionnaire, with a cutoff of 16 points or more indicating "good food handling practices," based on criteria from previous research. Descriptive statistics, pairwise correlations, and multiple linear regression analysis were employed for data analysis.

Results: The study indicated high knowledge (85.8%), positive attitudes (79.6%), and satisfactory safe food handling practices (72.3%) among food handlers. Education, years of service, and marital status influenced knowledge, attitudes, and practices. Knowledge and attitudes had a positive impact on practice scores in both simple (knowledge: AOR = 0.11; attitude: AOR = 0.31) and multiple logistic regression models (knowledge: AOR = 0.03; attitude: AOR = 0.19). The analysis revealed that education significantly improved knowledge ($p = 0.004$) and practices ($p < 0.001$) among food handlers. Additionally, years of service were found

to positively influence knowledge ($p < 0.001$) but negatively impacted practices ($p = 0.019$). Marital status also played a role, with significant associations observed in attitudes ($p = 0.046$) and practices ($p = 0.043$), suggesting that marital status can shape food handling behaviors.

The logistic regression analysis revealed that having a separate room for raw and RTE food storage reduced unsatisfactory food safety practice by 55% [AOR=0.45], a water facility in the kitchen decreased poor hygiene practices by 46% [AOR=0.54], and a hand-washing facility lowered the odds by 35% [AOR=0.65]. Food handlers with higher attitude scores had an 81% lower likelihood of poor food safety and hygiene practices [AOR=0.19].

Conclusions: The study highlights a high knowledge, positive attitudes, and satisfactory practices among food handlers in the SFP. Although participants exhibited high levels of awareness and knowledge regarding food safety, there are notable gaps in actual practices that need to be addressed. The findings underscore the necessity for targeted educational interventions that take into account regional and cultural influences on food safety behaviors. Additionally, future research should prioritize objective measurements to deepen the understanding of food safety practices and their implications for public health.

Keywords: Attitudes, Food safety, Food handlers, Knowledge, Practices

5.2 Introduction

Ensuring food safety is a significant challenge in both developing and developed countries, with foodborne diseases affecting up to one-third of the population in developed nations annually. The situation is likely even more severe in developing countries, where inadequate resources can hinder effective food safety measures (Ayalew *et al.*, 2013). In school meal programs, food safety is crucial, as lapses can expose students and staff to outbreaks of foodborne illness (Nagla *et al.,* 2014). Common factors contributing to these outbreaks include improper cooking, poor personal hygiene, unsafe food sourcing, contaminated equipment, and improper food storage (Sanlier, 2009; Sanlier & Konaklioglu, 2012b; Del Portal & Karras, 2013; July *et al*., 2017).

Personal hygiene is particularly critical, with studies indicating that approximately 89% of foodborne illness outbreaks are linked to contaminated food handled by food handlers (Green et al., 2006). In schools, around 45% of outbreaks are attributed to foodborne transmission (Lee & Greig, 2010; Nagla *et al.,* 2014), highlighting the vulnerability of children in these settings. For instance, Brazil has reported over 600 outbreaks in daycare and school facilities over the past eleven years (Nagla *et al.,* 2014), underscoring the urgent need for stringent hygiene practices among food handlers, as their knowledge and practices significantly influence food safety. Poor personal hygiene can lead to direct contamination or cross-contamination, further exacerbating the risk of foodborne illnesses (Tan *et al*., 2013).

The Addis Ababa SFP was established to combat hunger in public elementary schools while enhancing nutritional and educational outcomes. Launched as a pilot project in 2019, the program has expanded to serve 638,857 students across 264 public primary schools, creating job opportunities for over 10,120 mothers involved in food preparation and service (National School Feeding Policy Draft, 2019; Xie & Brownell, 2020). However, concerns regarding food safety particularly the quality of ingredients and hygienic conditions during meal preparation have emerged (Green et al., 2007a). The risk of contamination escalates when food is prepared in bulk and handled by multiple individuals, which can lead to outbreaks that threaten public health and disrupt educational environments (Annor & Baiden, 2011; Kortei *et al.,* 2020).

Food safety remains a critical global concern, causing millions of illnesses and fatalities each year (Asia, 2016; Kirk *et al.,* 2015), particularly in sub-Saharan Africa, where the burden is disproportionately high (Udgiri & Yadavnnavar, 2016). Despite this, research assessing

foodborne disease outbreaks in schools is limited (Akabanda *et al.,* 2017b). Schools are significant contributors to these outbreaks, with incidents in Brazil and South Africa illustrating the severe consequences of food contamination in educational settings (Madlala, 2022; Soares *et al.,* 2012a).

In Ethiopia, foodborne illnesses are prevalent, highlighting the urgent need to prioritize food safety in public primary schools (Kalekidan *et al.,* 2014; Tessema *et al.,* 2014). Contaminated food and improper handling practices are major contributors to disease outbreaks, exacerbated by inadequate hygiene practices and weak regulatory frameworks (Mensah *et al.,* 2012; Havelaar *et al.,* 2013; Aworh, 2021; Gebru *et al.,* 2023). Ensuring proper food safety practices among food handlers is essential to prevent disease transmission and protect public health (Lee *et al.,* 2017; Zain & Naing, 2002).

Numerous studies indicate that food provided in SFPs often suffers from compromised safety and quality assurance (Garayoa *et al*., 2011; Lockis *et al*., 2011; July *et al*., 2017). Research has shown that many schools fail to adhere to essential sanitation requirements for food preparation (Santana *et al.,* 2009). However, there is a notable scarcity of research focusing on the critical components of effective food safety measures, particularly in developing countries (Madlala, 2022). In Ethiopia, limited studies have addressed the nutritional and educational impacts of SFPs, with few localized assessments available (Destaw *et al.,* 2022a). Research indicates that food handlers in Ethiopia often lack sufficient knowledge, positive attitudes, and proper practices regarding food safety, increasing the risk of foodborne illness transmission in school environments (Lee & Greig, 2010; Nagla *et al.,* 2014)

The role of food handlers is particularly critical, as they can be sources of pathogens and contaminants during food preparation (Green *et al*., 2007b; Tan *et al*., 2013). Studies show that approximately 97% of reported food poisoning cases result from improper food handling (Akabanda, Hlortsi, & Owusu-kwarteng, 2017a). Human hands frequently come into contact with various pathogens, which can transfer to mucous membranes and contribute to outbreaks (Lee *et al.,* 2013). For example, research in South Africa has identified food contact surfaces and the hands of food handlers as potential vehicles for foodborne pathogens in SFPs (Groenewald, 2014). Cross-contamination is a significant factor in many foodborne disease outbreaks, making safe handling practices essential (Liz Martins & Rocha, 2014; Rossi *et al.,* 2017).

Despite the importance of food handling practices, limited research has been conducted on this topic among school food handlers in Addis Ababa (Azanaw *et al.*, 2019; Chekol, 2019; Dagne *et al.*, 2019; Yenealem *et al.*, 2020). Previous studies have documented unsatisfactory hygiene practices in the region. Given the risks associated with food contamination in schools, addressing food safety concerns is paramount (Annor & Baiden, 2011; Akabanda *et al.*,2017).

Recognizing the importance of education, the Ethiopian government has made efforts to ensure access for all children. However, evidence on food safety within this context remains limited. This study aims to assess the food safety knowledge, attitudes, and practices among food handlers in primary schools in Addis Ababa. The findings will provide a critical foundation for planning and implementing strategies to enhance food safety and hygiene practices in the SFP. Ultimately, this research will contribute baseline data necessary for designing a comprehensive food safety management system in primary schools within Addis Ababa, Ethiopia.

5.3 Methods

5.3.1 Study Setting

The study was conducted in Addis Ababa, the capital city of Ethiopia. Renowned as a hub for international organizations like the United Nations Economic Commission for Africa (ECA) and the African Union (AU) (Statistical, 2012; UNICEF, 2019). Addis Ababa is a bustling metropolis with a projected population exceeding 5 million by 2036 (Weldeghebrael, 2021). In 2019, the City Administration School Feeding Agency implemented an initiative that employed 10,000 mothers to supply, cook, and serve food to students (Xie & Brownell, 2020). Currently, this program covers all 264 public primary schools across 11 sub-cities, benefiting approximately 638,857 students (MoE, 2022). The study focused on the unique setting of public primary schools in Addis Ababa, specifically within the context of the SFP. This program, encompassing all 264 public primary schools, plays a crucial role in providing meals to students and promoting their overall well-being.

5.3.2 Study Design and Period

This study utilized a cross-sectional design and was conducted from April to May 2023, in Addis Ababa, Ethiopia

5.3.3 Source Population

The source population for this study consisted of all food handlers employed in public primary school food service operations in Addis Ababa.

5.3.4 Study Population

The study population consisted of food handlers employed in food service operations at the selected primary schools in Addis Ababa.

5.3.5 Inclusion Criteria

The inclusion criteria for this study encompassed food handlers who were actively involved in food service operations within public primary schools and directly engaged in the preparation and handling of school meals during the designated study period.

5.3.6 Exclusion Criteria

Food handlers on annual leave, experiencing significant illness during data collection, or recruited for one or two months were excluded due to potential lack of experience in safe food practices.

5.3.7 Sampling Design and Procedure

A multistage sampling approach was used to ensure a representative sample of food handlers in Addis Ababa. Five sub-cities were randomly selected from a total of eleven, and from each sub-city, four primary schools were chosen randomly. All the food handlers working in the selected schools were included in the study. This approach aimed to obtain a diverse and representative sample, including different sub-cities and primary schools within Addis Ababa.

5.3.8 Sample Size Determination

In this study, the sample size was determined utilizing a single-population formula considering the reported prevalence of knowledge of food safety from prior studies, estimated at 65.5%, and the prevalence of attitude towards food safety at 65.3% (Fekadu *et al.,* 2024). Additionally, the prevalence of food safety practices from previous research was estimated at 52.5% (Tessema *et al.,* 2014). With a desired confidence level of 95% and a margin of error of 5%, the sample size was computed using the following formula:

$$n = \frac{(Z\alpha/2)2 * p\,(1-p)}{d2}$$

Where: Z = Standard normal variable at 95% confidence level (1.96)

P = Anticipated proportion, (52.5%)

d = 0.05 (5% margin of error)

To accommodate potential non-response and the design effect, a 10% non-response rate and a 1.5 design effect were factored in.

The sample size for assessing food safety practices was calculated by inputting the following values into the formula: P = 0.655, Z = 1.96, d = 0.05

$$n = \frac{1.96^2 * 0.655(1-0.655)}{0.05^2}$$

n= 347

The sample size for assessing food safety practices was calculated by inputting the following values into the formula:

P = 0.525, Z = 1.96, d = 0.05

$$n = \frac{1.96^2 * 0.525(1-0.525)}{0.05^2}$$

n= 382

After incorporating a 10% non-response rate and a 1.5 design effect, the sample size calculated for understanding food safety practices surpassed that of assessing knowledge of food safety. Consequently, the final sample size for this study was determined as 382, which represents the largest sample size. The adjusted sample size for the study, accounting for a 10% non-response rate and a 1.5 design effect, was established at 632 respondents.

5.3.9 Data Collection Instruments and Procedures

In this study, a pretested, structured questionnaire was employed as the primary data collection instrument. The questionnaire comprised close-ended questions designed to evaluate the knowledge, attitudes, and self-reported practices of food handlers regarding food safety and hygiene. To ensure the questionnaire's quality, it was developed by adapting items from previous studies (Abdul-Mutalib *et al*., 2012; Al-Shabib *et al*., 2016; Akabanda *et al*., 2017c), and underwent a rigorous peer review process..

To minimize response bias, the questionnaire included both positive and negative statements, with scoring for negative statements being opposite to that of positive statements (Tan *et al.*, 2013). The questionnaire encompassed four parts, consisting of a total of 84 items. The first part focused on gathering sociodemographic information, the second part explored work satisfaction, the third part assessed knowledge, the fourth part examined attitudes, and the fifth part investigated food safety practices. Demographic and work satisfaction questions were adapted from existing sources (Jevšnik *et al.*, 2008; Soares *et al.*, 2012a).

The structured questionnaire was administered by a team comprising four public health professionals and one nutrition officer. Confidentiality was assured, and participants were encouraged to respond honestly, with the understanding that individual assessments would not be made. Before administering the questionnaire, the research team provided a comprehensive explanation of the study's purpose and the questionnaire items. During the interviews, questions were read aloud, and respondents were given ample time to provide their responses. By utilizing this carefully developed questionnaire and following standardized procedures during data collection, the study aimed to gather accurate and reliable information regarding food handlers' knowledge, attitudes, and practices related to food safety and hygiene.

5.3.9.1 Food Safety Knowledge, Attitudes, and Practices Questionnaire

In the assessment of food safety knowledge, a binary response questionnaire comprising 29 questions was employed to gauge food handlers' understanding of essential food safety principles. Correct responses were assigned a score of "1," while incorrect or unanswered questions received a score of "0." The total knowledge score was calculated on a 100-point scale, with a cutoff point of 70% or higher set to indicate good knowledge, supported by previous research (Soares *et al.*, 2012a).

Similarly, the Food Safety Attitudes Questionnaire utilized a 22-question scale to evaluate participants' attitudes towards food safety. Responses were scored on a 1 to 2 scale, with a score of 1 indicating agreement and 0 denoting disagreement with the statements. Conversion to a 100 point scale allowed for easier interpretation, with a threshold of 16 or more indicating a "favorable" attitude, based on established research (Soares *et al.,* 2012a).

In assessing food safety self-practices, a 22-question questionnaire examined respondents' adherence to recommended hygiene practices. Each correct practice reported as "most of the time" or "always" earned a score of 1, while incorrect practices reported as "never" or "sometimes" received a score of 0. A total score range of 0 to 22 was established, with a threshold of 16 points or more categorizing handlers as having "good food handling practice," aligning with the >70% accuracy rate standard from previous studies (Soares *et al.*, 2012a).

These scoring systems were implemented to provide a standardized and objective evaluation of participants' knowledge, attitudes, and practices regarding food safety. The established cutoff

points were chosen based on established thresholds in relevant literature, ensuring consistency and facilitating a clear categorization of participants' competencies in food safety principles.

5.3.10 Data Quality Control

To ensure the reliability and quality of the data collected, several measures were implemented in this study. Data collectors underwent extensive training to ensure a clear understanding of the study objectives, questionnaire administration, and data collection procedures. A pretest of the questionnaire was conducted on a 5% sample of individuals from outside the selected schools. This allowed for the identification and resolution of any potential issues or ambiguities in the questionnaire before the main data collection commenced.

To facilitate effective communication, the questionnaires were translated into Amharic, the local language, and then back-translated into English to ensure accuracy and consistency. Thorough data checks were conducted to align the collected data with the study's objectives and research questions. Any discrepancies or errors were promptly addressed. Clear instructions for data management were provided to the data collectors, ensuring consistency in data entry, coding, and storage. Supervisors and investigators conducted daily checks to ensure data completeness and consistency, enabling real-time identification and resolution of any issues or inconsistencies.

5.3.11 Data Management and Analysis

The study implemented a rigorous data management process to ensure the accuracy and completeness of the collected data. A careful check was conducted to verify the data's integrity, followed by coding and entry into Epi Data version 3.1, a specialized software for data management. Subsequently, the data was exported to STATA software version 16.1 for comprehensive statistical analysis. Descriptive frequencies were employed to provide a thorough description of the sociodemographic characteristics, as well as the knowledge, attitudes, and practices related to the study.

To explore the associations between variables, logistic regression analyses were performed. Statistical significance was determined using a significance level of $p \leq 0.05$. Odds ratios, accompanied by a 95% confidence interval, were calculated to assess the strength and direction of the associations. The fitness of the statistical models was evaluated using the Hosmer and Lemeshow tests, ensuring the models adequately fit the observed data. This evaluation enhanced

the reliability and validity of the study's results. By adhering to these rigorous data management and analysis procedures, the study aimed to produce accurate, meaningful, and statistically sound findings that contribute to a comprehensive understanding of the research topic.

5.3.12 Operational Definitions

Knowledge: Knowledge about food handling was assessed through 29 questions. Participants with a correct answer rate of 70% or higher were considered to have good knowledge, while those below 70% were categorized as having poor or insufficient knowledge. The cut-off point used in this study was higher than in other studies (Baş *et al.,* 2006; Rito, 2013).

Attitude: Participants who answered 15 or fewer questions correctly were categorized as having an unfavorable attitude, while those who answered 16 or more questions correctly were classified as having a favorable attitude (Soares *et al.,* 2012a).

Practice: Food handlers' practices were assessed using 22 questions. Participants scoring 16 points or more (>70% accuracy) were classified as having good food handling practices, while those scoring 15 points or less (<70% accuracy) were considered to have poor food handling practices. This criterion was based on previous studies (Soares *et al.,* 2012a; Gebru *et al.,* 2023).
Drinking water: safe and suitable water supplied to the consumer for direct human consumption (Ethiopian Standards Agency, 2019).

Potable water: water intended for drinking or suitable for human consumption (Guidelines for Assessing the Microbiological Safety of RTE Foods, 2009; Ethiopian Standard Prerequisite Programmes on Food Safety-Part 2 Catering, 2014).

Satisfactory: Test results indicate good microbiological quality (New, 2001; Centre for Food Safety, 2014)

Marginal: The results fall within the acceptable limits of microbiological quality, but they are borderline, indicating the potential for hygiene issues in the food preparation process (New, 2001; Centre for Food Safety, 2014)

Unsatisfactory: The results indicate that the microbiological levels exceed the acceptable limits, suggesting inadequate hygiene or food handling practices (New, 2001; Centre for Food Safety, 2014).

5.3.13 Ethical Approval

This study (IRB/04/2015/2023) obtained ethical approval from the Institutional Review Board (CNS-IRB) at Addis Ababa University. Necessary permissions, authorizations, and written consent were obtained from all participants to ensure voluntary participation, confidentiality, and the protection of their rights and well-being. Privacy, anonymity, and adherence to ethical guidelines and regulations were strictly maintained, and personal data was used solely for research purposes.

5.4 Results

5.4.1 Demographic Characteristics of Food Handlers

The study focused on 632 female food handlers actively involved in the Homegrown School Feeding Program. With a 100% response rate, these handlers provided a comprehensive look into their demographic composition. A significant majority, around 70.1%, were between 25 and 44 years old, representing a vibrant and essential workforce within the program. In terms of education, 39.7% had completed primary school, while 16.9% had no formal education, reflecting a diverse educational background. Work experience varied, with approximately 54% reporting 1-3 years of experience. Encouragingly, a substantial 96.04% of food handlers had received training. The accompanying table 5.1 offers a detailed overview of the socio-demographic profiles of these food handlers, providing valuable insights into the diverse talents and experiences contributing to the success of the Homegrown School Feeding Program.

Table 5. 1 Demographic profile of food handlers in 20 public primary schools in Addis Ababa, Ethiopia (n = 632).

Demographic Variable	Characteristics	Frequency (n)	Percentage (%)
Age (years)	18-24	58	9
	25-34	206	33
	35-44	237	37
	45-54	99	16
	55 and above	32	5
Marital status	Single	130	20
	Married	364	58

	Divorced	100	16
	Widow/ Widower	38	6
Level of education	No formal education	107	17
	Primary school	251	40
	Secondary school	229	36
	College and above	45	7
Length of employment as a food handler	Less than a year	49	8
	1 to 2 years	188	30
	2 to 3 years	153	24
	3 to 4 years	104	16
	4 to 5 years	60	10
	More than 5 years	78	12
Took Safe food handling training	Yes	607	96
	No	25	4

5.4.2 Perceptions of workplace Environment and Food Safety among food handlers

A significant majority of food handlers (94.8%, n=599) reported actively sharing personal concerns with their colleagues or supervisors, highlighting a culture of open communication within the workplace. Additionally, a substantial proportion (92.9%, n=587) expressed a willingness to leave their current job for better opportunities, indicating a desire for career advancement and growth.

Furthermore, an overwhelming majority (92.7%, n=585) affirmed that their workplace provided the necessary conditions for food safety, reflecting a commitment to maintaining a safe and conducive environment. These findings shed light on the work satisfaction levels among food handlers, emphasizing the importance of effective communication channels, opportunities for professional development, and the provision of optimal conditions for food safety. **(Table 5.2)** offers a comprehensive overview of these aspects, providing valuable insights into the employees' perspectives.

Table 5. 2 Work satisfaction assessment of food handlers, Addis Ababa, 2024 (N=632)

Statements	Response	Frequency	Percentage (%)
When you have personal trouble, do you share your feeling with your colleagues or principal? (n = 632)			
	Agree	599	94.8
	Disagree	33	5.2
	Don't know	0	0.0
Did you would leave this work, if they offered something better to you in another place? (n = 632)			
	Agree	587	92.9
	Disagree	44	6.9
	Don't know	1	0.2
The team of the kitchen is respected by the students, teachers and other workers of the school? (n = 632)			
	Agree	568	90.2
	Disagree	46	7.3
	Don't know	16	2.5
The workplace provide all the necessary conditions to guaranteeing safety of the food?(n=632)			
	Agree	585	92.7
	Disagree	41	6.5
	Don't know	5	0.8
Do the meals served in the school present health risks to the students? (n = 632)			
	Agree	63	9.97
	Disagree	54	85.6
	Don't know	28	4.4

5.4.3 Food Safety Knowledge of Food Handlers

The survey findings highlight a high level of food safety knowledge among food handlers. Notably, 94.6% recognized unhygienic practices as a potential source of contamination, showcasing their understanding of the importance of maintaining cleanliness. Furthermore, 96.8% demonstrated awareness of the significance of clean kitchen surfaces in preventing foodborne illnesses. Additionally, 87.8% acknowledged the need to keep cooked foods hot to ensure their safety. While there is a strong overall awareness of important practices such as washing fruits/vegetables (97.5%) and preventing cross-contamination (96.9%), there are specific areas that require attention. For instance, there is room for improvement in terms of reheating cooked food leftovers, with only 64.3% demonstrating awareness of this practice.

Efforts should be focused on reinforcing knowledge in areas where awareness is comparatively lower, such as the understanding of healthy food handlers carrying pathogens (69.2%). By addressing these gaps, food handlers can further enhance their understanding and contribute to a safer food handling environment. These findings highlight the existing strong foundation of food safety knowledge among food handlers while emphasizing the need to provide targeted education and reinforcement in specific areas. **(Table 5.3)** provides a detailed breakdown of the knowledge levels observed, facilitating a comprehensive understanding of the areas that require focused attention and improvement.

Table 5. 3 Food safety knowledge assessment of food handlers in primary schools, Addis Ababa, Ethiopia (n=632)

Questions	Options	Frequency	Percentage (%)
Food handlers with unhygienic practices could be the source of food contamination with food poisoning pathogens? (n = 632)			
	Yes	598	94.6
	No	34	5.4
Keeping kitchen surfaces clean reduces the risk of illness? (n = 632)			
	Yes	612	96.8
	No	20	3.2
Wiping cloths can spread microorganisms? (n = 632)			
	Yes	481	76.1
	No	151	23.9
Cooked foods should be kept very hot before serving? (n = 632)			
	Yes	555	87.8
	No	77	12.2
Cooked food leftover should be reheated thoroughly? (n = 632)			
	Yes	406	64.3
	No	225	35.7
Fruits and vegetables should be washed before eating/preparing? (n = 632)			
	Yes	616	97.5
	No	16	2.5
Keeping raw and cooked foods separate helps to prevent illness? (n = 632)			
	Yes	613	96.9
	No	19	3.1
Healthy food handlers might carry food-borne pathogens? (n = 632)			
	Yes	437	69.2
	No	195	30.9

It is important to throw away foods that have reached their expiry date? (n = 632)		
Yes	604	95.6
No	28	4.4
Contact between cooked and uncooked foods causes cross-contamination? (n = 632)		
Yes	612	96.8
No	20	3.2
Contamination of foodstuffs cannot be detected using sense organs? (n = 632)		
Yes	425	67.2
No	207	32.8
Use of the same knife to cut vegetables and meat exposed to food-borne diseases? (n = 632)		
Yes	611	96.7
No	21	3.3
Contaminated foodstuffs always change their characteristics? (n = 632)		
Yes	618	97.8
No	14	2.2
Frequent food contact surface cleaning can prevent contamination of the food? (n = 632)		
Yes	625	99.1
No	6	0.9
Washing hands before work reduces the risk of food contamination? (n = 632)		
Yes	627	99.2
No	5	0.8
Washing utensils with detergent leaves them free of contamination? (n = 632)		
Yes	526	83.2
No	106	16.8
Proper cleaning and sanitization of utensils increase the risk of food contamination? (n = 632)		
Yes	135	21.4
No	497	78.6
Eating and drinking at the work place increase the risk of food contamination? (n = 632)		
Yes	361	57.1
No	271	42.9
Food prepared in advance reduces the risk of food contamination? (n = 632)		
Yes	291	46.1
No	340	53.9
Children, healthy adults, pregnant women and older individuals are at equal risk for food poisoning? (n = 632)		
Yes	264	41.8
No	368	58.2
Typhoid fever can be transmitted by food? (n = 632)		
Yes	538	85.1
No	94	14.9

Bloody diarrhea can be transmitted by food? (n = 632)		
Yes	534	84.5
No	98	15.5
Microbes are on the skin, in the nose and mouth of healthy food handlers? (n = 632)		
Yes	519	82.1
No	113	17.9
Cross contamination is when microorganisms from a contaminated food are transferred by the food handler's hands or kitchen utensils to another food? (n = 632)		
Yes	584	92.5
No	47	7.5
Freezing kills all the bacteria that may cause foodborne illness? (n = 632)		
Yes	446	70.7
No	185	29.3
Contaminated foods always have some change in color, odor or taste? (n = 632)		
Yes	615	97.5
No	16	2.5
During infectious disease of the skin, it is necessary to take leave from work? (n = 632)		
Yes	616	97.5
No	16	2.5%
The health status of workers should be evaluated before employment? (n = 632)		
Yes	626	99.1
No	6	0.9
Use of jewels such as rings, watches, wearing during food handling cause food contamination? (n = 632)		
Yes	622	98.4
No	10	1.6

5.4.4 Attitudes of Food Handlers towards Food Safety

Food handlers demonstrated a highly positive attitude towards food safety, indicating a strong foundation for implementing and maintaining safe practices within the school food system. Notably, there was near-universal recognition of the importance of handwashing, with an impressive 99.7% of food handlers emphasizing its significance. Furthermore, a substantial majority displayed awareness of preventing cross-contamination (93.5%) and the importance of taking sick leave (98%) to ensure the safety of food.

Consensus was also observed on crucial practices such as storing raw and cooked foods separately (99.2%) and maintaining personal hygiene (98.7%). This collective understanding highlights the commitment of food handlers towards essential food safety measures. Food

handlers exhibited a keen awareness of specific risks, with a high percentage recognizing the potential hazards associated with beards (98.7%) and hand contamination (94.6%). This knowledge demonstrates their understanding of potential sources of contamination and the need for preventive measures.

The majority of food handlers emphasized the significance of training (98.3%) and proper handling and sanitation (87.2%). This underscores their awareness of the continuous learning and adherence required to maintain a safe food environment. These findings provide valuable insights into the attitudes of food handlers towards food safety, indicating a strong foundation for implementing and sustaining safe practices within the school food system. **(Table 5.4)** offers a comprehensive overview of these attitudes, highlighting the collective commitment to food safety among food handlers.

Table 5. 4 Food safety attitudes assessment of food handlers in primary schools, Addis Ababa, Ethiopia (n=632)

Questions	Options	Frequency	Percentage (%)
Washing hand before handling raw or cooked foods reduces risk of food poisoning? (n = 632)			
	Agree	630	99.7
	Disagree	2	0.3
Raw vegetables and meat should not be cut on the same cutting board? (n = 632)			
	Agree	591	93.5
	Disagree	41	6.5
Using caps, masks, protective gloves and adequate clothing reduce the risk of food poisoning? (n = 632)			
	Agree	628	99.37
	Disagree	4	0.63
I will take leave when sick, fever or catch cold? (n = 632)			
	Agree	620	98
	Disagree	12	2
Raw and cooked foods should be stored separately to reduce the risk of food contamination? (n = 632)			
	Agree	627	99.2
	Disagree	5	0.8
Covering mouth during coughing/sneezing avoids contamination of food? (n = 632)			
	Agree	620	98
	Disagree	12	2
Willing to change food handling practices when I know they are incorrect? (n = 632)			

Agree	615	97.3
Disagree	17	2.7
After touching some parts of your body, hand washing is must? (n = 631)		
Agree	627	99.2
Disagree	5	0.8
Proper hygiene of the hand can prevent food-borne illnesses? (n = 632)		
Agree	624	98.7
Disagree	8	1.3
Long and painted fingernails contaminate foodstuffs with pathogens? (n = 632)		
Agree	622	98.4
Disagree	10	1.6
Safe food handling is an important part of my job responsibilities? (n = 632)		
Agree	619	97.9
Disagree	13	2.1
Before jobs, the health condition of food handlers should be assessed? (n = 632)		
Agree	623	98.6
Disagree	9	1.4
To control food-borne diseases, it is necessary to maintain personal hygiene? (n = 632)		
Agree	625	98.9
Disagree	7	1.1
Hands are a source of most bacteria and microorganisms originate? (n = 632)		
Agree	598	94.6
Disagree	34	5.4
Training on food safety is important to me? (n = 632)		
Agree	621	98.3
Disagree	11	1.7
Beards could contaminate food with food-borne pathogens? (n = 632)		
Agree	624	98.7
Disagree	8	1.3
Food handlers can be a source of food-borne outbreaks? (n = 632)		
Agree	416	65.8
Disagree	216	34.2
Dish towels can be a source of food contamination? (n = 632)		
Agree	551	87.2
Disagree	81	12.8
I use different clean clothes to mop dining tables and food utensils? (n = 632)		
Agree	608	96.2
Disagree	24	3.8
Knives and cutting boards should be properly sanitized to prevent cross contamination? (n = 632)		

Agree	619	97.9
Disagree	13	2.1
I believe good personal hygiene can prevent foodborne illness? (n = 632)		
Agree	627	99.2
Disagree	5	0.8
Food handlers who have abrasions or cuts on their hands should not touch foods unwrapped foods or without gloves? (n = 632)		
Agree	623	98.6
Disagree	9	1.4

5.4.5 Food Safety Practices by Food Handlers

The assessment of food hygiene practices among food handlers revealed varying levels of adherence. Notably, there was commendable adherence to utensil cleaning, with 63.3% reporting always following proper cleaning protocols. Similarly, hand washing before food handling displayed positive adherence, with 71.2% reporting always practicing this essential hygiene measure. However, there are areas that require improvement. In terms of frequency, only 32.3% reported practicing proper hygiene most of the time, indicating a need for consistent adherence to food safety practices. Furthermore, the use of sanitizer during utensil washing was reported as never used by 23.9% of the food handlers, highlighting the necessity for increased awareness and implementation of this crucial step.

Adherence to Personal Protective Equipment (PPE) guidelines was identified as an area that requires improvement. Efforts should be made to enhance compliance with wearing appropriate PPE to ensure the safety of both food handlers and consumers. On a positive note, good adherence was observed in cleaning the food storage area and following the first-in-first-out principle, reflecting a sound understanding and practice of these essential food safety measures. However, hand washing after nose rubbing or body scratching demonstrated room for improvement, as only 77.2% reported always washing their hands in such situations.

These findings stress the importance of continuous education and reinforcement of food hygiene practices among food handlers. By doing so, a safe food service environment can be ensured in schools and beyond. **(Table 5.5)** provides a comprehensive overview of the specific practices and adherence levels observed, highlighting the areas that require focused attention and improvement.

Table 5. 5 Self-reported food hygiene practices of food handlers in Addis Ababa public primary schools (n=632)

Questions	Options	Frequency	Percentage (%)
Clean and sanitize cooking utensils after each use or when there is a chance that they have been contaminated? (n = 632)			
	Always	400	63.3
	Most of the time	204	32.3
	Sometimes	28	4.4
	Never	0	0.0
Hand washing with soap and water before handling and cooking food? (n = 632)			
	Always	450	71.2
	Most of the time	100	15.8
	Sometimes	82	13
	Never	0	0.0
Hand washing with soap and water after touching food? (n = 632)			
	Always	320	50.6
	Most of the time	200	31.6
	Sometimes	80	12.7
	Never	32	5.1
Use of sanitizer when washing service utensils (plates, mugs and spoons)? (N=632)			
	Always	284	44.9
	Most of the time	83	13.1
	Sometimes	114	18
	Never	151	23.9
Hand wash with soap and water after the toilet? (n = 632)			
	Always	515	81.5
	Most of the time	100	15.8
	Sometimes	17	2.7
	Never	0	0.0
Hand washing after counting money? (n = 632)			
	Always	325	51.4
	Most of the time	165	26.1
	Sometimes	100	15.8
	Never	42	6.7
Hand washing after handling dirty things? (n = 632)			
	Always	480	75.95
	Most of the time	115	18.2
	Sometimes	37	5.85
	Never	0	0.0

Wearing apron while working? (n = 632)		
Always	430	68
Most of the time	120	19
Sometimes	82	13
Never	0	0.0
Wearing of face mask when you distribute food? (n = 632)		
Always	360	56.9
Most of the time	250	39.6
Sometimes	22	3.5
Never	0	0.0
Proper cleaning of food storage area before storing new products? (n = 632)		
Always	610	96.5
Most of the time	16	2.5
Sometimes	6	0.9
Never	0	0.0
Use the oldest food products first (first-in-first-out)? (n = 632)		
Always	567	89.7
Most of the time	53	8.4
Sometimes	12	1.9
Never	0	0.0
Hand washing after rubbing your nose or scratching your body? (n = 632)		
Always	516	81.8
Most of the time	30	4.8
Some times	72	11.2
Never	14	2.2
Touching of food when you cut your fingers and the wound is not well covered? (n = 632)		
Always	0	0.0
Most of the time	0	0.0
Some times	35	5.5
Never	597	94.5
Eating, drinking or chew gum as you are preparing food? (n = 632)		
Always	0	0.0
Most of the time	0	0.0
Some times	160	25.3
Never	472	74.7
Do you use a separate utensils and cutting boards when handling raw and cooked food? (n = 632)		
Always	576	91.3
Most of the time	55	8.7
Some times	0	0.0

Never	0	0.0
Do you sanitize your workplace after finishing your service? (n = 632)		
Always	420	66.5
Most of the time	115	18.2
Some times	90	14.2
Never	7	1.1
Do you keep your hair completely covered with a cap while handling food? (n = 632)		
Always	550	87
Most of the time	23	3.6
Some times	49	7.8
Never	10	1.6
Do you make sure that your hands dry and clean when handling food? (n = 632)		
Always	488	77.2
Most of the time	105	16.6
Some times	39	6.2
Never	0	0.0
Do you talk while handling ready to eat food? (n = 632)		
Always	0	0.0
Most of the time	0	0.0
Some times	200	31.6
Never	432	68.4
Do you taste the food with your hand cupped? (n = 632)		
Always	474	75
Most of the time	45	7.1
Some times	100	15.8
Never	13	2.1
Do you use leftover food? (n = 632)		
Always	0	0.0
Most of the time	28	4.43
Some times	150	23.73
Never	454	71.84
Do you use gloves during work? (n = 632)		
Always	0	0.0
Most of the time	37	5.9
Some times	500	79.1
Never	95	15

5.4.6 Overall Assessment of Food Handlers' Knowledge, Attitude, and Practice towards Food Safety

Out of the 632 participants assessed, an encouraging number of participants, 543 (85.8%) demonstrated commendable knowledge of food handling. Furthermore, 457 (72.3%) exhibited good food hygiene practices, reflecting a significant commitment to maintaining proper standards. Equally noteworthy, 503 (79.6%) displayed favorable attitudes towards food safety, indicating a positive mindset among the majority. However, it is essential to address the remaining percentages where improvement is needed. Approximately 89 (14%) of the participants exhibited insufficient knowledge, suggesting a knowledge gap that requires attention. Additionally, 175 (27.7%) showed poor food hygiene practices, highlighting the need for targeted interventions in this area. Similarly, 129 (20.4%) had unfavorable attitudes, signifying the importance of fostering a positive mindset towards food safety.

These findings underscore the significance of continuous training and interventions to enhance knowledge, elevate food hygiene practices, and cultivate positive attitudes among food handlers. Efforts should be directed towards bridging the knowledge gap, promoting consistent adherence to best practices, and fostering a culture of food safety awareness and commitment **(Fig. 5.1.)** provides a visual representation of these findings, emphasizing the importance of addressing these areas for improvement.

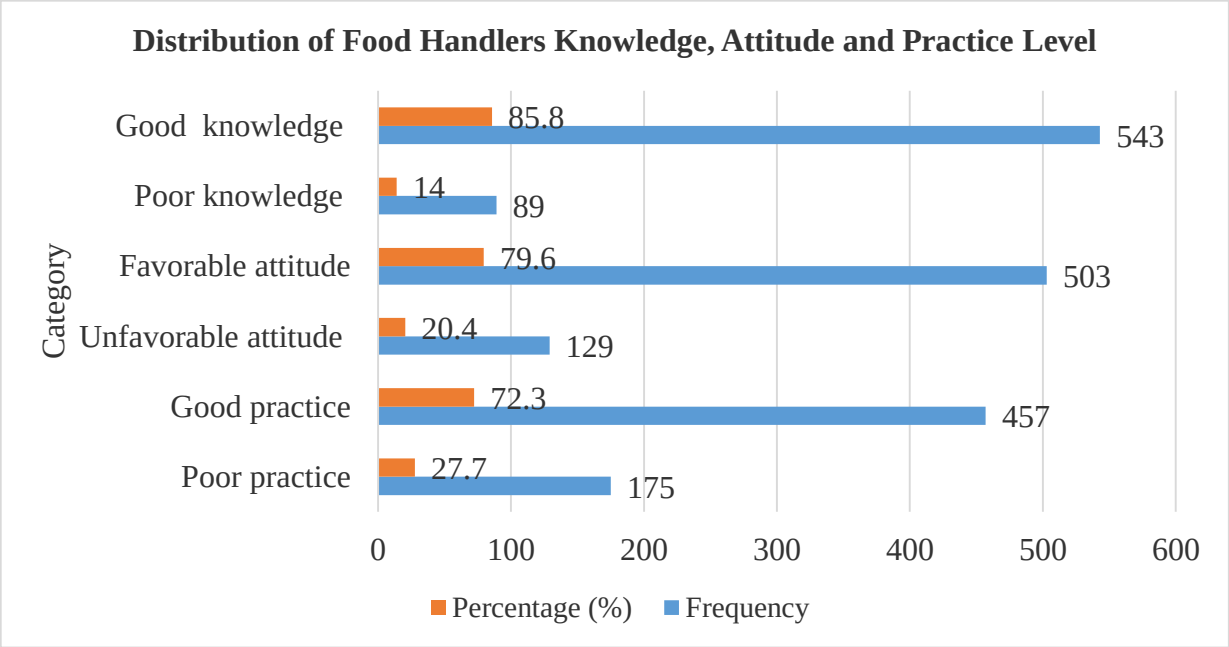

Figure 5. 1 Distribution of food handlers' knowledge, attitude, and practice levels towards food safety and hygiene in public primary schools, Addis Ababa, Ethiopia (n = 632)

5.4.7 Factros influencing Food Safety and Hygiene Practices among Food Handlers

The logistic regression analysis on food safety and hygiene practices among food handlers revealed that having a designated separate room for raw food and RTE food storage was found to decrease the likelihood of poor food safety practice by 55% [AOR=0.45 (95% CI: 0.01-0.90)]. Additionally, the presence of a water facility in the kitchen was associated with a 46% reduction in the odds of poor hygiene practices among food handlers [AOR=0.54 (95% CI: 0.16-0.93)], while having a hand-washing facility in the kitchen lowered the odds by 35% [AOR=0.65 (95% CI: 0.36-0.95)]. Moreover, food handlers with higher attitude scores towards food hygiene and safety demonstrated an 81% decrease in the likelihood of poor food safety and hygiene practices [AOR=0.19 (95% CI: 0.11-0.28)] **(Table 5.6).**

Table 5. 6 Factors associated with the food safety and hygiene practice among food handlers in public primary schools, Addis Ababa, Ethiopia.

Dependent variable: Practice score on food hygiene and safety				
Variables	Simple logistic regression		Multiple logistic regression	
	COR	95% CI of COR	AOR	95% CI of AOR
Educational status				
No formal education	1 (ref)		1 (ref)	
Formal education	1.32	1.00-1.63	0.78	0.48-1.07
Number of received training				
One	1.23	0.59-1.86	0.18	-0.49-0.86
Two	1.58	0.94-2.23	0.61	-0.08-1.30
Three and more	1.59	0.92-2.25	0.67	-0.02-1.36
None	1 (ref)		1 (ref)	
Provision of all the necessary conditions to guaranteeing food safety				
Yes	2.06	1.62-2.51	1.46	0.97-1.95
No	1 (ref)		1 (ref)	
Presence of separate room for raw food and RTE food storage				
Yes	0.94	0.56-1.31	**0.45**	**0.01-0.90**
No	1 (ref)		1 (ref)	
Presence of designated food safety assurance personnel				
Yes	1.50	0.70-2.31	-0.51	-1.35-0.33
No	1 (ref)		1 (ref)	
Adequate space for cooking				
Yes	0.56	0.25-0.88	0.27	-0.65-0.10
No	1 (ref)		1 (ref)	
Presence of water facility in the kitchen				
Yes	1.17	0.86-1.49	**0.54**	**0.16-0.93**
No	1 (ref)		1 (ref)	
Presence of hand-washing facility in the kitchen				
Yes	0.73	0.49-1.02	**0.65**	**0.36-0.95**
No	1 (ref)		1 (ref)	
Adequate space for serving/portioning cooked food				
Yes	1.27	0.87-1.66	-0.21	-0.68-0.26
No	1 (ref)		1 (ref)	
Presence of enough cleaning tools				
Yes	2.99	2.16-3.84	0.86	-0.11-1.84
No	1 (ref)		1 (ref)	
Knowledge score on food hygiene and safety	0.11	0.06-0.17	0.03	-0.02-0.08
Attitude score on food hygiene &safety	0.31	0.23-0.39	**0.19**	**0.11-0.28**

5.4.8 Associations Between Socio-Demographic Factors and Knowledge, Attitudes, and Practices of Food Handlers

In **Table 5.7**, the study explored the relationships between socio-demographic characteristics and food handlers' knowledge, attitudes, and practices. Age showed a positive association with attitudes (coef. = 0.064, p = 0.008), indicating older food handlers had more positive attitudes towards safe food handling. However, age had a negative association with practices (coef. = -0.054, p = 0.008), suggesting slightly lower adherence to proper food handling guidelines. Marital status displayed a positive association with attitudes (coef. = 0.037, p = 0.046), while showing a negative association with practices (coef. = -0.032, p = 0.043). Education exhibited positive associations with knowledge (coef. = 0.077, p = 0.004) and practices (coef. = 0.203, p < 0.001). Years of service showed a positive association with knowledge (coef. = 0.117, p < 0.001), but a negative association with practices (coef. = -0.070, p = 0.019).

Table 5. 7 Associations between Socio-Demographic Characteristics and Food Handlers Knowledge, Attitudes, and Practices

Variables		**Coef.**	**Std.Er.**	**t-value**	**P-value**	**95% CI**	**Sign. (p<0.05)**
Age	Knowledge	-0.023	0.017	-1.340	0.182	-0.056, 0.011	
	Attitudes	0.064	0.024	2.650	0.008	0.016, 0.111	***
	Practice	-0.054	0.020	-2.660	0.008	-0.093, -0.014	***
Marital	Knowledge	-0.023	0.013	-1.730	0.085	-0.049, 0.003	
Status	Attitudes	0.037	0.019	2.000	0.046	0.001, 0.074	**
	Practice	-0.032	0.016	-2.030	0.043	-0.063, -0.001	**
Education	Knowledge	0.077	0.026	2.920	0.004	0.025, 0.129	***
	Attitudes	-0.014	0.037	-0.370	0.712	-0.087, 0.059	
	Practice	0.203	0.031	6.540	0.000	0.142, 0.264	***
Years of	Knowledge	0.117	0.025	4.670	0.000	0.068, 0.166	***
service	Attitudes	-0.028	0.035	-0.790	0.429	-0.097, 0.041	
	Practice	-0.070	0.030	-2.350	0.019	-0.128, -0.012	**

**** p<.01, ** p<.05, * p<.1*

5.4.9 Correlations between School Food Handlers' Knowledge, Attitudes, and Practices in Food Safety

Table 5.8 presents the pairwise correlations among the knowledge, attitudes, and practices of school food handlers regarding food safety, based on a study with 632 participants. Correlations were determined using both Pearson and Spearman correlation tests, which assess the strength and direction of relationships between the variables.

The analysis reveals a weak positive correlation between knowledge and attitudes ($r = 0.139$, $p < 0.05$), indicating that as knowledge about food safety increases, attitudes toward food safety tend to improve slightly. The P-value of 0.000 signifies that this relationship is statistically significant and unlikely to have occurred by chance. Similarly, knowledge shows a weak positive correlation with practices ($r = 0.127$, $p < 0.05$), suggesting that greater knowledge is associated with a slight increase in the likelihood of practicing safe food handling, supported by a significant P-value of 0.001.

The strongest correlation is observed between attitudes and practices, with a moderate positive correlation of 0.340 ($p < 0.05$). This indicates that food handlers with favorable attitudes toward food safety are significantly more likely to engage in safe practices, as confirmed by a P-value of 0.000.

It is important to note the assumptions underlying the correlation tests. For the Pearson correlation, the relationships should be linear, both variables should be normally distributed, and the variance among groups should be similar. In contrast, the Spearman correlation requires a monotonic relationship and can accommodate ordinal data, provided that observations are independent.

Overall, these results suggest that while knowledge and attitudes are positively correlated with food safety practices, the associations are relatively weak. Enhancing knowledge and attitudes among food handlers may contribute to better food safety practices; however, other factors beyond knowledge and attitudes could also influence the effective implementation of safe food handling practices.

Table 5. 8 Correlations between knowledge, attitudes, and practices of school food handlers in relation to food safety (n=632)

Variables	Knowledge	P-value	Attitudes	P-value	Practice	P-value
Knowledge	1.000	-		-		-
Attitudes	0.139	0.000	1.000	-		-
Practice	0.127	0.001	0.340	0.000	1.000	-

The correlation is significant at the 0.05 level according to Pairwise correlations

5.5 Discussion

This study provides valuable insights into the knowledge, attitudes, and practices of food handlers in the SFP. Notably, the demographic characteristics of the participants, including age and gender, exhibited significant variations compared to previous studies in different regions. All participants in this study were female, contrasting with a male-only cohort in Saudi Arabia (Al-Shabib *et al*., 2016). This gender disparity underscores the importance of considering demographic factors in food safety research

Educational attainment among the food handlers was predominantly at the primary school level, aligning with findings from other Ethiopian regions (Kibret & Abera, 2012; Tegegne *et al.*, 2017a; Ncube *et al.,* 2020; Gebru *et al.,* 2023). In contrast, a study in Kebangsaan, Malaysia, reported a higher percentage of participants with secondary education (66.2%) (66.2%), indicating regional variations influenced by local demographics and food safety regulations. Additionally, the marital status of participants differed significantly; the majority were married, contrasting with findings from other Ethiopian regions where 68.2% and 84.4% of participants were unmarried (Kibret & Abera, 2012; Gebru *et al.,* 2023).

The overall knowledge score achieved by participants was high at 85.8%, comparable to studies conducted in Jimma (82.72%), Debark Town (79.1%), and Owerri, Nigeria (81%) (Mekasha Temeche, 2016; Iwu *et al.,* 2017; Chekol *et al.,* 2019b). This score significantly surpassed findings from other regions in Ethiopia, where knowledge levels were reported at 22% and 34.1% (Tegegne *et al.,* 2017a; Alemayehu *et al.,* 2021). Variations in how studies define knowledge levels may contribute to discrepancies in findings. In this study, knowledge about food handling was assessed using 29 questions, with a threshold of 70% for good knowledge, differing from cut-off points used in other research (Baş *et al.,* 2006; Rito, 2013).

The prevalence of safe food handling practices among participants was 72.3%, aligning with findings from Jimma (75.96%) (Mekasha Temeche, 2016) but surpassing percentages from various Ethiopian regions (Nigusse & Kumie, 2012; Tessema et al., 2014; Z et al., 2014; Legesse et al., 2017;). This prevalence also exceeded from those reported from Malaysia (59.30%), Turkey (48.4%), and Iran (66%) (Pengetahuan *et al.,* 2011; Sharif *et al.,* 2013; Mehrdad *et al*., 2014; Askarian *et al.,* 2014), although it was lower than the studies conducted in Jordan (89.43%) and Uganda (90%) (Baş *et al.,* 2006; Sylvia *et al.,* 2015). The evaluation of food

handling practices in this study used 22 questions, categorizing participants who scored 16 points or higher as having good practices, which may differ from the thresholds applied in other studies.

Most participants (79.59%) exhibited positive attitudes towards preventive food handling measures, consistent with findings from Jigjiga and Tigray (Tegegne *et al.,* 2017a; Gebru *et al.,* 2023). This percentage is higher than some previous studies (Buccheri *et al.,* 2007; Bou-Mitri et al., 2018; Askarian *et al.,* 2014), but lower than the study conducted in Jimma (86.67%) and studies in Malaysian and Jordanian hospitals (Sharif *et al.,* 2013; Temeche, 2016; Rohin, 2016). Differences in defining levels of attitudes among studies could contribute to these disparities. In this research, attitudes were assessed based on participants' correct responses to a series of questions, with those answering 15 or fewer questions labeled as having an unfavorable attitude. Recognizing these variations in threshold definitions is essential for accurately evaluating and contrasting research outcomes related to food handling practices.

Participants demonstrated high awareness levels regarding key food safety practices. A significant majority recognized the importance of regular handwashing (99%), the prevention of food-borne illnesses (98.7%), and proper storage of raw and cooked foods (99.2%), consistent with previous research (Tokuç *et al.,* 2009; Akabanda, & Owusu-kwarteng, 2017b; Gebru *et al.,* 2023). However, awareness varied for other practices, such as the risks of eating and drinking at the workplace (57.1%) and the effectiveness of freezing as a bacteria-killing method (70.7%), suggesting that regional and cultural factors significantly influence food safety knowledge (Buccheri *et al.*, 2010; Idris Ali & Immanuel, 2017; Gebru *et al.,* 2023).

Despite a strong emphasis on handwashing, with 97.9% reporting consistent practices before handling food and 93.8% after, some inconsistencies were noted. For example, over 40% reported using the same towel for multiple cleaning tasks (Abdul-Mutalib *et al.,* 2012), and limited availability of utensils like cutting boards led to their reuse, which raises food safety concerns. Nonetheless, 97.4% intended to use separate clean clothes for different purposes, reflecting an awareness of food safety practices.

The observed positive correlations between knowledge, attitudes, and practices are consistent with previous studies (Cempaka *et al.,* 2019), indicating that higher knowledge levels are associated with more positive attitudes towards food safety, which in turn correlate with better food handling practices. However, a study in Iran found a significant negative correlation

between knowledge/practices and attitudes/practices (Ansari-Lari *et al.*, 2010b), suggesting that increased knowledge and positive attitudes do not always translate into improved food handling behaviors.

This study highlights key aspects of food safety knowledge, attitudes, and practices among food handlers in the SFP. While participants demonstrated high levels of awareness and knowledge, gaps in actual practices remain. The findings emphasize the need for targeted educational interventions that consider regional and cultural influences.

5.6 Limitations of the Study

This study is limited by the reliance on self-reported data, which may introduce recall bias and social desirability bias. Recall bias can occur when participants struggle to accurately remember their food handling practices, potentially leading to underreporting or overreporting of safe behaviors. Social desirability bias may influence participants to provide responses that they believe are more acceptable or favorable, rather than reflecting their true practices. These biases can compromise the validity of the findings.

To enhance the robustness of future research, it is essential to incorporate objective measurements. Recommended methodologies include direct observations of food handling practices, structured audits, and the use of standardized instruments to assess knowledge and attitudes. These approaches would provide a more accurate representation of actual behaviors and knowledge levels among food handlers.

Additionally, while this study acknowledges the influence of regional and cultural factors on variations in awareness levels, this aspect could be explored in greater depth. For example, cultural beliefs regarding hygiene and food preparation practices may lead to differing perceptions of food safety measures. Future research could include qualitative studies, such as interviews or focus groups, to gain deeper insights into how these factors specifically impact food safety practices among food handlers. This would enrich the understanding of the context in which food safety behaviors occur and could lead to more effective interventions tailored to specific cultural settings.

5.7 Conclusions

This study highlights the commendable knowledge, positive attitudes, and satisfactory practices exhibited by food handlers in the public primary SFP regarding food safety. While these strengths are encouraging, our findings also reveal critical areas in need of improvement, particularly in reheating practices, hand hygiene adherence, sanitizer usage, compliance with personal protective equipment guidelines, and reinforcing hand hygiene after specific activities. Addressing these gaps is essential for creating a safer food service environment.

Implementing tailored educational and training initiatives is imperative. By equipping food handlers with the necessary knowledge and skills, we empower them to uphold and enhance food safety standards. Continuous monitoring and evaluation are vital for assessing the effectiveness of these programs and identifying areas that require further attention.

The study demonstrates the positive correlation between knowledge, attitudes, and practices, as revealed through multiple linear regression analyses. These findings emphasize the interconnectedness of these components in cultivating a robust food safety culture. By focusing on comprehensive education and fostering positive attitudes, we can enhance food safety practices among food handlers. This underscores the potential of targeted interventions to reinforce adherence to best practices in food handling within this population.

In summary, while the study reveals high levels of knowledge and positive attitudes, it also highlights the pressing need for focused educational interventions that consider regional and cultural influences. Future research should prioritize objective measurements to further enrich our understanding of food safety practices and their implications for public health, ultimately fostering a healthier and safer school environment for all.

CHAPTER 6: PERCEIVED BENEFITS AND CHALLENGES OF SCHOOL FEEDING PROGRAM IN ADDIS ABABA, ETHIOPIA

JNS
JOURNAL OF NUTRITIONAL SCIENCE

RESEARCH ARTICLE

Perceived benefits and challenges of school feeding program in Addis Ababa, Ethiopia: a qualitative study

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(Received 2 November 2023 – Revised 26 February 2024 – Accepted 27 July 2024)

Journal of Nutritional Science (2024), vol. 13, e32, page 1 of 13 doi:10.1017/jns.2024.42

Abstract

Addis Ababa initiated a universal Home-Grown School Feeding Program (HGSFP) in February 2019 to address hunger and improve the educational outcomes of schoolchildren. This study aimed to document the perceived benefits and challenges of the HGSFP in Addis Ababa, where such information was lacking. In May 2023, a qualitative phenomenological study was conducted to collect data from 20 schools participating in the HGSFP. Data were collected through key informant interviews and focus group discussions (FGDs) involving 98 purposively selected participants. The study encompassed 48 student mothers in 5 FGDs, 20 student interviews, 20 school principals, and 10 experts from the Ministry of Education, Sub-cities, and the School Feeding Agency for in-depth interviews. Data collected in the local language were transcribed, translated into English, and thematically analysed using ATLAS-TI software. The study's findings unveiled the transformative impact of the HGSFP in Addis Ababa, Ethiopia. It demonstrated remarkable improvements in attendance, concentration, academic performance, reduced dropout rates, financial relief, enhanced behaviour, and a safer learning environment. However, urgent measures are imperative to tackle pressing challenges such as underpaid kitchen workers, operational issues, reduced reading time, rising food costs, limited market access, inadequate infrastructure, and growing dependency. To ensure the enduring sustainability of HGSFP, addressing challenges like workload reduction, kitchen infrastructure enhancement, government guideline implementation, promoting self-reliance, overcoming budget limitations, and addressing school gardening obstacles is vital.

Key words: **Addis Ababa: Benefits: Challenges: Ethiopia: Home-Grown School Feeding Program**

6.1 Abstract

Background: Addis Ababa initiated a universal SFP in February 2019 to address hunger and improve the educational outcomes of schoolchildren. This study aimed to explore the perceived benefits and challenges of the SFP in Addis Ababa, Ethiopia.

Methods: In May 2023, a qualitative phenomenological study was conducted to collect data from 20 schools participating in the SFP. Data were collected through key informant interviews and FGDs involving 98 purposively selected participants. The study encompassed 48 students' mothers in 5 FGDs, 20 student interviews, 20 school principals, and 10 experts from the Ministry of Education, Sub-cities, and the School Feeding Agency for in-depth interviews. Data collected in the local language were transcribed, translated into English, and thematically analysed using ATLAS-TI software.

Result: The study revealed the notable impact of the SFP in Addis Ababa, Ethiopia. It demonstrated remarkable improvements in attendance, concentration, academic performance, reduced dropout rates, financial relief, enhanced behaviour, and a safer learning environment. However, several challenges were identified that need to be addressed: underpaid kitchen workers leading to low morale and lack of interest; operational issues affecting food quality; reduced reading time due to poor meal scheduling; rising food costs straining budgets; limited market access hindering ingredient variety; inadequate infrastructure compromising food safety; and a growing dependency on school feeding programs that may discourage families from seeking other food sources.

Conclusions: The study highlights the substantial benefits of the SFP, including the creation of a safer learning environment, the alleviation of hunger, and improved educational outcomes. However, urgent measures are imperative to tackle pressing challenges such as underpaid kitchen workers, operational issues, reduced reading time, rising food costs, limited market access, inadequate infrastructure, and growing dependency. To ensure the sustainability of SFP, addressing challenges like workload reduction, kitchen infrastructure enhancement, government guideline implementation, promoting self-reliance, overcoming budget limitations, and addressing school gardening obstacles is vital.

Keywords: Addis Ababa, Benefits, Challenges, Ethiopia, School Feeding Program

6.2 Introduction

The school feeding program is one of the world's largest and most widespread social safety net programs, benefiting nearly half a billion school children worldwide (WFP, 2022). An estimated 66 million primary school children, of which 23 million are in Africa, attend school hungry, struggle to learn, have poor concentration, and have little interest in learning (Nkhoma *et al*, 2013; Kretschmer & Spinler , 2014; Kristjansson *et al*., 2016; Wang *et al*., 2021). Furthermore, approximately 67 million children do not attend school at all (Kretschmer & Spinler, 2014). Attending classes while hungry hurts children's and adolescents' ability to learn, thrive, and reach their full potential (Bundy *et al*., 2017; Wang *et al*., 2021).

The SFPs are widely regarded as a game-changing option for improving food availability and education, as well as a prominent and innovative vehicle for addressing multiple Sustainable Development Goals (SDGs) outcomes (Global Food Banking Network, 2021; WFP, 2022). The SFPs help school-age children and adolescents develop physically, mentally, and emotionally, especially in low and middle-income nations (Wang *et al.,* 2021). The World Bank and the WFP published a joint review of SFPs in 2009 (B. et Al., 2009b) reinforcing the rationale and objectives of SFPs. The three main goals identified were to provide safety nets for families to absorb social and economic shocks, to improve school-aged children's education and scholastic performance, and to improve children's nutrition and health status (B. et Al., 2009b).

Malnutrition impairs the academic performance of schoolchildren from low-income families (Destaw *et al*., 2021). A 2015 study in Ethiopia found that malnutrition affected 31% of schoolchildren (19.6% stunted, 15.9% underweight, and 14.0% wasted) (Hussein *et al*., 2023). Furthermore, studies have shown that adolescent girls and boys aged 15 to 19 years are prone to chronic energy deficiency (Destaw *et al*., 2021).

School feeding in Ethiopia began in 1994 as a pilot project by the WFP in war-affected zones in Tigray Region (Gallenbacher, 2018; Xie & Brownell, 2020; Desalegn *et al.,* 2022b). Later, the aid was expanded to the remaining five food-insecure regions in the Somali Regional States: Afar, Amhara, Oromia, and SNNPR (Gallenbacher, 2018). Currently, in Ethiopia, SFPsare run by locally produced food products (Cohen *et al*., 2021). From the perspective of the WFP, SFPs aim to both increase children's well-being and promote local agricultural production and development by providing an ongoing market for small landholders (WFP, 2018b).

The program is implemented through three approaches: government-owned and financed HG-SFPs, NGO-run SFPs like the WFP, and community-initiated and owned SFPs. It is supported by national school feeding policy, food and nutrition policy, and strategy (Federal Democratic Republic of Ethiopia (FDRE), 2018; National School Feeding Policy Draft, 2019). The program also receives political attention and support from various stakeholders.

In Addis Ababa, the SFP was initiated on a small scale by charitable societies, NGOs, and other stakeholders and now the city administration has expanded the program and assumed full ownership. Earlier, economically disadvantaged students used to be targeted by the program; however, since February 2019, the program has covered all public pre-primary and primary schools (grades 1-8) in the city (MoE, 2020; Destaw *et al*., 2021). Ethiopia's government has made every effort to ensure that all of the country's children have access to education. In order to increase learning achievement, reduce temporary hunger, and enhance the health and nutritional status of schoolchildren, the Addis Ababa City Administration School Feeding Agency is currently implementing SFPs (MoE, 2020; Destaw *et al*., 2021).

Furthermore, little is understood about the benefits and challenges of SFPs in Ethiopia. Research conducted in the Sidama Region, Southern Ethiopia, and the Somali Regional State revealed several challenges (Aregawi, 2012; Haile & Ali, 2019; Desalegn *et al.,* 2022b). These include the absence of a consistent supply of clean water, the delay in the delivery of rations, poor quality food provision, the insufficient amount of food allotted for the academic year, the lack of program infrastructure, the lack of sanitation and hygiene training for cooks, inadequate funding for schools and independent structures, inconsistent resource mobilization, ineffective monitoring and evaluation, and inappropriate use of the allotted food (Aregawi, 2012; Haile & Ali, 2019; Desalegn *et al.*, 2022b). Another study carried out in the Jigjiga Zone, Somali regional area, Ethiopia, revealed that the main program challenges were water supply, storage facility shortages, kitchen utensil issues, and delays in ration delivery. The benefits include raising students' academic performance and attendance in class. Additionally, the program helped the parents save money and time (Aregawi, 2012).

Several donors and national governments from both developed and developing countries have also invested millions of dollars in SFPs (Mcewan, 2013; Change, 2016). Despite the attention and resources devoted to SFPs, little rigorous evidence exists to support these investments

(Mcewan, 2013), and no adequate research on SFPs has been conducted in our country to date (Kristjansson *et al*., 2007b; Change, 2016), and there is a lack of studies that directly address the unknown perceptions of parents, school principals, students, and other stakeholders towards SFPs (Mary and Mbewe, 2018).

Our study focuses on the SFP in Addis Ababa, the capital city of Ethiopia. This urban setting presents unique characteristics that contribute to our understanding of SFP. By examining the perceived benefits and challenges of urban SFP, our research informs policy frameworks and implementation strategies not only in Addis Ababa but also in other urban areas. Through qualitative methods like interviews and focus groups, we gather diverse perspectives on the perceived benefits and challenges of SFP in public primary schools. Our findings have broad applicability, filling a crucial literature gap and contributing to the fields of nutrition and education.

6.3 Methods

6.3.1 Study Setting and Period

The study was conducted in twenty primary schools in five selected sub-cities in Addis Ababa, the capital city of Ethiopia (Weldeghebrael, 2021), from April 10 to May 26, 2023. Addis Ababa is the country's largest city and plays an important political, economic, and symbolic role in the country (Weldeghebrael, 2021), with an estimated population of approximately four million residents (Gezahegn *et al.*, 2017). In 2019, the City Administration School Feeding Agency employed 10,000 mothers from various unions to participate in the SFP. Each mother was responsible for preparing meals for a group of 30 to 50 children (Xie & Brownell, 2020). The SFP has now been implemented in all 264 public primary schools located in all 11 sub-cities, and the city government provides a SFP for about 638,857 students (MoE, 2022).

6.3.2 Study Population

The study population consists of several key groups involved in the SFP. First, it includes mothers of beneficiary students from 20 schools that are participating in the program. Additionally, the study focuses on students in grades 6 and 7 who are enrolled in these SFP schools. Public primary school directors who are directly engaged in implementing, coordinating, or managing the SFP within the selected schools are also part of the population. Finally, experts from the Ministry of Education, Sub-cities, and the School Feeding Agency play

a crucial role, as they are responsible for overseeing, coordinating, planning, executing, supervising, and managing various aspects of the SFP.

6.3.3 Inclusion Criteria

The inclusion criteria for the study encompass several specific groups. First, it includes mothers of beneficiary students who are actively participating in the SFP. Additionally, the criteria involve students in grades 6 and 7 from schools that participate in the SFP, provided they are capable of conducting independent interviews. School administrators or directors who are directly engaged in the implementation, coordination, or management of the SFP are also included. Finally, experts from the Ministry of Education, sub-city authorities, and the School Feeding Agency, who are involved in the oversight, coordination, planning, execution, supervision, and operational aspects of the program, are part of the inclusion criteria.

6.3.4 Exclusion Criteria

First, individuals who are not mothers of beneficiary children in the SFP were excluded. Additionally, those who are not actively engaged in the SFP or who do not have direct responsibilities related to its implementation are also excluded from the study. Individuals who are unable to provide informed consent or whose circumstances may impact their ability to respond accurately during interviews were not included in the study.

6.3.5 Study Design

This study employed a quantitative phenomenological study with a case study approach to examine the challenges and perceived benefits of SFPs in the public primary schools of Addis Ababa city. A case study is a qualitative research method that enables an in-depth examination of a phenomenon or a program using a variety of data sources in its natural context context (Tong *et al.,* 2007; Baxter & Jack, 2015).

6.3.6 Obtaining Parental Consent

To obtain parental consent, we employed strategies such as parent-teacher meetings, existing platforms, and in-person discussions led by school directors. We explained the study's purpose, procedures, risks, benefits, and confidentiality measures in detail. Consent forms were carefully explained, and parents were encouraged to ask questions and express concerns. Our procedures followed institutional and ethical guidelines, guaranteeing data security, anonymity, and

confidentiality. These strategies successfully obtained parental consent while honoring their autonomy.

6.3.7 Sampling Procedure

A multi-stage sampling procedure was employed to select the participants for the study. Three rounds of sampling were used to choose the final research subjects. In the first step, five of the eleven sub-cities (or 50% of the sub-cities) were selected using a lottery technique. Arada, Bole, Kirkose, Ledeta, and Yeka Sub-city were the five sub-cities that were selected. In the second phase, after identifying each sub-city's public primary school, four were selected at random from each sub-city. In the study, twenty primary schools with SFP were included.

In consultation with the school principals, all study participants who had major roles in the SFPs (parents, students, SFP coordinators, and school directors) were specifically chosen. Furthermore, the current study purpose fully included experts from the sub-cities, the Addis Ababa City Administration School Feeding Agency, and the Ministry of Education.

The study involved five parent focus groups, twenty key informant interviews with SFP coordinators and school directors, and interviews with twenty beneficiary students. Moreover, in-depth interviews were conducted with three experts each from the Ministry of Education and the Ababa City Administration School Feeding Agency, along with four experts from the sub-city.

We decided the number of study participants based on the study's design, the population's diversity, and the depth of the data. Many academics advise using a range of research participant sizes. For example, Lincoln and Guba advise 12–20 participants for studies based on interviews (Sim *et al.,* 2018). Considering these factors, the key informants in this study were purposefully selected. There were 48 participants in all for the FGDs; each FGD had an average of ten participants. According to data saturation principles, which defined the point at which additional interviews produced no new data, the study's final sample size was 98 participants (Saunders *et al.,* 2018).

The following table shows the four-dimension criteria strategies adapted from Lincoln and Guba:

Table 6. 1 The four-dimension criteria (credibility, dependability, confirmability, and transferability) strategies adapted from Lincoln and Guba (Enworo, 2023)

Rigour Criteria	Purpose	Original Strategies	Strategies applied in our study to achieve rigor
Credibility	To establish confidence that the results (from the perspective of the participants) are true, credible and believable	• Interviewing process and techniques	• Interview guide or protocol was prepared and tested before application, and pilot interviews were conducted • Intervewiew guid was translated to local language • Experienced interveiwe and facilitors were employed for the data collection
		• Establishing investigators' authority	• We ensured the investigators had the required knowledge and research skills to perform their roles
		• Collection of referential adequacy materials	• We asked interviewers to send all the field notes to the principal investigator for analysis and storage.
		• Peer debriefing	• We had regular debriefing sessions with multi-disciplinary co-authors
Dependability	To ensure the findings of this qualitative inquiry is repeatable if the inquiry occurred within the same cohort of participants, Coders, and context.	• Rich description of the study methods	• We prepared detailed drafts of the study protocol throughout the study.
		• Establishing an audit trail	• We developed a detailed track record of the data collection process. Keeping records of the raw data, field notes, transcripts
		• Stepwise replication of the data	• We measured the coding accuracy and inter-coders' reliability of the research team.

			• ensure the research process is logical, traceable, and documented
Confirmability	To extend the confidence that the results would be confirmed or corroborated by other researchers	• Reflexivity	• Periodic investigators and coauthors meetings.
		• Triangulation	• We applied several triangulation techniques (methodological, data source, investigators, and theoretical).
		• Establishing that the researcher's interpretations and findings	• Reasons for theoretical, methodological, and analytical choices throughout the entire study, so that others can understand how and why decisions were made.
Transferability	To extend the degree to which the results can be generalized or transferred to other contexts or settings	• Purposeful sampling to form a nominated sample	• We used a combination of three purposive sampling techniques.
		• Data saturation	• We quantified operational and theoretical data saturation.

6.3.8 Sampling Strategy

To comprehensively analyse the SFP, we employed a sampling strategy by selecting four schools from each of Addis Ababa's five sub-cities. This approach captures variations in program implementation, contextual factors, and stakeholder perspectives, enhancing the reliability and generalisability of our findings. We considered practical factors like socioeconomic, demographic, and geographic characteristics to understand the factors influencing the SFP's success or limitations within each sub-city. Our strategy encompasses diverse school characteristics, stakeholder perspectives, and potential variations in challenges and commitment-related issues across sub-cities. It acknowledges the unique challenges and commitment levels faced by schools in different sub-cities due to socioeconomic factors, population density, and infrastructure. Including multiple schools from each sub-city provides a comprehensive understanding of challenges and commitment related issues from various stakeholders, including

students, parents, school directors, program administrators, and experts. This strategy also enables us to explore intra-sub-city variations resulting from differences in school demographics, resources, and community involvement.

To achieve a comprehensive understanding of our research topic, we selected participants from diverse households, including individuals with varying family backgrounds, socio economic statuses, and living conditions. This approach enhances the representativeness of our sample and improves the validity and reliability of our data by incorporating independent perspectives from students and parents. Furthermore, the inclusion of participants from diverse households increases the generalisability of our findings to a broader population. Although establishing a direct link between specific family characteristics and student experiences or outcomes may have limitations, we employ statistical techniques and control for relevant variables to extract valuable insights. This approach aligns with our research objectives, capturing a wide range of perspectives and facilitating a comprehensive understanding of the factors under study.

6.3.9 Data Collection Tools and Procedure

Semi-structured interview and FGD guides were developed to assess the challenges and perceived benefits of the SFP in the study area. These guides were created through a review of relevant literature and evaluated by three experts in the field prior to actual data collection. The guides were prepared in both Amharic, the local language, and English, following established literature guidelines (Tong *et al*., 2007; Akeju *et al*., 2016; Boene *et al*., 2016; Buus & Perron, 2020).

Data for this exploratory qualitative study was collected from twenty primary schools that implemented SFPs. The data collection involved key informant interviews, FGDs, beneficiary student interviews, in-depth interviews with school principals, and interviews with experts from the Ministry of Education, Addis Ababa City Administration, School Feeding Agency, and sub-cities. The interviews took place in private settings, and audio recordings were made in Amharic (the national language) with the participants' consent.

Data were audio-taped and transferred to a personal computer to which only investigators had access. Audio-taped files were transcribed verbatim using the local language and translated into English. Each FGD and KII was transcribed before the next data collection, which enabled the

capture of emerging insights into the semi-structured guide to enhance the credibility and comprehensiveness of the conversations. The principal investigator conducted a triangulation of the data generated from FGDs and KIIs. The principal investigator has experience gathering qualitative data and has taken advanced qualitative research methodologies.

Data was collected using pre-tested, semi-structured, indepth interview guides. These guides included predetermined questions and prompts, allowing flexibility in participants'responses. The interviews occurred in relevant locations like schools and government offices, chosen for participant convenience and a comfortable environment.

The data collection team comprised five individuals with a master's degree in public health and nutrition, experienced in qualitative inquiries. After a three-day training session covering study objectives, data collection techniques, and ethical principles, the trained data collectors conducted in-depth interviews. FGDs were moderated by the principal investigator and a note-taker. Interviews with school principals and stakeholders from the Ministry of Education, sub-cities, and the school feeding agency took place in the mornings at their respective offices.

To address the potential influence of work-related exhaustion on data quality, interviews with principals were scheduled in the morning hours, taking into account our natural productivity rhythms. All respondents engaged in face-to-face interviews, while in-depth interviews with principals were conducted in their respective offices, lasting approximately forty to sixty minutes. Furthermore, five FGDs with parents of students were held in a private conference room within the school, with each session spanning between 60 and 90 minutes minutes.

To reduce socially desirable responses to interview questions, all of the student interviews took place in a separate room with just the interviewee present. After reaching a saturation level, interviews with students were stopped. An average of ten parents of students participated in each focus group discussion (n = 48; 10, 10, 9, 9, and 10 participants) and ranging from 6 to 12 participants (Tong *et al.*, 2007).

6.3.10 Data Quality Assurance

Appropriate note-taking, audio recordingand abstraction were carried out to maintain the quality of the data. The data's credibility and dependability were maintained through continuous follow-up and data triangulation in time, person, and place.

6.3.11 Reflexivity

Reflexivity was employed to increase the data collection's rigor. This made it possible to conduct interviews with better probing, fewer assumptions, avoidance of early interpretation, and an amplified feeling of curiosity. To increase engagement and trust, share interview control, and ultimately increase the richness of the interview content, we also used reciprocity between the interviewer and interviewee as a technique.

6.3.12 Trustworthiness and Rigor

Lincoln and Guba developed strict standards for determining trustworthiness in qualitative research, known as credibility, dependability, confirmability, and transferability (Jones *et al*., 2012;Forero *et al*., 2013; Nahidi *et al*., 2019). Different measures were taken to ensure the trustworthiness of these findings, including participant triangulation (data were gathered from students, parents, and teachers), a method of triangulation (in-depth interviews, FGDs, and document reviews), and extended engagement to build rapport and trust among participants. Expert-reviewed interviews and FGD guides were employed.

Credibility was addressed using a variety of approaches, such as prolonged involvement, persistent observation, data collection, and researcher triangulation. Frequent peer debriefing was carried out to assess referential adequacy, check preliminary findings and interpretations against the raw data, and conduct an external check on the study process to boost credibility. The study sites for the findings' transmission were unknown to the principal investigator and researchers. All research processes were logical, traceable, and documented to ensure dependability. Furthermore, in this study, the research's interpretations and conclusions relied heavily on the collected data as a reliable source. To ensure the dependability, credibility, transferability, and confirmability of the findings, all necessary measures were implemented in the research (Ahmed, 2024) **(see Table 6.1).**

6.3.13 Study Procedure

In this study, we used and applied Lincoln and Guba's established strict standards known as credibility, dependability, confirmability, and transferability for determining and enhancing the trustworthiness of the research. To assess and ensure the robustness of the study, we carefully organized and carried out a series of semi-structured interviews and FGDs based on the above-mentioned criteria. These standards have been applied in numerous qualitative studies on health in the past (Forero *et al*., 2018).

6.3.14 Data Analysis

Data collection and analysis commenced simultaneously. The verbatim Amharic transcriptions of the audio files were translated into English following their initial translation into Amharic for the analysis. The theme analysis method recommended by Braun and Clark (Braun *et al*., 2006), was employed, which involved a thorough examination of the transcripts using the theoretical lens of the resilience framework (Braun *et al*., 2006).

The transcripts were independently read and reread by two authors to gain a comprehensive understanding of the data and generate initial codes. Thematic analysis was conducted by grouping related codes into categories and categories into themes. The software Atlas IT was utilized to analyze the data and develop a final coding scheme based on emergent themes. As new themes emerged, existing themes were modified and added. Through multiple discussions, the research team refined, mapped, and organized the codes into themes. These themes underwent further refinement until a consensus was reached on their interpretation and meaning. The draft findings were shared with culturally competent academics and stakeholders for validation and deeper contextual insights. The analysis concluded after thorough discussions between the authors.

6.3.15 Ethical Considerations

The research study obtained ethical approval (Ref. No. CNCSDO/623/15/2023) from the CNS-IRB of Addis Ababa University, aligning with the Declaration of Helsinki. Ethical practices with student participants included using age-appropriate consent forms, obtaining parental permission and student assent, ensuring confidentiality, emphasizing voluntary participation, and obtaining ethical approval. Participants were informed of their right to withdraw without consequences. Written consent and assent were obtained from all participants, adhering to confidentiality requirements, and all individuals participated voluntarily. Permission was granted by the Addis Ababa Education Bureau.

6.4 Results

6.4.1 Socio-demographic Characteristics

The study included a diverse group of participants: mothers aged 25 to 45 (averaging 10 participants per focus group discussion, with 6–12 mothers per group), school directors aged 25 to 52, and students aged 12 to 18. Additionally, interviews were conducted with experts from the Ministry of Education, sub-city, and the School Feeding Agency. In total, 98 participants were involved in examining the benefits and challenges of school feeding programs in Addis Ababa. For more details, see **Table 6.2.**

Table 6.2. Socio-demographic characteristics of study participants

Participants	Gender	Age range	Number of study participants
Mother	Female	25–45	48
School director	(F/M)	25–52	20
Students	(F/M)	12–19	20
Ministry of education expert	(F/M)	35–55	3
Sub-cities experts	(F/M)	30–42	4
School feeding agency experts	(F/M)	32–46	3
Total study participants			98

6.4.2 Themes and Sub-themes

Although there have been many challenges to the implementation of SFPs in Addis Ababa, this study only identified two main themes and twelve sub-themes. Perceived benefits of SFPs and perceived challenges to SFPs emerged as the two main themes. For a detailed description of the themes and subthemes, please refer to **Table 6. 3.**

Table 6. 3. Summary of themes and their respective sub-themes

	Themes		**Sub-themes**
1	Perceived benefits of SFP	1	Improved academic performance, class attendance, attention and reduced dropout rates and class repetition
		2	Reduces the socioeconomic burden of the family
		3	Improved student behavior and reduced disruptive behavior
		4	Reducing psychosocial stress and increasing social integrity
2	Perceived barriers and challenges to SFP	5	Underpayment of workers
		6	The poor market linkage between fostering mothers and consumer cooperatives
		7	Poor infrastructure
		8	Increased sense of dependency
		9	Increase workload for school staff
		10	Provision of poor-quality food
		11	Lack of adequate collaboration between the government and stakeholders
		12	Lack of linkage between SFP and school gardening

Theme 1: perceived benefits of the school feeding program. The significance of the SFPs in preventing hunger among students from low-income households was attested to by all FGD participants, students, and key informants. Additionally, the mothers of the students have acknowledged this. According to the key informants from schools, the program has helped to cut dropout and class repetition, and improved school attendance, academic performance, and concentration of students, Reportedly, before the initiation of the program, some students used to

come to schools without lunch boxes and sometimes students collapsed in classes due to hunger. Arriving late for class, which used to be a big problem for the schools, has been solved since the program started. The perceived benefits of SFPs in Addis Ababa, Ethiopia, were found to be categorized under the following themes.

Sub theme-1.1: improvements in student attendance, concentration, academic performance, school dropout, and class repetition reduction. Most of the participants of this study explained that the school feeding program has improved students' attendance, academic performance, and completion through reduced hunger. They also believed that providing school meals incentivizes households to send their children to school through a transfer (the daily meal) that is intended to help offset the financial and opportunity costs of schooling.

One of the key informants explained that before the provision of school meals, students who arrived at school on an empty stomach had trouble focusing on their education. Now, school meals can provide immediate relief from hunger, reducing distraction and increasing attention span among students. One of the FGD participants explained that the program also prevents students from missing school due to hunger, which saves parents time and money by reducing the amount of meal preparation required.

"Imagine the severity of the issue that caused mothers to send their kids to school with empty lunch boxes……I observed students carrying empty lunch boxes even before the program started." SFP monitoring expert, sub-city education office

"Previously, we used to conduct action research to reduce students late coming to school. Yet, there is no longer any worry following the SFP's implementation." SFP improvement and monitoring team leader, sub-city education office

"Most of the time go to school with an empty stomach, so I feel tired and sleepy. However, since the feeding program started in our school, I get food every day, and feel energetic; I don't feel hungry anymore. Now I am happy and enjoy the class" (An interview from an SFP beneficiary student)

"Had poor academic performance and no interest in learning before the school feeding program, but now he is much more interested in learning and his academic performance has considerably improved." (An interview from SFP beneficiary student)

Sub theme 1.2: reducing burdens on the family. In addition to positive effects on education, the school feeding program offers several socio-psychological benefits. According to FGD participants, parents are relieved from the financial and physical strain of cooking meals for their school-age children every day. Additionally, this has indirectly increased food security in the home through the phenomenon known as spillover effects, in which the family's usage of one resource by one child may help another. Children from poor households are no longer suffering from the psychological pressure of being unable to bring lunch to school.

The program has also made kids happy and focused. The majority of participants concurred that the school feeding program lessened the financial strain on students' families as well as the stress placed on them associated with their poor economic status. One of the FGD participants said the following "I work at this elementary school, where my daughter and son attend. Because of my low monthly income, I find it difficult to feed my entire family. Before the feeding program, I was unable to give my school-age children breakfast and lunch, but now, thanks to the government, the problem has been rectified."

"I had a lot of difficulty deciding what my children should eat for breakfast and lunch before the school feeding program started, as well as what I should cook for them. Most of the time, they went to school without eating breakfast or holding their lunch. Now, thanks to God, my stress has been resolved." (FGDs participants).

In Addis Ababa, the homegrown school feeding program has so far only covered elementary schools, and the program has not reached high school students. As reported by sub-city education

offices, poor students get challenged as they advance to high school. Many high school students from economically disadvantaged families stay the whole day at school without lunch boxes, while others share the lunch with other students.

"High schools have to benefit from the program as well. After entering high schools, underprivileged students who were previously served by the program are having difficulty, and some high school students have illegally entered the nearby elementary school to get school meals." (A school director, at a primary school).

Sub theme-1.3: change in students' behavior. The majority of key informants believed that students had improved behaviour and safety at school as a result of the school feeding program. Besides, respondents said it increased the student's motivation to avoid harm, go to unnecessary places, and skip school compounds. Before the implementation of SFP, students reported used to climb over the school fence to look for food when they became hungry. Additionally, they explained that when students go looking for food, they get exposed to crime or threats, sexual abuse, harm, or harassment, and get victimized. Student violence is supported and influenced by out-of-school gangs, juvenile delinquents, street drug dealers, and drug addicts.

According to one of the key informant explanations, before the implementation of the homegrown school feeding program, many students were subjected to unnecessary behaviours such as chewing khat and shisha. Since the introduction of the school meal program, they have stayed at the school the whole day, and as a result, they are safer than ever and focusing only on their education.

"Various misconduct offenses, such as those that disrupt the learning environment and those that involve aggressive behavior, such as fighting, bullying, and student assault, were observed on students before the implementation of the school feeding program, but these disciplinary issues have now significantly decreased." (A school director, at a primary school)

The majority of participants in focus groups and key informant interviews acknowledged that food insecurity and hunger among children have a detrimental impact on their academic focus, performance, and behavioural patterns. Moreover, the majority of research participants reported that the HGSFP has led to a reduction in student misconduct, including conflicts with school security guards, class skipping, and financial theft from parents. Notably, access to free school meals, especially, has been associated with a decrease in disciplinary infractions.

"Before the school feeding program started, some students used to steal money from their parents to buy bread and various sweets and spend the stolen money. It was causing them to grow up with inappropriate behavior, but after the school feeding program was started, the problem was significantly reduced." (FGD participants)

"Before the implementation of the school food program, there were numerous behavioral issues among students, and occasionally, students would fight with the school security staff for various reasons. However, now these issues have significantly decreased." (A school director, at a primary school).

Sub theme-1.4: decreased psychological stress and increased social integrity. Before the start of the school feeding program, only students from low-income families were eligible for the program, which subjected students to discrimination, as was commonly mentioned by some FGD and key informant participants. Furthermore, the majority of participants also described that the SFP increased unity and social integrity and decreased discrimination among students when they ate together, regardless of their families' economic status.

"Students are protected from psychological harm and shame by the school meal program. Many students did not bring food to school prior to the school feeding program's implementation, and those from families with comparatively higher incomes brought lunch boxes. This caused psychological trauma for the students, but these issues have since been resolved thanks to the government, and all students now share the same meal." (A school director, at a primary school)

"The school feeding program helps alleviate perceived discrimination, instead fosters strong relationships with students through eating together and enabling them to concentrate on their studies by providing equal access to services for all students." (FGDs participant).

Theme 2: perceived challenges to the HGSFP in Addis Ababa city. The Addis Ababa City Administration School Feeding Agency recently assigned 1-2 nutrition experts to each school, which improved program quality and encouraged ownership. The experts oversee the program's execution and offer technical support. Although assigning nutrition experts at the school level has been taken as a positive step, sub-city and district education offices continue to lack the staff needed to consistently offer schools supportive supervision.

The women groups receive 20 birr per student payment to prepare two meals per day for each student. With this modest budget and given the ongoing food price inflation, the women are struggling to prepare the meals according to the standard menu. Due to budget shortages, the women are losing interest, and sometimes they provide substandard meals.

Sub theme-2.1: underpayment of workers. The majority of key informant interviews and focus group discussion participants agreed that the salary currently provided to women who prepare meals for students is insufficient to cover inflation or the actual cost of living. During the focus group discussion, a study participant mentioned that food handlers face a lot of pressure due to their low salaries, which makes them demoralized at work and forces them to take on other jobs like housecleaning and washing clothes to support their families. As a result, there might be a detrimental effect on the quality of services provided. According to one of the key informants, the government must assess the food handlers' payment, and before determining how much to pay for them, a market evaluation study that takes into account the challenges imposed by the current cost of living must be conducted.

According to one of the key informant's opinions, with the existing budget, the quality of school meals may deteriorate to the extent that it threatens the very significance of the program. The current food price inflation is even pushing SFPs run by NGOs to compromise their meal plans.

"A daily budget of 20 birr is set aside for breakfast and lunch for each student. It is challenging to feed children on this budget in the current market." SFP monitoring expert, sub-city education office

"An egg currently costs 12 or 13 birrs. So, how can you feed a student for two meals with a budget of 20 birr a day?" SFP improvement and monitoring team leader, sub-city education office

"A kilogram of bananas cost 25 birr when our school feeding program first began; the price has now doubled. Thus, the banana must be eliminated from the menu." Respondents from an NGO implementing SFP

The majority of FGD participants explained that they were unhappy with the refusal of the government not to pay for food handlers during maternity leave and the summer when schools are closed. Food handlers lack alternate means of income, which makes it difficult for them to support their families and lead during this time as a result of these issues.

"The problem of not paying the mothers who prepare food for the students after June 30 when the school is closed. Along with this, breadwinner mothers are exposed to problems as they will not have monthly income until the school opens." (FGD participant)

"During maternity leave, the government is not paid for food handlers like other workers, and due to this feel discrimination and dissatisfied with their work." (FGD participant).

Sub theme-2.2: the poor market linkage between fostering mothers and producers. The major challenge explained by FGD participants and key informant participants was the lack of market connections or linkage between foster mothers and suppliers of market items and agricultural products. Some participants indicated that the SFP's inability to obtain essential supplies like tef, flour, oil, sugar, and bread sufficiently, as vegetables and fruits did not get.

The women groups providing school meal service have some market linkage with consumer cooperatives (specifically for sugar, flour, and oil) and Sheger Bakery. However, according to the key informants, the linkage is not adequate to financially sustain the program. Schools also do not have any established linkage for other supplies like vegetables and fruits. As reported by the key informants, the cost of grains and vegetables might have been lower if there had been direct market connections established with farmers or agricultural cooperatives. Despite the government's previous promises, there has been no development of this type of market linkage.

Thus, women's unions that organize food for public school children in Addis Ababa face a threat to their sustainability due to the current inflation and rising prices of supplies and commodities in the city. The mothers who participated in the FGDs explained that they were unhappy working as cooks in the school feeding program because the payment they received did not consider the high workload and the current market inflation.

"There is a link between sugar, oil, flour, and the sheger bread association, but it is insufficient because it does not account for the quantity and number of students." (FGDs participant).

Sub theme 2.3: poor infrastructure. Most participants in focus groups and key informants agreed that schools did not have the necessary infrastructure for a successful school food program. Many schools also do not have adequate dining halls to accommodate students; therefore, classrooms and libraries have to be used for the same purpose. Also, there is a lack of standard kitchens and standard stores; instead, they use the floor or improvised areas for food storage. As a result, the school feeding program's food safety is at risk due to the aforementioned issues.

Even though every school in the city has access to safe drinking water, the program has been impacted by the regular outages of water supplies and electricity, as well as the absence of conventional water storage facilities. Since most schools currently lack access to three-phase electricity, which is necessary for mass cooking, biomass fuel is used instead.

"Among the public primary schools under the Addis Ababa City Administration, only a few have standard kitchens. It is difficult to talk about food safety issues while the kitchen is substandard" SFP improvement and monitoring team leader, sub-city education office

"Frequent water and electricity outages in our schools had a major challenge on the implementation of the school feeding program." (A school director, at primary schools)

"Most schools' kitchens for preparing meals for students are made of tin, which prevents sufficient airflow. So it is very difficult for the mothers to do their work and risk for their health." (FGDs participant).

Sub theme 2.4: increased sense of dependency. One of the school directors explained during a key informant interview that the school feeding program causes families of children to feel dependent on the program. Another school director stated during a key informant interview that the school feeding program forces students to refocus their attention on school meals rather than their schoolwork and causes them to spend too much time eating at the nearby dining room, not providing enough time for studying.

“ SFPs are beneficial for students. However, it would be preferable if it just applied to low-income parents of students. The school feeding program has unnecessarily raised dependence on the parents of students. They are no longer able to take on responsibility or handle problems alone, and as a result, they develop a dependency mentality.” (A school director, at primary schools).

Sub theme 2.5: increased work burden. The initiation of the SFP has also caused a burden for the school in terms of managing operational issues and facilitating the finances needed for the program. The SFP has increased the work burden on principals, teachers, and admin staff. The feeding program is also compromising the time allotted for learning activities. However, considering the benefits of the program, the school community has so far taken on the burden of positivity.

“SFP has increased the work burden on school directors, teachers, and administrative staff. But they are aware of the benefit of the program as well.” SFP improvement and monitoring team leader, sub-city education office

“Some students give a lower priority to their educational activities, including study time, rather than spending much time eating breakfast and lunch.” (A school director, at primary schools).

Sub theme 2.6: provide poor meal quality. The Addis Ababa School Feeding Agency (SFA) prepared the current school menu to diversify diets, standardize meals, and ensure that children’s nutrient needs are satisfied. The SFA has introduced standardized recipes based on locally available ingredients.

Despite adhering to a set menu, some key informants have expressed concerns about the nutritional value of school meals. Financial constraints prevent the inclusion of animal-based products like milk and eggs, while limited resources make it challenging to provide sufficient fruits and vegetables. As a result, the quality of the meals served to students may be compromised. Key informants from sub-city education offices have reported that bulk preparation sometimes leads to unappealing school lunches, affecting student satisfaction.

During a key informant interview, one of the school directors indicated that the lack of adequate funding for the school feeding program made it impossible to include animal products, fruits, and vegetables in the food menus. A student who participated in this study expressed dissatisfaction

with the current food quantity and quality provided in the school feeding program. Another student also provided the following explanation: “We are unhappy because the food they received throughout the week was not varied and had no animal products, like eggs, milk, and meat.”

“Sometimes students bring lunch boxes from home complaining that the school meals are not palatable” SFP improvement and monitoring team leader, sub-city education office.

Sub theme 2.7: engaging diverse stakeholders in SFP. According to a key informant from the Ministry of Education (MoE), with the recent food price inflation, it is not possible to fully finance SFP with the government budget alone. So, efforts have to be made to mobilize resources from the community and other partners. There is also increasing interest from NGOs to support the SFP. However, the collaboration between the SFA and NGOs engaged in SFPs is far from ideal. Effort to engage individual local contributors is also low.

Although the Addis Ababa City Administration greatly needs multi-stakeholder engagement, there is currently no clear government directive on how to involve NGOs in school food programs. Instead, the SFA is pressuring NGOs and contracting out the food preparation to a local women’s union, which has lowered the standard of services offered to students.

Sub theme 2.8: linkage between SFP and school garden. According to a key informant from the MoE, some schools in the Amhara, Oromia, and SNNP regions have started school gardening to strengthen their HGSFP. The respective regional structures of the agriculture sector are supporting the initiative by providing technical and material support, including agricultural inputs like improved seeds. Experience from elsewhere outside Addis Ababa indicated that school gardening has improved access for schools to a fresh supply of vegetables and fruits. Further, it has also excluded middlemen from the market chain and reduced the expenses of the program.

“One major approach to ensuring students access to fresh and nutritious vegetables and fruits is the initiation of school gardens.” Health and Nutrition Expert, MoE

In contrast, the achievement of school gardening is modest in Addis Ababa because, unlike rural schools, schools in the city do not have adequate space to initiate gardening at scale. The Addis Ababa City Administration (AACA) still has not initiated urban agriculture within the school environment. High schools in Addis Ababa are comparatively bigger than elementary schools. However, since high schools are not currently enrolled in the SFPs, this cannot be directly linked to the SFP.

School gardening has the potential to improve the accessibility of the SFP and to get vegetables at better prices and quality. This has also been observed in schools that started gardening. So far, most schools that run SFP in Addis Ababa have not started gardening. Many of the schools have no adequate space to establish meaningful urban agriculture, while others have not received technical support for doing so. Those had experience with school gardening, scarcity of water, lack of personnel to take care of the farm, and limited production. Many key informants assumed urban agriculture may help students understand how agriculture works. Furthermore, it will serve as a demonstration site for the agriculture course that will be included in formal education starting in the coming year.

One major challenge that hinders the linkage between urban agriculture and SFP is the low productivity of school gardens. Experience from the schools that implemented urban agriculture at different levels suggests that the scale of production is too small to have a meaningful effect on the meals delivered to students.

"The existing space in schools does not allow for large-scale production. However, school gardening is used as a demonstration center so that students will apply the experience at home." SFP monitoring expert, sub-city education department

"We are implementing school gardens and we have been acknowledged for that. However, the demand of the SFP is large and cannot be met by the gardens alone." A SFP coordinator.

6.5 Discussion

Our study aimed to address gaps and limitations in previous research on SFP. To fill these gaps, we conducted a qualitative phenomenological study in Addis Ababa, Ethiopia, comprehensively exploring the perceived benefits and challenges of SFP. Our findings indicate improved student nutrition and education outcomes but persistent challenges in infrastructure, logistics, operational, and financial issues. These findings align with previous research emphasising the importance of contextual factors in SFP implementation (Andam *et al.,* 2024).

In terms of benefits, our study identified increments in school enrollment, attention span, academic performance, and attendance, along with reductions in dropout rates and class repetition. The program also alleviated the socio-economic burden on students' families, decreased social psychological pressure, improved social integrity among students, and prompted changes in students' behavior. However, challenges such as poor-quality meal provision, lack of market linkage, poor infrastructure, underpayment of workers, dependency on the program, lack of collaboration between stakeholders, and inadequate linkage between SFPs and school gardening were identified as key barriers in the effective and efficient implementation of SFPs in Addis Ababa City, Ethiopia.

Our research enhances the theoretical understanding of SFP by revealing the intricate interplay between local contexts and program effectiveness. These findings can serve as a foundation for future studies to explore long-term impacts and formulate scaling strategies specifically for urban environments. Offering school meals has multiple benefits, including improved academic performance, increased enrollment, attendance, retention, and completion rates for pre-primary and primary school students. It also reduces hunger, enhances students' health and nutritional status, and helps break the generational cycle of malnutrition. Additionally, providing daily meals lowers the opportunity and financial costs of sending children to school, encouraging families to prioritize their education.

According to the results of the current study, the feeding program has improved enrollments, decreased the dropout rate, improved academic achievement and concentration, and decreased absenteeism and dropout rates. Thus, the SFPs may have enhanced educational and nutritional outcomes by reducing short-term hunger. This keeps students from having to leave school to get food and makes them more interested in class. This result is consistent with a quantitative study

conducted in Addis Ababa, Ethiopia, (Desalegn *et al*., 2022b; Mohammed *et al*., 2023), which revealed a favorable relationship between academic achievement and SFP.

This result is in line with a review (Meshkovska *et al*.,2023) of qualitative studies that examined the consequence of SFP on the education outcomes of students' such as enrollment, completion, and academic success and were conducted in Nigeria and Niger, (Cammelbeeck, 2020; Agu *et al*., 2023). Therefore, strengthening the SFP could be a crucial intervention to enhance students' academic performance and improve the quality of their education.

The lessened socioeconomic strain on student families was the other perceived advantage of SFPs in Addis Ababa. It was difficult for low-income families to feed their kids breakfast and lunch, and when students went hungry and looked for food, the families experienced worry and anxiety. However, the SFPs helped them reduce the pressure that society's socioeconomic system placed on families, especially those with lower incomes.

This finding is supported by a systematic review report (Meshkovska *et al*.,2023), and a study conducted in the Sidama region of Ethiopia (Desalegn *et al.*, 2022b). This conclusion was further supported by a Tennessee, USA study that found school lunch programs decreased family stress regarding time and money spent on food shopping, cooking, and packing for their kids (Philbrick, 2023). Therefore, the SFP has the potential to be a crucial strategy for enhancing the quality of life for families, particularly those with low incomes.

According to the study, the SFP led to a reduction in social psychological pressure and an increase in social integrity among students. Previously, there was a school feeding program exclusively for students from the poorest families, which placed psychological pressure on the students. However, with the endorsement of the SFP in all public primary schools in Addis Ababa, this pressure has been alleviated.

Currently, there are no eligibility requirements for students to receive breakfast and lunch at school, irrespective of their parents' financial situation. This inclusive approach has led to a decrease in psychological stress and an enhancement of social integrity among students. This finding is supported by evidence from a qualitative study conducted in India (Jalal & Sareen, 2022), and a systematic review that reported an increase in social interaction and integrity among students through the SFP (Meshkovska *et al*., 2023).

The SFPs contribute to reducing poverty both directly and indirectly through improving community wellbeing. The study found that implementing the SFP resulted in a decrease in inappropriate student behaviours, including class absenteeism, substance use, and exploitation. This finding is consistent with a study conducted in Niger, which also highlighted the role of SFPs in reducing student misconduct such as theft, drug use, sexual assault, and delinquency (Saliu, 2020). This suggests that SFP could be applied as a strategy for generating a disciplined and productive generation in the future.

Ethiopian school feeding policy made clear direction that the government is responsible for providing schools with basic facilities that are appropriate for the local environment (National School Feeding Policy Draft, 2019). However, this study indicated that inadequate facilities, such as those in the kitchen, food storage, dining room, water supply, and electric supply, were among the main obstacles to the implementation of SFP. When there was no water in the school, the food handlers paid laborers to fetch water, and when the electricity went out, the food handlers used a wood fire to cook the food instead, which exposed them to hazardous smoke. Qualitative research in the Sidama region of Ethiopia (Desalegn *et al.,* 2022b), Nigeria (Agu *et al.,* 2023), and Uganda (Fungo, 2023), as well as a qualitative systematic review undertaken globally (Meshkovska *et al.,* 2023), all provide credence to this finding. Therefore, building basic facilities as well as improving the water and electric supply could positively impact the success and sustainability of SFPs in settings with scarce resources, such as Ethiopia.

This study also indicated that underpayment of workers under SFP, absence of payment for workers in the summer season, maternity leave, and budget that doesn't consider inflation were other challenges to the effective implementation of SFPs. This finding is supported by evidence from a qualitative systematic review in a global context (Meshkovska *et al.,* 2023), and a qualitative study conducted in Addis Ababa (Lemma, 2020). These studies reported that the absence of a budget that considers inflation was a challenge for the smooth implementation of SFPs. Therefore, this program should give due emphasis on adjusting the budget according to the living cost of the country.

In this study, a key obstacle to effective SFPs was the lack of networking among producers, suppliers, and the program. This resulted in shortages of essential supplies and commodities for the SFP, a finding supported by a global review of SFPs (Meshkovska *et al.,* 2023). Thus, it is

crucial to prioritize the improvement of the food supply chain, as emphasized in the school feeding policy (National School Feeding Policy Draft, 2019).

According to Ethiopian school feeding policy (National School Feeding Policy Draft, 2019), effective and sustainable SFPs need cross-sectoral cooperation, and the local community is expected to oversee the implementation and allocation of resources with a sense of ownership. The SFPs were, however, found to be developing a sense of dependency among the parents of the students. Thus, to maximize the sense of ownership and minimize the sense of dependency on it, as already mentioned in the national school feeding policy, program implementers should pay appropriate attention to engaging parents of students in particular and the local community in general in the process of planning, implementing, and evaluating this program (National School Feeding Policy Draft, 2019).

6.6 Strengths and Limitations

One of the strengths of this study is the inclusion of diversified potential study participants who have in-depth information and rich insight into the homegrown school feeding program. Furthermore, the interview facilitators were proficient in the local language, well-versed in the community, and had prior experience with qualitative research. Relationships were established before data collection by approaching the primary school directors for prior permission. The analysis was conducted as a team with the help of multiple researchers. Considering the study's limitations, its qualitative nature limits the generalization of its findings due to the lack of a representative sample. This study would have benefited more from a mixed-methods approach to quantifying the size of each perceived benefit and challenge associated with SFPs so that planners and policymakers may more easily prioritize problems.

6.7 Conclusions and Recommendations

Awareness-raising efforts should be started to address the parent's incorrect perception of their dependence on the school feeding program. To lessen problems and enhance the quality of SFP's, all primary schools must fulfill the necessary infrastructure for the program, like constructing standard dining halls that can accommodate the number of students as well as standard food storage and cooking areas. They also must have ready-to-use water storage facilities and private generators.

In addition, the government should establish market links for fruits and vegetables, which will contribute to the SFPs and meet the nutritional needs of the students. Furthermore, starting and supporting urban agriculture and school gardening should be the alternative strategy. Besides, direct market connections with agricultural cooperatives are essential for decreasing the current inflation of food prices and securing food supplies at lower costs.

To improve the efficiency of the SFP, lessen the workload on administrators, teachers, and other staff members, and streamline the handling of program-related operational and financial issues. It is better to entirely outsource to the appropriate body. In addition, it is important to assign the right people to each position, clearly define roles and responsibilities, and allocate funds at all levels.

According to the researchers, future studies should be needed, to quantify the perceived benefits and drawbacks of SFP to make it straightforward for policymakers and program designers to prioritize problems based on their magnitude. The SFPs are not stand-alone interventions; therefore, they need to be strengthening the network of local private and public partners and NGOs working in SFP related fields by developing a coordinated partnership strategy with well-defined roles, management, financial responsibilities, and implementation guidelines.

In order to overcome the operational and strategic obstacles to the program and improve the effectiveness of the domestic school feeding program, a framework for coordination between the various sector ministries and task forces must be established.

CHAPTER 7: GENERAL DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

7.1 General Discussion

This comprehensive study aimed to assess multiple aspects of the SFPs in in Addis Ababa, Ethiopia. The objectives included evaluating the dietary quality of meals, assessing the microbiological quality of school meals, examining the food safety knowledge, attitudes, and practices of food handlers, and exploring the perceived benefits and challenges of the program from the perspectives of students, parents, teachers, and principals. For this, dietary intake data were collected using a multiple-pass 24-hour recall method, and nutrient adequacy was assessed based on RDA and dietary diversity was evaluated using a 12-food group score, microbiological analysis of food samples conducted using ISO and NMKL recommended techniques, surveys of food handlers, and a qualitative phenomenological study was conducted. The findings revealed that while school meals provided an adequate contribution of carbohydrates (74.4% of the RDA), the contribution for other nutrients was low: energy (34.1%), protein (42.5%), calcium (9.3%), zinc (14.6%), iron (52.9%), vitamin A (14.0%), thiamine (16.7%), vitamin B12 (12.8%), and niacin (3.8%). The study also showed a high prevalence of inadequate intakes of priority nutrients among school adolescents, including protein (57.5%), carbohydrates (25.6%), calcium (90.7%), zinc (85.4%), iron (47.1%), vitamin A RAE (86.0%), vitamin C (86.0%), thiamine (83.3%), vitamin B12 (90.2%), and niacin (96.2%). Despite a diverse diet, significant nutrient inadequacies were observed in both school meals and overall 24-hour dietary intake.

The study revealed that school meals in the SFPs did not meet recommended energy and nutrient requirements set by the WFP (WFP, 2017b). They lacked dietary diversity, similar to Ethiopian school meals (Destaw *et al.,* 2022b), while Ghana had more diverse meals (Agbozo *et al.,* 2018). Adolescents had diets high in cereals (89.1%), spices, condiments, and beverages (88.1%), and oils (87.4%), which was consistent with previous research in Meshenti (99.8%) and Dembia (64%) in Ethiopia (Gonete *et al.,* 2020; Ayal *et al.,* 2022), and the Solomon Islands (94%) and Zambia (99.4%), where cereals were also commonly consumed (Caswell *et al.*, 2015; Horsey *et al.,* 2019). School meals provided 84.0% of the daily fiber requirement, contrasting with Slovenia where dietary fiber was insufficient (Gregorič *et al.,* 2015). Adolescents' 24-hour meals were nutritionally inadequate, with deficiencies in beta-carotene and vitamin B12, possibly due to the absence of fruits and vegetables in the meals. Carbohydrates (86.7%) and iron (92.5%),

but inadequate intake of zinc (96.6%), vitamin B12 (85.3%), thiamine (84.0%), and niacin (92.3%) were consistent with a previous study in Ethiopia (Ayal *et al.,* 2022). School meals should meet one-third of the daily energy and protein requirements, and supply two-thirds of the daily iron needs (WFP, 2017b). This aligns with previous studies conducted in Ethiopia (Destaw *et al.,* 2022b), and Ghana (Agbozo *et al.,* 2018), but differs from findings in Nigeria (Ayogu *et al.,* 2018). The inclusion of iron-rich Injera and/or Firfir made from Teff in the school meals may have contributed to the observed higher iron intake.

The microbiological analysis highlighted Yeasts and molds exceeded the reference standards in 78.4% of samples (>10^2 CFU/ml,), *E. coli* exceeded the standards in 10.8% of samples (>10^2 CFU/ml), and *S. aureus* counts exceeded the limits in 5.4% of samples (10^3 -10^4). Cooked rice showed the highest microbial counts, particularly for *E. coli* and *S. aureus*. Overall, approximately 14.4% of food samples were unsatisfactory, indicating issues with *E. coli*, *S. aureus*, and yeasts and molds. For drinking water, the non-potable percentage was 23.4%, indicating concerns with APC microbial count, *TC*, and *FC*. Specifically, 72% of drinking water samples exceeded the APC standard (>100 cfu/ml), 16% exceeded the *TC* standard (>1 CFU/ml), and 5.5% exceeded the *FC* standard (>1 CFU/ml).

The study found regional variations in the quality of RTE cooked food samples, with 68.7% satisfactory, 16.9% marginal, and 14.4% unsatisfactory. Similar patterns were observed in Argentina (Tessi *et al.,* 2002), Italy (Marzano & Balzaretti, 2013), and Burkina Faso (Compaore *et al.,* 2022), indicating regional variations. Ongoing monitoring and adherence to food safety standards are crucial. *S. aureus* was detected in 5.4% of the samples in this study, while the Argentina study found no *S. aureus* (Tessi *et al.,* 2002), Italy (Marzano & Balzaretti, 2013), and Burkina Faso (Compaore *et al.,* 2022), and the Brazilian study reported no *S. aureus* (Santana *et al.,* 2009). Another Brazilian study on the school food program showed a much higher presence of *S. aureus* at 32.4% (Nagla *et al.,* 2014). The study found unacceptably high levels of *E. coli* in 10.8% of the samples, exceeding the threshold of (>10^2) CFU/ml, consistent with findings by (Petruzzelli *et al.,* 2018). A Brazilian school food program study detected *E. coli* in 1.5% of the samples (Nagla *et al.,* 2014). High levels of yeasts and molds were found in 78.4% of the samples, surpassing the contamination rate in Burkina Faso (24.75%) (Compaore *et al.,* 2022). In drinking water samples, significant contamination was observed: 72% positive for *APC*, 16%

with TC, and 5.5% with FC, indicating poor conditions. In contrast, the study in Argentina found no coliforms or thermotolerant coliforms (Tessi *et al.,* 2002). Italian kindergartens/schools showed a similar pattern, with 10.0% exceeding bacteriological limits (Marzano & Balzaretti, 2013). Various regions exhibited different percentages of coliform-contaminated water samples (12-70%) (12-70%) (Ali *et al.,* 2013; Singh *et al.,* 2014; Aly & Elbadawy, 2017). No *E. coli* was found in the collected samples, consistent with Argentina's findings (Tessi *et al.,* 2002). However, studies in Assam, India, Peshawar, Pakistan, and Bo, Sierra Leone reported high proportions of *E. coli* contamination (61-78.1%) (Borah *et al.,* 2010; Ali *et al.,* 2013; Jimmy *et al.,* 2013).

The evaluation of food handlers' knowledge, attitudes, and practices in this study revealed promising results: a high knowledge score of 85.8%, positive attitudes at 79.6%, and satisfactory safe food handling practices at 72.3%. These findings indicate a strong foundation for food safety within the School Feeding Program. Notably, education emerged as a significant factor, enhancing both knowledge ($p = 0.004$) and practices ($p < 0.001$) among food handlers. In contrast, while years of service positively influenced knowledge ($p < 0.001$), it negatively impacted practices ($p = 0.019$), suggesting that experience alone may not ensure better food handling behaviors. Additionally, marital status demonstrated significant associations with attitudes ($p = 0.046$) and practices ($p = 0.043$), indicating that personal circumstances can shape food handling behaviors.

The analysis also revealed meaningful correlations among knowledge, attitudes, and practices. Positive correlations were found between knowledge and attitudes ($r = 0.139$), attitudes and practices ($r = 0.340$), and knowledge and practices ($r = 0.127$), highlighting the interconnectedness of these factors in promoting safe food handling.

Logistic regression analysis further underscored the importance of the physical environment in food safety. Specifically, having a separate room for raw and RTE food storage reduced contamination risk by 55% [AOR=0.45 (95% CI: 0.01-0.90)]. The presence of a water facility in the kitchen was linked to a 46% reduction in poor hygiene practices [AOR=0.54 (95% CI: 0.16-0.93)], while the availability of a hand-washing facility lowered the odds by 35% [AOR=0.65 (95% CI: 0.36-0.95)]. Importantly, food handlers with higher attitude scores towards food

hygiene and safety exhibited an 81% decrease in the likelihood of poor practices [AOR=0.19 (95% CI: 0.11-0.28)].

Comparatively, the high overall knowledge score (85.8%) aligns with findings from similar studies conducted in Jimma and Debark Town (Mekasha Temeche, 2016). and exceeded findings from other Ethiopian regions (Gebru *et al.,* 2023). However, it was lower than studies conducted in Jordan and Uganda (Baş *et al.,* 2006; Sylvia *et al.,* 2015). The majority of participants exhibited positive attitudes towards preventive food handling measures (79.59%), consistent with findings from Jigjiga and Tigray (Tegegne *et al.,* 2017a; Gebru *et al.,* 2023), but lower than the study in Jimma and studies in Malaysian (Mekasha, 2016; Rohin, 2016).

Participants demonstrated a high level of awareness regarding food safety practices, including handwashing, preventing food-borne illnesses, and proper food storage. This aligns with previous research (Tokuç *et al*., 2009; Akabanda *et al*., 2017; Gebru *et al*., 2023; Rito, 2013). However, awareness levels varied for other practices, influenced by regional and cultural factors (Buccheri *et al.,* 2010; Idris Ali & Immanuel, 2017; Gebru *et al.,* 2023).

The positive correlations found between knowledge, attitudes, and practices are consistent with other studies (Cempaka *et al.,* 2019), reinforcing the idea that higher knowledge fosters positive attitudes, which in turn promote better food safety practices. However, contrasting findings from a study in Iran indicate that increased knowledge and positive attitudes do not always lead to improved food handling behaviors (Ansari-Lari *et al.,* 2010b). This highlights the complexity of behavior change in food safety and suggests that additional factors may influence the translation of knowledge and attitudes into practice.

The SFP had positive effects on attendance, academic performance, dropout rates, behavior, and the learning environment by promoting student interaction, relationships, and a sense of belonging. It alleviated financial burdens for parents and reduced family stress through free food provision. However, challenges such as underpaid kitchen workers, operational issues (tap water and light interruption), reduced reading time, rising food costs, limited market access, inadequate infrastructure (insufficient kitchen space, inadequate storage facilities), and growing dependency were identified.

The study demonstrates that SFPs have multiple benefits, including improved enrollments, reduced dropout rates, enhanced academic achievement, increased concentration, and decreased absenteeism. These findings align with studies conducted in Ethiopia (Dheressa, 2011; Zenebe *et al.,* 2018; Desalegn *et al.*, 2022b), and a review conducted in Nigeria and Niger (Saliu, 2020) (Agu *et al*., 2023). The study also highlights the alleviation of socioeconomic strain on student families, supported by a systematic review report (Meshkovska *et al*., 2023), and studies conducted in the USA (Philbrick, 2023). And Ethiopia (Desalegn *et al.*, 2022b). Furthermore, the implementation of SFPs in Addis Ababa positively influenced students by reducing social pressure and promoting social integrity. Inclusive meal provision to all students fostered unity, supported by studies in India and a systematic review (Jalal & Sareen, 2022; Meshkovska *et al*., 2023). The study also noted a decrease in inappropriate student behaviors, consistent with findings in Niger (Saliu, 2020).

The Ethiopian school feeding policy (National School Feeding Policy Draft, 2019), emphasizes the government's responsibility to provide basic facilities for schools. However, this study identified significant barriers to implementing SFPs, including inadequate infrastructure such as kitchens, food storage, dining rooms, water supply, and electric supply facilities. Similar challenges were observed in Sidama, Ethiopia (Desalegn *et al.*, 2022b), in Jigjiga, Somali, Ethiopia, Ghana (Atta & Jacob, 2015) (Sulemana *et al.*, 2013a), and Nigeria (Agu *et al*., 2023), Uganda (Fungo, 2023), and a global qualitative systematic review (Meshkovska *et al*., 2023). The study identified challenges to effective SFP implementation, including underpayment of workers, lack of payment during summer and maternity leave, and an insufficient budget that ignores inflation. These findings are supported by a global systematic review (Meshkovska *et al*., 2023), and a qualitative study conducted in Addis Ababa (Lemma, 2020). Ensuring fair compensation, recognition, manageable workloads, and adjusting the budget to reflect the cost of living are crucial for the program's success. Similar issues were observed in India's school lunch program (Whittaker, 2024). Prioritizing employee treatment, adequate remuneration, and benefits not only reduces poverty and inequalities but also improves the effectiveness of SFPs.

The study identified challenges to effective SFPs implementation, including underpayment of workers, lack of payment during summer and maternity leave, and an insufficient budget that ignores inflation. These findings are supported by a study conducted in Addis Ababa (Lemma,

2020). Similar issues were observed in India's school lunch program (Whittaker, 2024). The study also highlighted supply shortages due to a lack of networking among producers, suppliers, and the program (Meshkovska *et al*., 2023). Additionally, it revealed the program's tendency to foster dependency among parents.

While this research provides valuable insights, it is important to acknowledge a few limitations that may influence the interpretation of the results. The sample size, while sufficient for the study's purpose, may limit the generalizability of the findings to the broader adolescent population in Addis Ababa. Additionally, the reliance on self-reported data introduces the possibility of recall bias. Despite these considerations, the study effectively highlights key aspects of dietary diversity and nutritional quality in school meals, contributing to a better understanding of the School Feeding Program's impact.

7.2 Conclusions and Recommendations

7.2.1 Conclusions

This study provides critical insights into adolescent nutrition within the context of school meals, revealing significant inadequacies in essential nutrients despite adequate carbohydrate provision. The nutrients such as protein, calcium, iron, and vitamins including vitamin A, thiamine (B1), vitamin B12, niacin (B3), and vitamin C were found to be insufficient both in school meals and in the overall dietary intake of adolescents. This prevalent inadequacy highlights a failure to meet nutritional requirements, even among individuals consuming what appears to be a diverse diet. Addressing these deficiencies is imperative for promoting the health and well-being of adolescents, as these nutrients are crucial for growth, development, and overall physiological functioning. Strategies aimed at enhancing the nutrient content of school meals and encouraging balanced dietary habits among adolescents are essential for mitigating these deficiencies and supporting optimal health outcomes during this critical developmental phase.

The assessment of microbial quality raised significant concerns regarding contamination levels in both food and water samples. The presence of yeasts, molds, *E. coli*, and *S. aureus* highlights the important need for improved water quality, enhanced hygiene practices among food handlers, and the establishment of regular monitoring protocols to ensure the safety and microbial integrity of meals served through the SFP.

Furthermore, the study highlights the strong knowledge, positive attitudes, and satisfactory practices of food handlers regarding food safety. The presence of designated storage areas for raw and RTE foods, a functional water facility in kitchens, and hand-washing facilities significantly reduce the likelihood of poor food safety and hygiene practices. Notably, food handlers with higher scores in attitudes toward food hygiene exhibited a marked decrease in the probability of poor safety practices. However, despite high levels of awareness and knowledge, significant gaps in actual practices remain, necessitating targeted educational interventions that consider regional and cultural influences on food safety behaviors. Future research should prioritize objective measurements to gain deeper insights into food safety practices and their public health implications.

Moreover, our findings regarding the perceived benefits and challenges of the SFP indicate a positive impact on various aspects, including student attendance, academic performance, reduced

dropout rates, family finances, behavior, and the creation of a safer learning environment. However, persistent challenges such as underpaid kitchen workers, operational inefficiencies, limited market access, and increasing dependency on the SFP must be addressed to ensure the program's sustainability and maximize its intended benefits.

7.2.2 Recommendations

Based on the findings of this study, several targeted recommendations are proposed to enhance the quality and safety of school meals within the Addis Ababa SFP. The collaborative involvement of the Addis Ababa Education Bureau, the Addis Ababa School Feeding Agency, the Addis Ababa Health Bureau, the Ministry of Education, the Ministry of Health, and other relevant stakeholders is essential for effective implementation. These recommendations aim to improve the nutritional status and educational outcomes of school-aged children.

For the Addis Ababa Education Bureau, the Addis Ababa School Feeding Agency, and the Addis Ababa Health Bureau:

- Implement comprehensive protocols to elevate hygiene standards in school kitchens. This includes improving food handler practices, ensuring water quality, and conducting routine microbial monitoring of meals to safeguard safety.
- Equip food handlers with necessary resources and tools to enhance practices related to reheating, hand hygiene, sanitizer usage, and adherence to safety protocols after food preparation.
- Develop targeted training programs for food handlers that focus on food safety, nutritional adequacy, and best practices, thereby fostering a knowledgeable workforce capable of ensuring meal quality.
- Implement continuous assessments of training programs to evaluate their effectiveness, refining them based on feedback and observed outcomes to enhance food safety practices.

For the Addis Ababa School Feeding Agency and the Addis Ababa Education Bureau:

- Tackle systemic issues such as underpaid kitchen staff, limited sourcing options for ingredients, and dependency on external resources to ensure the sustainability of feeding programs.
- Formulate and implement strategies to overcome operational challenges, ensuring efficient and sustainable management of school feeding initiatives.
- Enhance collaboration with key stakeholders including government agencies, nutritionists, educational institutions, and community representatives during the planning, execution, and oversight of programs.
- Encourage stakeholder engagement in decision-making processes to incorporate diverse insights, fostering a sense of ownership and commitment to program implementation.
- Work closely with the Ministry of Education, Ministry of Health, and other relevant partners to systematically monitor and evaluate the implementation of these recommendations.
- Adjust school meal menus to include nutrient-dense foods, specifically targeting identified deficiencies such as protein, calcium, and iron.
- Establish partnerships with local producers to ensure access to high-quality, cost-effective ingredients that meet the program's nutritional standards.
- Create robust systems for ongoing monitoring and reporting on the nutritional quality and safety of school meals, ensuring compliance with established standards and facilitating continuous improvement.

For the Ministry of Education, Ministry of Health, and Other Partners:

- Collaborate to develop and implement rigorous nutritional standards for school meals, directly addressing deficiencies in essential nutrients and promoting overall student health.
- Focus on initiatives that enhance the nutritional quality and safety of school meals, thereby supporting the health and well-being of adolescents and ensuring the long-term effectiveness of school feeding programs.

For Researchers:

- Conduct longitudinal studies to explore the long-term effects of improved school meal quality on the nutritional status and academic performance of students.
- Assess the effectiveness of various intervention strategies aimed at enhancing the overall health and well-being of students participating in school feeding programs, providing valuable insights for future improvements.

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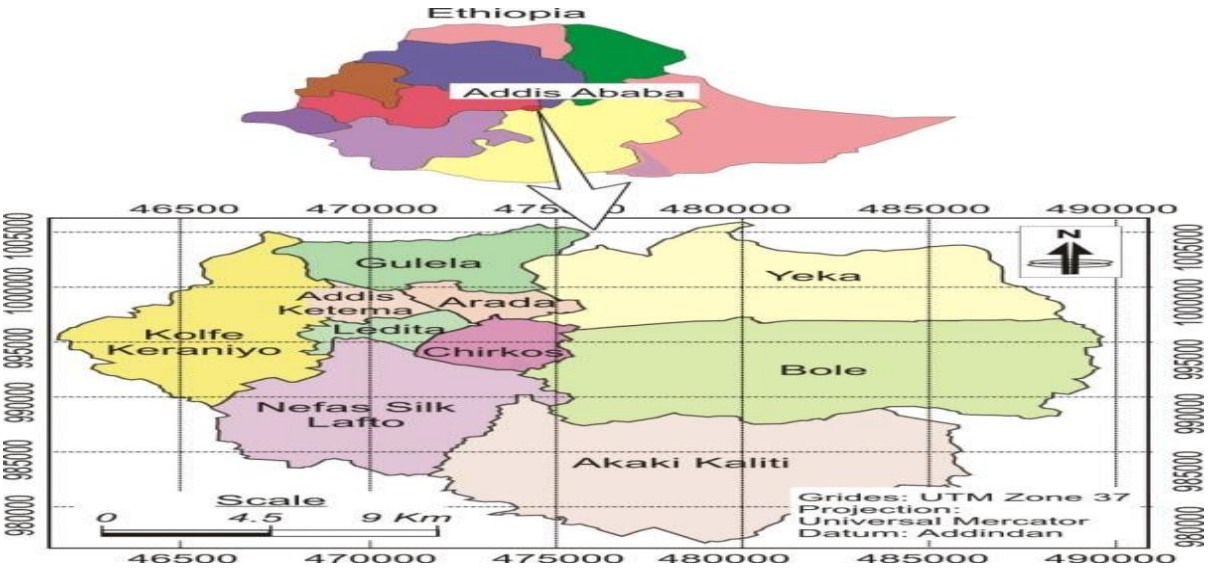
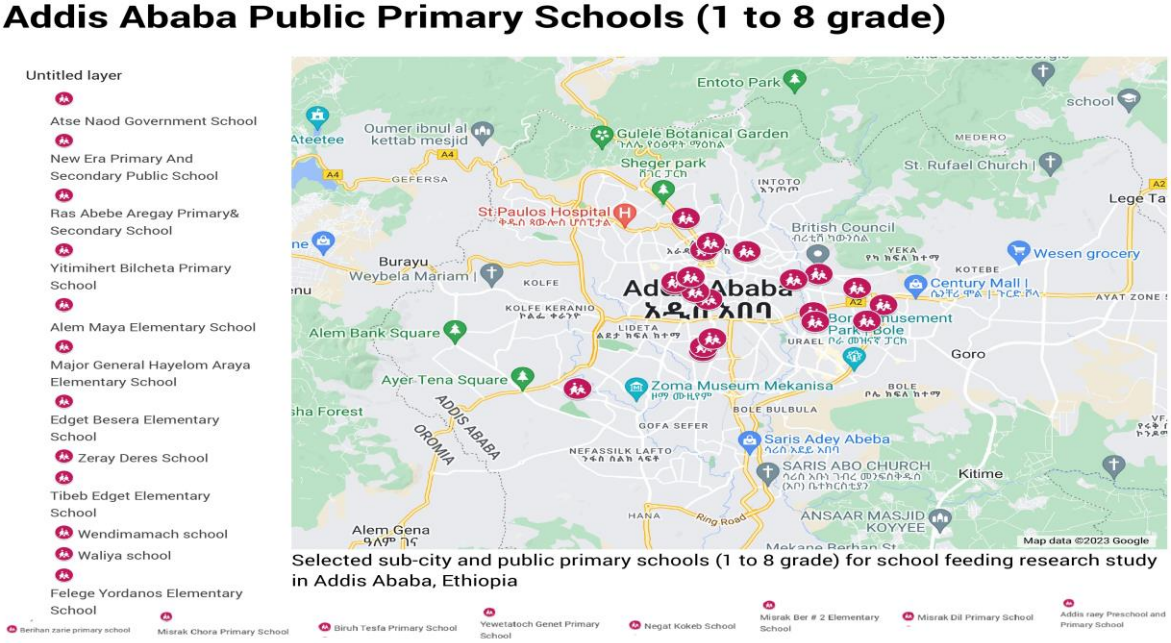
Appendices

Appendix 1: Map of study sites of Addis Ababa and sub-cities' public primary schools (grades 1-8)





Selected sub-city and public primary schools (1 to 8 grade) for school feeding research study in Addis Ababa, Ethiopia

https://www.google.com/maps/d/u/2/edit?mid=1xTkGYSAjjQzRzsNM0gIb9xvQIIQoU9k&ll=9.01761041553678%2C38.7590445&z=13

Appendix 2: Comprehensive informed consent form for study participants in the school feeding program (SFP) study

School Name: _____

Date: _____

Dear Participants,

We are conducting a research study to evaluate various aspects of the SFP in public primary schools in Addis Ababa, Ethiopia. This study aims to:

- Assess the dietary quality of meals provided through the SFP.
- Evaluate the microbiological quality of school meals served to students.
- Examine the food safety knowledge, attitudes, and practices of food handlers participating in the SFP.
- Explore the perceived benefits and challenges of the SFP from the perspectives of students, parents, teachers, and principals.

Participation Information

Your child or you (if you are a food handler or a parent/guardian) have been invited to participate in this study. Here are important details regarding participation:

Voluntary Participation: Participation in this study is entirely voluntary. You have the right to decline or withdraw participation at any time without any negative consequences.

Confidentiality: All information collected will be treated with strict confidentiality. Your identity will remain anonymous, and no personally identifiable information will be disclosed in any reports or publications.

Data Collection Methods: Depending on your role:

For Students: Data will be collected through a multiple-pass 24-hour recall method regarding their food intake.

For Food Handlers: You will answer a series of questions about food safety KAPs.

For Parents/Guardians: You may participate in a FGD or survey about the SFP.

For Principals: You will be interviewed regarding your insights on the SFP.

No Anticipated Risks: There are no anticipated risks associated with participating in this study. Your involvement will greatly contribute to understanding and improving the SFP.

Contact Information

If you have any questions or need further information about the study, please feel free to contact the researcher, Yihalem Tamiru, at ***0911378982,*** Center for Food Science and Nutrition, AAU.

Consent Agreement

By signing below, you acknowledge that you have read and understood the information provided in this consent form. You voluntarily grant permission for participation in the study and confirm that you are aware of your right to withdraw participation at any time without any negative consequences.

I give consent for my child to participate in the study: _____

I do not give consent for my child to participate in the study: _____

Parent/Guardian's Name: _____

Signature: _____

Date: _____

For Food Handlers:

Signature: _____

Date: _____

For Principals (MoE/SFA/Sub-city/School director):

Signature: _____

Date: _____

Thank you for your time and consideration. Your contribution to this research is greatly appreciated.

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Appendix 3: 24- Quick List for 24-Hour Dietary Recall Assessment

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Pass 1: Quick list

Enumerator code: _____ Date: _____

24-hour dietary recall

Unique ID Woman: |__|__|__|__|__|__|__| **Unique ID Child:** |__|__|__|__|__|__|__|__|__|

Interview Date: Date - _ _/_ _/_ _ _ _ **Day -** 01=Mon 02=Tue 03=Wed 04=Thu 05=Fri

Please describe the foods and drinks that consumed yesterday from the time you woke up until you went to sleep (sunrise yesterday to sunrise today). Please list all foods or drinks you ate, whether you ate or drank them at home or somewhere else. Please think about snacks and small meals as well as main meals.

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Write down all foods and drinks mentioned. When composite dishes are mentioned, ask for the list of individual food items When the respondent has finished, probe for meals and snacks not mentioned. □□□□□□□ □□□□ □□ □□□□ □□□ □□□. □□□□□ □□□□ □□□□□ □□□□□□ □□□□ □□□□ □□□□ □□□ □□□ □□□□□ □□□□□□ □□□□□ □□ □□□□ □□□□□

Early morning: □□□□**:**
Mid-morning : □□□ □□
Noon: □□□
Afternoon: □□□□
Evening: □□□
Late-evening: □□□ □□**:**

Summary sheet

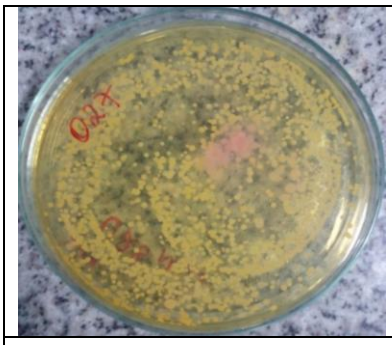
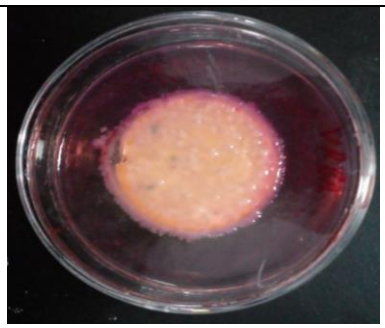
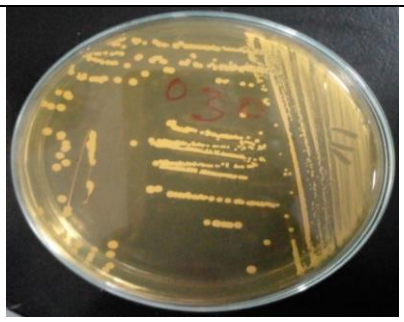
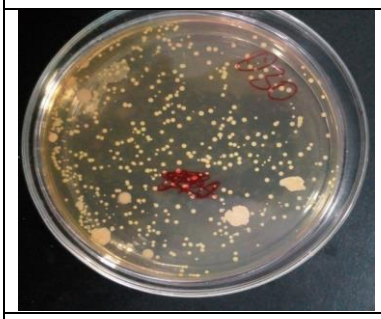
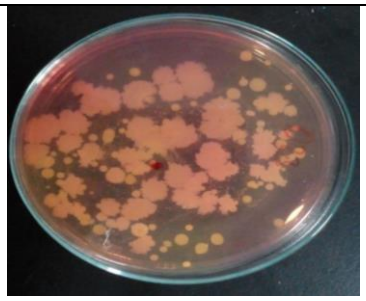
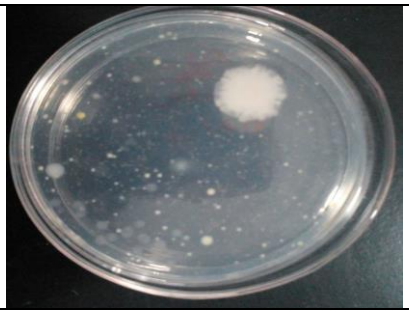
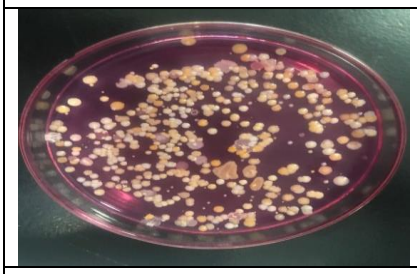
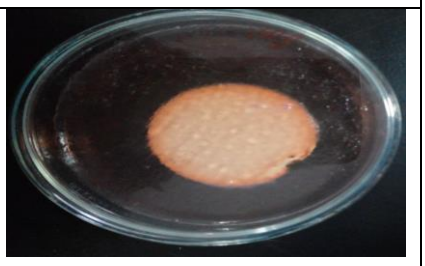
Food #	Pass 1 food name	PSEM used for a food item	Recipe ingredients □□□□ □□□□□□ □□□ □□□□	PSEM for ingredient	Amount of ingredients used □□□ □□ □□□ □□□ □□□□ □□□

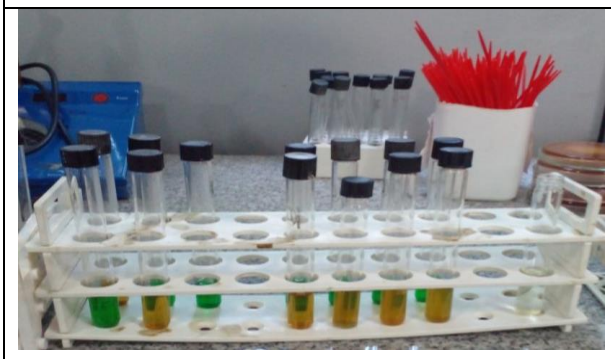
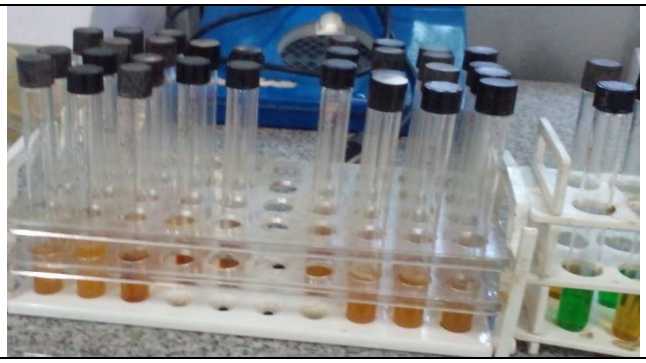
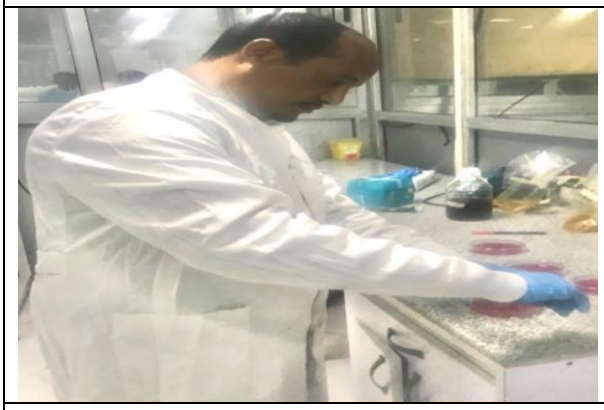
Appendix 4: Food Groups

- Cereals

- White Roots and Tubers
- Vegetables
- Meat and Meat Products
- Egg Products
- Legumes and Seeds
- Fish
- Fruits
- Milk Products
- Oils and Fats
- Sweets
- Spices and Condiments

Appendix 5: Microbial Growth Patterns on Selective Agar Media for Food Microbiological Analysis

		
a) Microbial growth patterns on plate count agar (PCA)	b) Total coliform growth on violet red bile agar (VRBA)	**c)** Staphylococcus aureus growth on Mannitol Salt Agar
		
d) Growth Characteristics of Staphylococcus aureus on Mannitol Salt Agar	**e)** Fungal Elements Observed on Rose Bengal Agar	**f)** Mold Growth on Rose Bengal Agar
		
g) Mixed Colonies Observed on Mannitol Salt Agar (MSA)		**h)** Microbial Growth on Violet Red Bile Lactose Agar Using Membrane Filtration Techniques

 	
i) Various Reagents Employed for Analysis of Food Microbiological Indicators, including VRBA Agar, BCG Broth, and E. coli Broth	
	
j) Analysis of Total Coliform Confirmation in Food Samples	**k)** Fecal Confirmation using EC Broth
	
l) Food Sample Analysis at the Food Microbiology Laboratory, Ethiopian Public Health Institute	**m)** Standardized Procedure for Water Sample Collection

Appendix 6: Questionnaires

Table 20: Questionnaire on Food Safety Knowledge, Attitudes, and Practices (KAP).

Part 1: General Information				
□□/ Code:	□/□□□/Subcity:_____	□/□□/School:____	Woreda:	□□/Date:_____
□.□. /No.	□□□□□/Questions			□□□□/Responses
1	□□□□ □□□□/□□□□ □□ □□ Name of staff/ handler			
2	□□/Gender	1. □□□/Male		
		2. □□ /Female		
3	□□□/Age	1. 18-24		
		2. 25-34		
		3. 35-44		
		4. 45-54		
		5. 55 and above		
4	□□□□□ □□□□□ □□□□□? /Have you ever attended school?	1. □□/Yes	2. □□□/No	
5	□□□□□□ □□□ □□□□/ Literacy	1. □□□□/ None		
		2. □□□□/ Read		
		3. □□□/ Write		
		4. □□□□□ □□□/ Read and Write		
6	□□□□ □□□/Marital Status		1	□□□□/Single
			2	□□□/Married
			3	□□□□ /Divorced
			4	□□ □□□□□/Widower
7	□□□□ □□□□□□ □□□□?/ What is the highest level of school you attended?		1	□□□□ □□□□□ □□□/No formal education
			2	□□□□ □□/□□□ □□□ □□□□/Can read and/orwrite

		3	□□□/Grade 1- 4
		4	□□□/Grade 5- 8
		5	□□□/Grade 9-10
		6	□□□/Grade11-12
		7	□□□□□ □□□□/Certificate
		8	□□□ □□ □□□□□□ /College andUniversity
8	□□□□ □□□□ □□□□□□□ □□/□□□ Years of service? How long have you been working as a food handler in food Preparation in SFP?	1	□□□□ □□□ □□□/Less than a year
		2	1 to 2
		3	2 to 3
		4	3 to 4
		5	4 to 5
		6	□ 5 □□□□ □□□ /More than 5 years

	Part 2. □□□□□ □□□□ **/Employees Work Satisfaction**	
	□□□□**/Responses 1.** □□ **/Yes 2.** □□ **/No 3.** □□□□□ **/Don't know**	
9	□□□ □□□ □□□□□□ □□□ □□□□□□□ □□ □□□□□?/When you have personal trouble, do you share with your colleagues?	
10	□□ □□ □□ □□□□ □□□ □□□□ □□□ □□ □□□ □□□□□?/Would you leave this work if you are offered Something better at another place?	
11	□□□ □□□ □□ □□?/Is the workload adequate?	
12	□□□ □□ □□□□□ □□□□ □□□□ □□□□□ □□□□□ □□□?/Is the kitchen staff respected by other workers of the institution?	
13	□□□ □□□ □□□□ □□□□□□ □□□□□□ □□□□ □□□□□ □□□□□ □□□□□?/Does the workplace provide all the necessary conditions to guarantee food safety?	
14	□□□□□□ □□□□ □□□□□□ □□□ □□□ □□□ □□?/Do the meals served	

	present health risks to the students?		
	Part 3. □□□□□ □□□ □□□□□ □□□ □□□□ □□□□□□ □□□□□□□ /**Food-Service Facilities at the Primary Schools**		
15	□□□ □□□ □□ □□□□□ □□□ □□□ □□□□ □□□□ □□□□ □□□ □□□□?/Do you have a separate room for raw food and ready-to-eat food storage?	1	□□/Yes
		2	□□/No
16	□□□□□□ □□ □□□ □□□□□□ □□□□ □□□□□ □□□□□ □□□□□□ □□□□?/Does your SFP designate food safety assurance personnel?	1	□□/Yes
		2	□□/No
17	□□□ □□□□□□ □□ □□? /Where is the food prepared? (Select one).		
	1. □□□□□ □□ □□/Designatedkitchen		
	2. □□□ /Classroom		
	3. □ □□ /Outbuilding		
	4. □□□ □□/ Outdoor		
	5. □□ /Other (pleasespecify)		
	□□□□/**Responses 1.** □□ **/Yes 2.** □□**/ No**		
18	□□□ □□□□□ □□ □□ □□?/Is there adequate space for cooking?		
19	□□□□□ □□□ □□□□ □□□□ □□□□ □□ □□?/Is there a water facility in your kitchen forfood preparation?		
20	□□□□□ □□□ □□□ □□□□ □□?/Is there a hand-washing facility in yourkitchen?		
21	□□□□ □□□ □□□□□/□□□□□□ □□ □□ □□?/Is there adequate space for serving/portioning cooked food?		
22	□□ □□□ □□□□□ □□ □□□□ □□□□□□ □□ □□□□□–□□□□□□ □□□□□□ □□□□□ □□□□□ □□□?/Are there enough cleaning tools to clean the kitchen e.g., broom, mop, cloths, sponge, etc?		
	Part 4. □□□□□ □□□ □□□□□□ □□ □□□□□ □□□□□ □□□□ □□□□□□□		

	/Training Information for SFP Food Handlers	
23	□□ □□□ □□□□□□ □□□ □□□□□□ □□□□ □□□□ □□□□? Have you ever attended any food safety training course so far?	
24	□□ □□□□ □□□ □□? Your answer for Q.501 is Yes, How manytimes participating in training since startedthis job?.	
	1. □□□□□□ □□□ □□ /Once a semester 2. □□□□□□ □□□ □□/ Twice a semester 3. □□□□□□ 3 □□/ Three times a semester 4. □□□□□□ 4 □□/ Four times a semester 5. □□□ /None	
25	□□□□□□ □□□□ □□ □□□□ □□□□ □□□□? Have you received training regarding the following?	
	1. □□□ □□□□ □□□□□/Personal hygiene	
	2. □□□□ □□□ □□□□□□□/ Chemical storage	
	3. □□□ □□□□ /Purchasing procedures	
	4. □□□□ □□□□□/Pest control	
	5. □□□□□□ □□□□ □□□□ □□□□□/Equipment cleaning procedures	
	6. □□□□ □□ □□/□□□□ □□□ □□□□/Kitchen operation procedures	
	7. □□□□ □□□□□□/ Food preparation	

	Part 5. □□□□ □□□□ □□□□□□ □□□□/ **Food Safety Knowledge**	
	□□□□□**/Questions** **1.** □□□□/ **Correct 2.** □□□□ □□□□□/ **Incorrect 3.** □□□□□/ **Don't know**	
1	□□□□ □□□ □□□ □□□□ □□□□ □□□□□ □□ □□□ □□□ □□□□ □□□□ □□□□-□□□ □□□□□ □□□□ □□□□□□ □□□ □□□ □□□□/ Food handlers who are sick due to foodborne diseases and	

	have bad personal hygiene can be a risk for food outbreak	
2	□□□ □□□ □□□□ □□□□ □□□□□□ □□□ □□□□□/Keeping kitchen surfaces clean reduces the risk of illness.	
3	□□□□□ □□□□ □□□ □□□□□□□ □□□□□ □□□□/Wiping cloths can spread microorganisms	
4	□□□□ □□□□ □□□□□ □□□ □□□ □□□ □□□ □□□□□/Cooked foods should be kept very hot beforeserving	
5	□□□□□ □□□ □□□□□ □□□□□□ □□□ □□□□ □□□□□□□□ □□□□ □□□□□ □□□□□□ □□□□/ Failure reheating thoroughly could be a risk of food contamination	
6	□□□□□□ □□□ □□ □□□□□□ □□□□□ □□□□□□□ □□□ □□□□ □□ □□□□ □□□□□/Fruits and vegetables should be washed using clean water before eaten	
7	□□ □□ □□□□ □□□□□ □□□□ □□□□ □□□□□□ □□□□ /Keeping raw and cooked foods separate helps to prevent illness	
8	□□□ □□□□ □□□□□ □□□□□□□ □□□ □□□□ (□□□□□□ □□□ □□) □□□ □□□ □□□ □□□□□ □□□□ □□□ □□□□/ A healthy food handler can be a carrier of infectious bacteria that can cause food- borne diseases	
9	□□□ □□□□□□□ □□ □□ □□□□ □□□□□ □□□ □□□□□ □□ /It is important to throw away foods that havereached their expiry date	
10	□□□□□ □□□□ □□□□ □□□ □□ □□□□□/□□□ □□ □□□□□ □□□□ □□□□ □□□□ □□□□ □□□ □□□□/ If raw foods are contacted with prepared foods or stored together, food contamination could occur	
11	□□□□ □□□□□ □□□□□ □□□□ □□□□□ □□□□ □□□□ □□□□□/Contamination of foodstuffs cannot be detectedusing sense organs.	

12	□□□□□□□ □□ □□□ □□□□□ □□□□□ □□□ □□□□ □□□□ □□□ □□□□□ □□□□ □□□□/Use of the same knife to cut vegetables and meat exposed to food-borne diseases.	
13	□□□□□ □□□□ □□□□ □□□□□□ □□ □□□□□□□□ □□□□□/Contaminated foodstuffs always change their content quality and safety.	
14	□□□□ □□□ □□□□□ □□□□□ □□□□ □□□□ □□□□□ □□□□□□ □□□□/Regularly cleaning food contact surfaces can help prevent food contamination.	
15	□□□□ □□□□ □□□□□ □□□ □□□ □□□□ □□□□ □□□□ □□□□ □□□□□ □□□□□ /Handwashing with clean water and soap before food preparation can reduce food contamination	
16	□□□□ □□□□ □□□□□ □□□□□ □□□□□ □□□□ □□□□ □□□□ □□□□□ □□□□□/ Washing and sanitizing equipment and utensils reduce food contamination	
17	□□□□□□ □□□□□□□□ □□□□□□ □□□□□ □□□□ □□□□□ □□□□□ □□□□□ □□□□□/ Cleaning food preparing equipment and dinning dishes keep food safety	
18	□□□ □□□□□□□ □□ □□□□ □□□□□□□ □□□□ □□□ □□□□□ □□□□ □□□□ □□□ □□□□ □□□□ □□□□□ □□□□□□ □□□□/ Eating or drinking during preparing food or around clean food serving equipment could increase the risk of food contamination	
19	□□□□□ □□□□□ □□□ □□□□ □□□□□ □□□ □□□□□/ Food prepared in advance reduces the risk of foodcontamination	
20	□□□□ □□□ □□□□□□ □□□□ □□□ □□ □□□□□□ □□□ □□□□□ □□□□ □□□□ □□□ □□□□□□□ / Children, healthy adults, pregnant women, and older individuals all face a similar risk of food poisoning.	
21	□□□□□ □□□□ □□□□ □□□□□ □□□□/ Typhoid can be	

	transmitted by contaminated food	
22	□□□□□ □□□ □□□□ □□□□□□□ □□□□ / Contaminated food can transmit diarrhea.	
23	□□□ □□□ □□□□□□□ □□□□□, □□□□□ □□ □□□ □□□ □□□□□□ □□□□□. /Healthy food handlers have microbes on their skin, in their noses, and in their mouths.	
24	□□□□ □□□□ □□□□□□ □□□□□ □□□ □□□ □□□□ □□□ □□□□□□ □□□□ □□□ □□□□ □□□□□□ □□□ □□ □□□□ □□ □□ □□□ □□□□□ □□/Cross contamination occurs when microorganisms from contaminated food are transferred to another food by the hands or kitchen utensils of the foodhandler.	
25	□□□□ □□□□ □□□ □□□ □□□□□□ □□□□□□ □□□□ □□□□□□□ □□□□□□/Freezing eliminates all bacteria that can cause foodborne illness.	
26	□□□□□ □□□□ □□□□ □□ □□□, □□ □□□ □□□ □□□□□ □□□□/Contaminated foods often exhibit changes in color, odor, or taste.	
27	□□□ □□□□□□ □□ □□□ □□□□ □□□□ □□□□□ □□/ It is important to take time off work during a skin infection.	
28	□□□ □□□□□□ □□□ □□□ □□□□ □□□□□ □□ □□□ □□□□/ Having health examination for food handlers is important	
29	□□□ □□□□□□ □□ □□□ □□□□ □□ □□□ □□□ □□□□ □□□□ □□□□ □□□□□ □□□□□□ /Wearing jewelry like rings and watches while handling food can lead to food contamination.	

	Part 6. □□□□ □□□□ □□□□□□ □□□□□□/□□□□/**Food safety attitude**	
	□□□□ **Answers** 1. □□□□□□/ Agree 2. □□□□□□ /Disagree 3. □□□□□/ Don't know	
1	□□ □□□ □□□□ □□□□□ □□□□□□ □□□ □□□ □□□□ □□□□ □□□□ □□□□ □□□□ □□□□□/Washing hands before handling raw or	

	cooked foods lowers the risk of food poisoning.	
2	□□ □□□□□□ □□ □□□□ □□□□□□ □□□□□ □□□ □□ □□□□ □□□□□□/ Raw vegetables and meat should not be cut on the same cutting board.	
3	□□□□ □□□□□ □□□□□ □□□ □□ □□□ □□□ □□□□ □□□□ □□□□□ □□□□ □□□□ □□□□□/Wearing caps, masks, protective gloves, and appropriate clothing helps reduce the risk of food poisoning.	
4	□□□□ □□□ □□□□□ □□□□ □□ □□□ □□□ □□□□ □□□□ □□□□ □□□□ □□□□□ □□□□ □□□□□ □□□ □□□□□/Food handlers who are ill from foodborne diseases and have poor personal hygiene can pose a risk for food outbreaks.	
5	□□□□□ □□ □□□□ □□□□ □□□□□ □□□□ □□ □□□□□ □□□ □□□ □□ □□□□□, □□□□ □□□□ □□□□ /If raw foods come into contact with prepared foods or are stored together, contamination may occur.	
6	□□□□□□□ □□ □□□□□□□ □□ □□□ □□□□ □□□□ □□□□□ □□□□□□ /Covering the mouth while coughing and sneezing helps prevent food contamination.	
7	□□□□ □□□□□□ □□□ □□□□ □□□□ □□□□□ □□□□□ □□□ □□ /I am open to changing my food handling practices when I recognize that they are incorrect.	
8	□□□ □□□□□□□ □□□□□□ □□□□□ □□□ □□□ □□□ □□□□□ □□□□ □□□□□/Food handlers should wash their hands after touching any part of their body.	
9	□□ □□□ □□□□ □□□□□ □□□□ □□□ □□□□□□ □□□□□□ □□□□/Good hand hygiene can help prevent foodborne illnesses.	
10	□□□ □□ □□□ □□□□ □□□□□ □□□□ □□□□ □□□□□ □□□□ □□□□/Long and painted fingernails can contaminate food with pathogens.	
11	□□□□□ □□□□□ □□□ □□□□ □□□□ □□□ □□□□□ □□/Safe food handling is a key responsibility of my job.	
12	□□□□ □□□□□□ □□□ □□□ □□□□□□ □□□□□ □□□ /Health examinations for food handlers are essential.	

13	□□□□ □□□ □□□□□□ □□□□□□ □□□ □□□□□ □□□□ □□□□□ □□/ Maintaining personal hygiene is essential for controlling foodborne diseases.	
14	□□□ □□□□□□□ □□□ □□□ □□□□ □□□□□ □□□ □□□ □□□ □□□□ □□□□□ □□ □□□□ □□□□□□ □□□□□/Failing to wash hands before food preparation can increase the risk of abdominal diseases or diarrhea for you and other consumers.	
15	□□□ □□□□ □□□□/ □□□□□□□ □□□ □□□□ □□ □□□□ □□□□□□/ I require training in safe food preparation.	
16	Beards could contaminate food with food-bornepathogens	
17	□□□ □□□ □□□□□ □□□□ □□□ □□□□□□ □□□□□□ □□□□ □□□□ □□□□□□□□ □□□ □□□□/A healthy food handler can carry infectious bacteria that may lead to foodborne diseases.	
18	□□□ □□□□ □□□□ □□□□ □□□□ □□□ □□□ □□□□/Dish towels can be a source of food contamination.	
19	□□□□□□ □□□□□□□ □□ □□□□ □□□□□ □□□□□ □□□□□ □□□ □□□□□ □□□□□□□/I use different clean cloths to wipe dining tables and food utensils.	
20	□□□□ □□□□□ □□□□□□ □□□ □□ □□□□□ □□□□□ □□□□ □□□□ □□□□□/Knives and cutting boards should be thoroughly sanitized to prevent cross-contamination.	
21	□□ □□□ □□□□ □□□□□ □□□□ □□□ □□□□ □□□□□□ □□□□ □□ □□□□□/I believe that good personal hygiene can help prevent foodborne illness.	
22	□□□□□ □□ □□□□□ □□□ □□□□□ □□□ □□□□□□ □□□ □□□□□ □□□□ □□□ □□□□□□/ Food handlers with cuts or abrasions on their hands should not handle food without wearing gloves.	

	Part 7. □□□□ □□□□□ □□□□/ **Food Safety Practices**
	Please select (x) one of the four practice answers for each of the statements below:

	1. □□□□**/Always 2.** □□ □□/**Most of the time 3.** □□□ □□□/**Sometimes 4.** □□□**/Never**	
	□□□□ □□□□□□ □□ □□? **Hand washing times**	
1	□□□□ □□□□ □□□ □□□□ □□ □□□□□ □□ □□□□□/ When transitioning between different activities.	
2	□□□□ □□□□ □□ □□□□□ □□□/ Before starting food preparation	
3	□□□□ □□□ □□□ □□□□□ □□□□□ □□□□□□ □□□/Before handling food or clean cooking utensils.	
4	□□□□□□ □□□□□□ □□□ □□□□□ □□□□□□ □□□ □□□□□ □□□ □□□/After coughing, sneezing, or touching your mouth, nose, or hair.	
5	□□□□ □□ □□□□□/ After using toilet	
6	□□□□ □□□□ □□□□□ □□□□□ □□□□□□ □□□ □□□□□ □□□□ □□□/After touching acne fluid, as well as your mouth, nose, or hair.	
7	□□□ □□□□□ (□□□ □□□□ □□□ □□□ □□□ □□□□ □□□□□ □□□□□) □□□ □□□/After touching personal items (such as clothes, wallets, or beauty creams).	
8	□□□ □□□□□ □□ □□□□□ □□□/ After collecting and removing waste	
9	□□□□ □□□□ □□□□ / □□□□ □□□ □□□ □□□/□□□□□□ □□□□□ □□□/After using a mobile phone, switches, or door handles/windows.	
10	□□□□ □□□□□ □□□□□□□ □□□ □□□□ □□□□ □□□□ □□□□ □□□□?/Do you clean the food storage area thoroughly before adding new products?	
11	□□□□□ □□□ □□□□ □□□□□ □□□□ / Use the oldest food products first (first in, first out).	
12	□□□□□ □□□□□ □□□ □□□ □□□ □□ □□□□□/Use a single towel to dry your hands.	

	Part 8. □□□□ □□□□ □□ □□□□□□ □□□□/ **Food Hygiene and Safety Practices**	
	□□□□□ **/Questions**	
13	□□□□ □□□□□ □□ □□□□□?/What do you use to wash your hands?	1. □□□□ □□/Cold-water
		2. □□ □□/Warm/hot water
		3. □□ □□ □□□/Water and soap
		4. □□□ □□□ □□ □□□ □□□ □□□/Water, soap, and hand sanitizing liquid
14	□□□□ □□□□ □□□ □□□□ □□□□ □□□□?/ How do you dry your hands after washing them?	1. □□□ □□□□/With tissue paper
		2. □□□□ □□□/With a dry cloth
		3. □□□□□□/ On whatever I am wearing.
15	□□□□ □□□ □□□ □□□□ □□ □□□□□□ □□□□□?/What actions do you take when you have a cold or illness?	1. □□□□□/Do not work
		2. □□□□ □□□□/Wear a mask
		3. □□□□□□□□ □□□□□□ □□□□/Continue working as normal
16	□□□ (□□□□, □□□□) □□□□ □□ □□□□□□□ □□□□□?/What steps do you take when you have a wound (e.g., a cut)?	1. □□□□ □□ □□□□□□ □□□□/Wash it and continue working
		2. □□□ □ □□□ □□ □□□□ □□□□/Get it cleaned, covered, and continue working
		3. □□□ □□□□ □□ □□□□□□ □□□□/Wear gloves and continue working
		4. □□□□ □□□□/Nothing, just continue working
		5. □□□□ □□□/Stop working
	1. □□□□ **/Always 2.** □□ □□ **/Most of the time 3.** □□□ □□□ **/Sometimes 4.** □□□□□ □□ **/Rarely 5.** □□□□ **/Never**	
17	□□□□□□ □□□ □□□ □□□ □□□□ □□□□ □□□?□□□□ □□□□□/Do you	

	wash your hands after rubbing your nose or scratching your body?	
18	□□□□□ □□□□□□ □□□ □□ □□□□□ □□□ □□□□?/Do you handle food if you have a cut on your finger that is not properly covered?	
19	□□□ □□□□□□□□ □□ □□□□□□ □□□□□ □□□ □□□□ □□□□□?/Do you eat, drink, or chew gum while preparing food?	
20	□□□ □□ □□□□ □□□ □□□□ □□ □□ □□□□□ □□□ □□□□□?/Do you use separate utensils and cutting boards for raw and cooked food?	

	□□□□ □□□□□ □□□□□ □□□□□□ □□ □□□□□ □□ □□□ □□ □□□□□□ **/Food Safety Knowledge, Attitudes, and Practices (KAP) and Kitchen Observations**		
	Part 9. □□□□□ □□ □□□□□□□ □□□ □□□□/**Premises and Equipment Inspection Checklist**		
	□□□□□/Questions	□□/Yes	□□□□□/No
	□□□□**/Hygiene**		
	□□□ □□□ □□ □□□□□ □□□ □□□ □□□ □□ □□□ □□□□ □□□ □□□□□ /All kitchen staff wore clean and appropriate uniforms, including shoes		
	□□□ □□□ □□ □□□□□ □□□□ □□□□ □□□□□□□□ □□□□□ □□□□□/All kitchen staff wore effective hair restraints properly.		
	□□□ □□□ □□ □□□□□ □□□□□□□ □□□□ □□□□ □□□□□ □□ □□□ □□ □□□ □□□ □□□□□□□□ /All		

	kitchen staff kept their fingernails short, clean, unpolished, and free of artificial nails.		
	□□□ □□□ □□ □□□□□ □□□□ □□□□□ □□□□□□, □□□□ □□□□ □□□□□/All kitchen staff refrained from wearing jewelry, except for wedding ring.		
	□□□ □□□ □□ □□□□□ □□□□□□ □□□□□□□□□□□□ □□ □□□□□ □□ □□□□ □□□/All kitchen staff washed their hands properly, frequently, and at the appropriate times.		
	□□□□ □□ □□□□□ □□□□□□□□ □□□□□□□ □□□ □□□□□□□ □□□ □□□□□□ □□□ □□□□ □□□□□ □□□□ □□□ □□ □□□□ □□□□□ □□□□□ □□□□ /Kitchen workers used disposable tissues when coughing, sneezing, or touching their nose or hair, and then immediately washed their hands		
	□□□ □□ □□□□□ □□□□□□□□□ □□□ □□□□□□□ □□ □□□□□□ □□□□□□□ □□□□□/Kitchen workers cover their mouth and nose when sneezing or coughing.		
	□□□ □□ □□□□□ □□□□□ □□□ □□□□□ □□□ □□□□□ □□□□□ □□□□□. /Kitchen workers wash their hands immediately after coughing or sneezing.		
	□□□ □□□□ □□□□□ □□□□ □□□□/A handwashing reminder sign is displayed.		
	□□□□□□ □□□□ □□□ □□□ □□ □□□□ □□□/Employee restrooms are clean and operational.		
	□□□□□□ □□□□□□ □□□ □□□□□ □□□□□ □□ □□□ □□□□□ □□□□ □□□ □□□□/Reminder signs, handwashing stations, and soap were available in the restrooms.		
	□□□□□ □□□□ □□□ □□ □□□ □□□□□□□□ □□□□□ □□□ □□□□□□□ □□□/There were proper handwashing facilities for students to use before and after eating.		

	□□□□ □□□□ /**Food Preparation**		
	□□□□ □□□□□ □□□ □□□□ □□ □□□ □□ □□□□ □□□□□ □□ □□□ □□□□□/All utensils and kitchen materials contaminated with food were washed properly and in a timely manner.		
	□□□□ □□□ □□ □□□□□ □□□□□ □□□□□/Washed kitchen materials were dried with towels.		
	□□□ □□□□□□ □□□□□□ □□ □□ □□□□ □□ □□□□ □□□□ □□□□□ □□□□□□ □□□□□ □□□ □□□□□□□ /Food items like onions, condiments, and raw foods were stored in conditions that prevent contamination.		
	□□□□ □□□□□□ □□□ □□□□□ □□□ □□ □□/The food preparation procedure is free from the risk of cross-contamination.		
	□□□ □□ □□□□□ □□□□□ □□□□□□/ Kitchen workers understand cross-contamination.		
	□□□□ □□□□ □□ □□□ □□□□/**Food storage and dry storage**		
	□□□ □□□□ □□□□ □□ □□□□□□ □□□□ □□ □□ □□ □□□□□□□□ □□ □□□□□□□/All food items and supplies were stored on shelves elevated off the ground.		
	□□□□ □□□□ □□□ □□□□ □□□□□ □□□□□/The food storage room safeguards food from contamination.		
	□□□ □□□□ □□□□□ □□□ □□□/All food surfaces were clean.		
	□□□ □□□□ □□□ □□□□ □□□□□ □□□□□ □□ □□□□ □□□□□□ □□□□□ □□ □□□□ □□□□ □□□□ □□ □□□□□□ □□□□□ □□□□□□□/Items such as soap, liquid soap, chemical sanitizers, and pest control chemicals were stored separately from food items and supplies.		
	□□□□ □□□□ □□□□□ □□□□ □□□□ □□□ □□□ □□□/There was a regular cleaning schedule for all food surfaces.		

	□□□□□ □□ □□□□□□ □□□□□ □□□□/**Cleaning and Sanitizing Cooking and Dining Utensils**		
	□□□□□ □□□□□ □□□ □□□□□ □□□□ □□□□□ □□□ □□□□ □□□ □□□/There was a well-organized sink designated for washing utensils.		
	□□□□ □□□□□□ □□□□□□□ □□□□□ □□□ □□□□ □□□□ □□□□□ □□□□□ □□□□□/Oils and other lipids used for roasting food were disposed of through waste disposal lines.		
	□□□□ □□□□ □□ □□□□ □□□□□, □□□□ □□ □□□□ □□□□□/Small equipment and utensils are washed, sanitized, and air-dried.		
	□□□□□ □□□□□ □□ □□□□□ □□□ □□□ □□□□ □□□□□□ □□ □□□□ □□□□ □□ □□□□□□ □□□□ □□□□/All small equipment and utensils, including cutting boards and knives, are cleaned and sanitized between uses.		
	□□□□□□□ □□□□□ □□□ □□□ □□□□ □□□□ □□ □□□□/Work surfaces are cleaned and sanitized after each use		
	□□□□□□ □□ □□□□□□□□ □□□ □□□/Drawers and racks are clean.		
	□□□□ □□□□□□ □□ □□□/**Garbage Storage and Disposal**		
	□□□□ □□□ □□□□ □□ □□□□□ □□□□ □□ □□□□□ □□ □□□□ □□□ □□□□ □□□ /Garbage cans and the surrounding area were clean, odor-free, and located far from the kitchen.		
	□□□□ □□□ □□ □□□□ □□□□□□□□ □□ □□□□□ □□□□□□□ □□□□□/Garbage boxes and containers around the kitchen were removed regularly.		
	□□□□ □□□□□□/**Pest Control**		
	□□□□ □□□□□ □□□ □□ □□□□□ □□ □□□□ □□ □□□ □□□ □□□□□ □□□□□□□ /The kitchen rooms, doors, and		

	windows allow ample light to enter the kitchen.		
	□□□ □□□ □□ □□□□ □□ □□□ □□□□□□ □□□□□□ □□□ □□ □□□□□ □□□□ □□□/The doors and windows were sturdy enough to prevent pests, such as mice, from entering the kitchen.		
	□□□□□ □□□□ □□□□ □□ □□□ □□□□ □□□□□ □□□□□ □□□□□□□□/ Cockroaches were observed moving around the food storage and cooking materials.		
	□□□ □□□ □□ □□□□□, □□□□, □□□□□□ □□ □□□□□, □□ □□□□□ □□ □□□□□ □□□ □□□/All kitchen materials, including floors, walls, and ceilings, were smooth, did not retain water, and were easy to clean.		

Appendix 7: □□□ □□□□ □□ □□□□□□□ □□□□□□ □□ □□□ □□□□□ □□□□/

Key Informant Interviews (KII) for SFP Assessment

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School Directors, Ministry of Education Representatives, Sub-City Experts, and Experts from School Feeding Agencies:

- □□□□□□ □□□ □□ □□□□□□□□ □□□□ □□□□□□□□ □□□□□□ □□ □□□ □□□ □□□ □□□□ □□□ □□□□ □□□□□□□? How would you describe the perceived benefits of the School Feeding Program as reported by members of your school and community?
- □□□□□ □□□□□ □□□□□□ □□ □□□ □□□□□ □□□□□□ □□□□ □□□□□□ □□ □□□□□□ □□□□□ □□□ □□□□ □□□□ □□ □□□□□□ □□□□ □□□□□□□? /From your observations, how would you evaluate the impact and effectiveness of the School Feeding Program in enhancing education and well-being among students?
- □□□□□□ □□ □□□ □□□ □□□ □□□□ □□ □□□□□□ □□□□□□ □□□□□ □□ □□□□□ □□□□□ □□/□□□ □□ □□□□ □□□□□ □□□□□□□□ □□? /What specific actions are being taken at your school to address the challenges identified in the implementation of the School Feeding Program and to enhance its benefits?
- □□□□□□□ □□□ □□ □□□□□ □□□□□□ □□□□□□ □□□ □□ □□□□□ □□□□ □□ □□□□ □□□□□□? /How do you collaborate with schools and stakeholders to ensure the program's success and sustainability?
- □□□□□□□ □□□□ □□□□□ □□ □□□□ □□□ □□□□□□□□□ □□□ □□□□□□ □□□□□ □□□□ □□ □□□□ □□□□□ □□ □□□□ □□□□? /What recommendations do you have for improving stakeholder engagement and collaboration, including with NGOs and local contributors?
- □□□□□ □□□□□□□ □□□□□□ □□ □□□ □□□□□ □□ □□□□□ □□□□□ □□ □□□□□□□ □□□□□ □□ □□ □□□□□□ □□□□□□□□? /In your opinion,

what benefits do you see for students participating in the School Feeding Program, and what challenges do they encounter?

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- □□□□□□ □□□□□□ □□ □□□ □□□□□□ □□ □□□□ □□□□□□□ □□□ □□□□□ □□□□□□ □□? /Are there any logistical or operational challenges encountered in implementing the program at the school level?
- □□□□□□□ □□□□□ □□□□□ □□□□ □□□□ □□□□ □□□ □□□□? /How do you think the program could be improved to enhance its effectiveness?
- □□□□□□ □□ □□□□□ □□□□□□ □□ □□□□□ □□□□□ □□□ □□ □□□□□ □□□ □□ □□□□□□ □□□□□□□ □□ □□□□□ □□□□ □□□□ □□□□? /What challenges do school staff encounter in managing their workload related to the program, and how can these be addressed?
- □□□□□□ □□□□ □□□□□ □□□ □□□□□ □□ □□□□ □□□□? /What recommendations do you have for improving the quality of meals provided by the program?

□□□□□□ □□□ □□ □□ □□□□□/**Adolecent Students:**

1. □□□□□□ □□ □□□ □□□ □□□ □□□□□□ □□□□□ □□ □□ □□□□ □□□□□? /How has the School Feeding Program impacted your performance at school?
2. □□□ □□□ □□□□□□ □□ □□□□□□□ □□□□□□□ □□ □□□□□□□ □□□□ □□□□□ □□ □□□□□ □□□ □□ □□□□ □□□□□□□□? /What benefits do you receive as a student from the program, and what challenges do you encounter in accessing and consuming the meals provided?
3. □□□□□ □□□□□□□ □□□□□ □□□□□ □□□□□□□ □□ □□□□□□ □□□□□□ □□ □□ □□□□ □□□□□? /In your opinion, has the program positively impacted your health, nutrition, and overall well-being?

4. □□□□□□□ □□□□ □□□ □□□□□ □□ □□□□□ □□□□□ □□□□□□ □□□□□ □□□□ □□□□□? /How would you recommend improving the program to better meet your needs and enhance its benefits?

□□□□□ □□ □□□□/**For Focus Group Discussions (FGD) with Parents:**

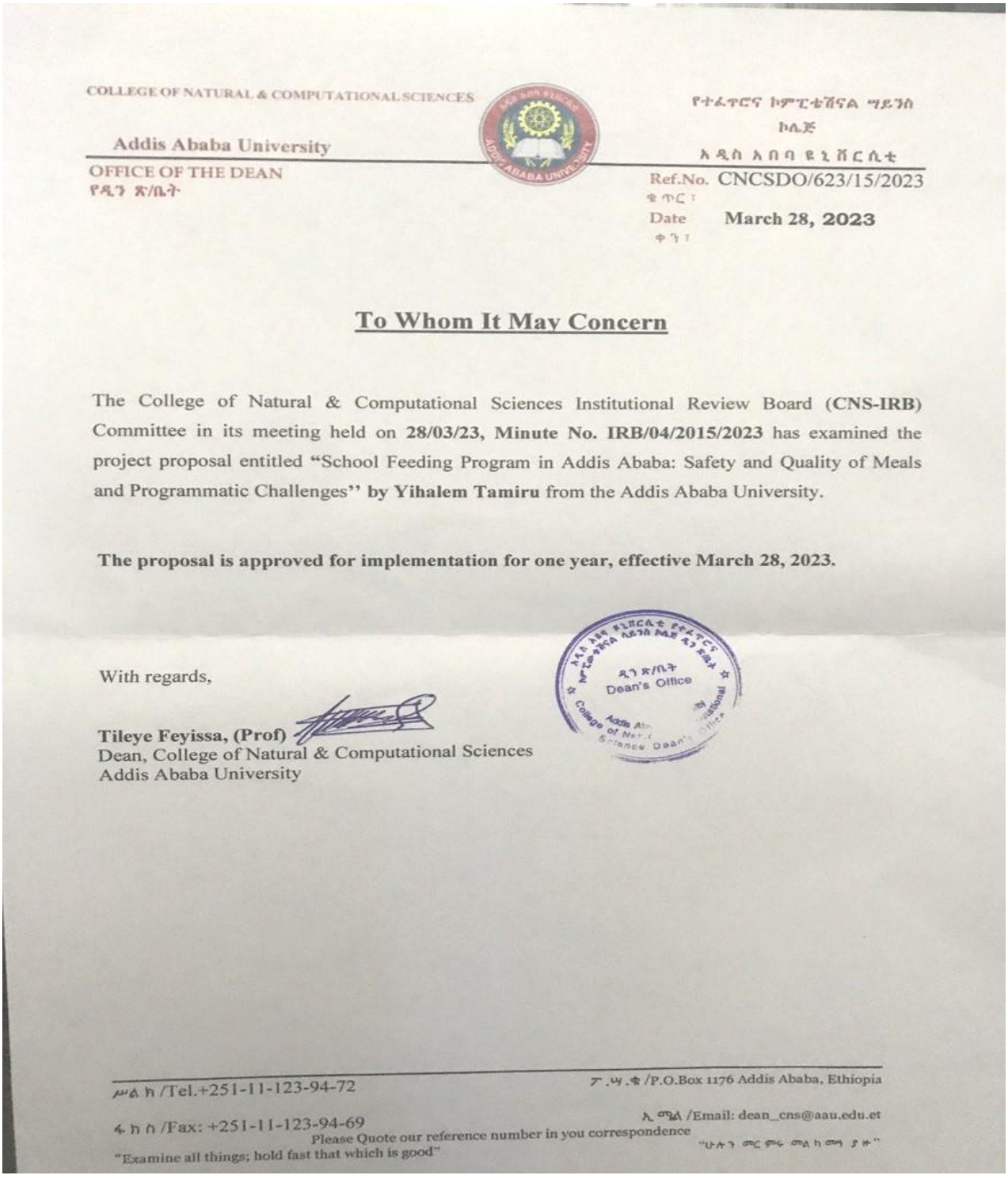
5. □□□□□□ □□ □□□ □□□□□ □□□□ □□□□□□ □□□□□ □□ □□□□□ □□□□□□ □□□□ □□ □□ □□□□ □□□□□? /How has the School Feeding Program influenced your child's education, well-being, and family economic issues?
6. □□□□□□ □□□□□□ □□□ □□□□ □□□□□□ □□□□ □□ □□ □□□□ □□□□□□□? /What challenges, if any, do you face with the implementation of the program or the meals provided to your child?
7. □□□□□□ □□□□□□□ □□ □□□ □□□□ □□□ □□□□□□ □□□□ □□ □□□□□ □□□□ □□ □□□ □□□□ □□□□□ □□□□□ □□□□□□□? /Have you observed any positive changes in your child's health, academic performance, and overall development since the program began?
8. □□□□□□ □□ □□□□□□□□ □□□ □□□□□ □□□□□ □□□□□ □□□ □□□□□□□ □□□□□□ □□□□ □□□□ □□□□? /How can the program be improved to address the concerns and preferences of parents and guardians, while ensuring its continued benefits?

Appendix 8: Sampling Frame Listing Table

Table: Sampling Frame Listing

Sub city/Kifle Ketema:				No. of Meal Providers/food handlers: _____	
Name of school:				Contact (Mob):	
School Director:					
Grade of student (___): ___ Section:					
Contact (Mob):					
Contact (Email):					
No.	Name of targeted student		Sex	No.	
	Student's name	Father Name	M|F		Name of food handlers
1				1	
2				2	
3				3	
4				4	
5				5	
6				6	
7				7	
8				8	
9				9	
10				10	
11				11	
12				12	
13				13	
14				14	

Appendix 9: Ethical Clearance from Addis Ababa University's Institutional Review Board



COLLEGE OF NATURAL & COMPUTATIONAL SCIENCES

Addis Ababa University

OFFICE OF THE DEAN
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Ref.No. CNCSDO/623/15/2023
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Date March 28, 2023
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To Whom It May Concern

The College of Natural & Computational Sciences Institutional Review Board (**CNS-IRB**) Committee in its meeting held on **28/03/23, Minute No. IRB/04/2015/2023** has examined the project proposal entitled **"**School Feeding Program in Addis Ababa: Safety and Quality of Meals and Programmatic Challenges**''** **by Yihalem Tamiru** from the Addis Ababa University.

The proposal is approved for implementation for one year, effective March 28, 2023.

With regards,

Tileye Feyissa, (Prof)
Dean, College of Natural & Computational Sciences
Addis Ababa University

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Please Quote our reference number in you correspondence

"Examine all things; hold fast that which is good"

"ሁሉን መር ምሩ መል ከ መጣ ያ ዙ"