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Studies on the Bacteria in the Oral Cavities of In-patient Malnourished Children at Specialist Hospital, Sokoto, Nigeria

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ABSTRACT

The study highlights the importance of food security in preventing malnutrition, particularly in fragile nations and regions affected by conflicts, wars, and periodic floods. Improving food security and access to proper nutrition can have a significant impact on reducing malnutrition in children. Addressing malnutrition is crucial for improving overall health and preventing the associated short-term and long-term adverse effects. Proper oral hygiene, including regular brushing and flossing, is essential for maintaining a healthy oral microbiota. Inadequate oral hygiene can lead to dental and gum diseases, which can exacerbate malnutrition and affect overall health. It is essential to study the oral microbiome and its role in malnutrition since malnutrition can lead to severe illnesses and even death in children. The study acknowledges that malnutrition is a multifaceted problem influenced by various factors, including infections and antibiotic use that can alter the intestines' microbiota composition and affect nutrient absorption. The study aims to understand the oral microbial profiles of malnourished children in the area and their potential impact on health. Malnutrition is a significant public health issue in Nigeria, particularly in the northern region, and this research could provide insights into the association between oral health and malnutrition in children.

Keywords: Malnutrition in children, Oral health, Oral hygiene

INTRODUCTION

Dietary deficiencies cause malnutrition. Wealthy nations have obesity, whereas Africa, Asia, and the Americas have under-nutrition (World Health Organisation, 2021). The WHO defines malnutrition as an energy or nutrient shortfall, excess, or imbalance (2022). Early growth requires a robust immune system and sustenance. South and Central Asia and sub-Saharan Africa are plagued by child malnutrition [1]. Nutrient deficiency, overabundance, or inefficiency can cause malnutrition. Malnutrition kills kids worldwide. 60% of the 10.9 million under-5 fatalities occur in the first year (WHO, 2021). Malnutrition or Failure To Thrive (FTT) is a clinical disorder in which a new born or child falls out of the main growth pattern and is regularly under the 3%

curve for height and weight or more than 2 standard deviations below mean height and weight [2]. Nearly 100 million under-5s have Protein-Energy Malnutrition (PEM) or Failure to Thrive (FTT) [3]. Childhood malnutrition causes delayed growth, small height, mental development difficulties, recurring infections, and treatment resistance. 11% of Iranian children are severely underweight, and 15% are moderately underweight, according to UNICEF [4].

Underweight, wasting, and stunted development characterise childhood under-nutrition [5]. A recent food shortage or weight-loss infection like diarrhoea causes wasted (low weight-for-height) malnutrition. Waste and hunger, MUAC of 115 mm, significant wasting, and nutritional oedema indicate severe acute malnutrition [6]. Malnutrition is 50% worsened by undernourishment, obesity, and diet-related NCDs. Malnutrition causes wasting, stunting, and being underweight and nutritional deficits. Wasting and stunting Wasted is acute malnutrition induced by a lack of food or an illness such as diarrhoea that causes weight loss (low height for age). Weight-for-height -3Z scores of the median WHO growth standard, MUAC of 115 mm, severe wasting, and nutritional oedema indicate severe acute malnutrition [7]. Height-related leanness defines waste. Fast weight loss may prolong it. This syndrome occurs when a patient hasn't eaten or been ill for a long time. Untreated child waste kills. Stunted growth, Poor baby and childhood feeding and care create these issues. Chronic micronutrient deficiencies are connected to poverty, pregnancy issues, recurrent illness, and food insecurity. Tooth cavities serve as evidence that the oral microbiome, which consists primarily of immune-resistant bacteria, can be advantageous to the host. Mouth bacteria thrive. It provides water, nutrients, and temperate temperatures [8]. Mouth bacteria adhere to teeth and gums to escape mechanical flushing to the stomach, where hydrochloric acid kills acid-sensitive microbes [9].

Actinomyces, Arachnia, Bacteroides, Bifidobacterium, Eubacterium, Fusobacterium, Lactobacillus, Leptotrichia, Peptostreptococcus, Propionibacterium, Selenomonas, Treponema, and *Veillonella* are anaerobic oral bacteria. Oral fungi include *Candida*, *Cladosporium*, *Aspergillus*, *Fusarium*, *Glomus*, *Alternaria*, *Penicillium*, and *Cryptococcus* [10]. *Streptococcus salivarius* quickly colonises a newborn's mouth. First-year teeth and gingiva are colonized by *Streptococcus mutans* and *S. sanguinis*. Other streptococci attach to gums and cheeks but not teeth. Anaerobic microbes live in gingival crevices. Bacteroides and spirochetes colonise the mouth around puberty. This study analyses oral bacteria in malnourished children.

The immune system controls oral microorganisms and tissue infections. Dental plaque bacteria and the host's immune system keep plaque in the mouth after other biofilms are washed away. Saliva eliminates sugar-fermented bacterial biofilm but not dental plaque. Uncontrolled oral bacteria promote tooth decay and periodontal disease. Studies have linked inadequate dental hygiene to dangerous bacterial infections. Maintaining several oral health variables prevents oral microbiota development and diseases. Dental plaque contains salivary polymers, extracellular products, and bacteria (mostly *S. mutans* and *S. sanguis*). Plaque is tooth biofilm. Bacterial metabolites from microorganism accumulation cause dental disease. Plaque can become tartar and cause gingivitis or periodontal disease if not cleaned. Proteins involved in *Streptococcus mutans* colonisation of teeth can produce antibodies that suppress cariogenic processes, which can be used to make vaccines. Bacterial vaginosis patients have oral microbiota bacteria. Mouth fungi include *Candida, Cladosporium, Aspergillus, Fusarium, Glomus, Alternaria, Penicillium*, and others. Poor dental health and oral microbial invasion are associated with cardiac and cognitive disorders. Oral pathogen antibodies to *Campylobacter rectus, Veillonella parvula, and Prevotella melaninogenica* cause hypertension. Oral microbiota health is essential. Oral hygiene best preserves it. Insufficient brushing and flossing can promote gum disease and tooth loss. Poor oral hygiene can cause osteoporosis, diabetes, and cardiovascular disease. Some illnesses and medicines limit salivary flow, letting oral bacteria grow unchecked. To avoid dental health issues, brush and floss regularly, have regular cleanings, eat healthy, and use a fresh toothbrush (Mayo Clinic). Stunted kids mature slowly. Underweight is a low BMI. Underweight kids may hamper their growth. Micronutrient deficiencies-vitamin and mineral deficiencies-hinder enzymes, hormones, and other molecules needed for healthy growth and development.

Diet and nutrition are flexible health predictors. Oral and gut microbiota and the microbiome control the gastro-intestinal tract's emulsifying agents and nutrition extraction. These bacteria generate short-chain fatty acids, vitamin

K, and biotin. Immune system development and pathogen displacement through colonization competition play other roles. Six million northern under-5s will be acutely malnourished from May to April 2023.

512,000 pregnant and nursing women are acutely malnourished (UNICEF, 2022). 5.8 million under-5s die annually. These deaths occur 80% in underdeveloped Asia and sub-Saharan Africa. Malnutrition causes 45% of under-5 deaths in LMICs. SAM affects sub-Saharan Africa and Asia the most. Nigeria has 2 million children with SAM and the second-highest stunting rate. The International Medical Corps and the State Ministry of Health (SMoH) found 16.9% Global Acute Malnutrition (GAM) and 5.1% SAM in children under five in various LGAs in Sokoto. The WHO's 15% GAM and UNICEF's 2% SAM criteria indicate major public health issues.

In north-western and north-eastern Nigeria, insecurity, warfare, and floods increase family food insecurity. Malnutrition affects children under 5 most in poor nations. Oral-gastrointestinal flora alignment affects nutrition absorption. Ahmed hypothesised that pathogenic infections and antibiotics alter the intestines' microbiota and microbial ecology, altering nutrition absorption. Infections increase, causing severe illness and death in malnourished children today and in the future. Host-gene alterations affect food absorption and metabolism. Severe acute malnutrition kills more northern Nigerian children under five. Food security prevents malnutrition in vulnerable countries (FAO, WFP, IFAD, 2012).

Poor diet, prenatal and neonatal toxin exposure, acute infection, chronic illness, and psychological maltreatment can cause malnutrition. Under-nutrition has affected public health worldwide, notably in LMICs, sub-Saharan Africa, and Nigeria, especially the north. Malnutrition increases common illness prevalence, severity, case fatality, and post-acute death. The "vicious cycle" between nutrition and infection now includes dysbiosis, pathogen colonisation, intestinal dysfunction, mal-absorption, nutritional and metabolic dysregulation, inflammation, and bacterial translocation. These alter kids' nutrition and settings. Nigerian under-5s die from malnutrition. Instability increases diarrhoea, malaria, respiratory tract infections, and other child illnesses. Diseases and poverty induce under-nutrition in northern Nigeria. Acute infections can cause malnutrition in undernourished children (FAO, WFP, IFAD, 2012). Nigeria contributes disproportionately to global and sub-Saharan under-five malnutrition. Malnutrition kills 1 in 7 Nigerian children before school. SAM microorganisms are poorly understood. Studies show that SAM influences food, carbohydrate, and lipid metabolism. Multiple factors cause malnutrition. Treating underlying illnesses and other factors can prevent and cure this. Malnutrition and infections cause short-term illness, disability, and death in children. Malnutrition decreases cognition, economic output, and reproduction. Children, families, communities, and the nation suffer. Malnourished children's oral microbial profiles and effects should be studied. While acknowledging the multiple causation routes, this research focuses on immediate explanations at the individual level, including the relationship between illnesses and hunger, ignoring household-level issues. Infection and malnutrition worsen poverty (Figure 1).

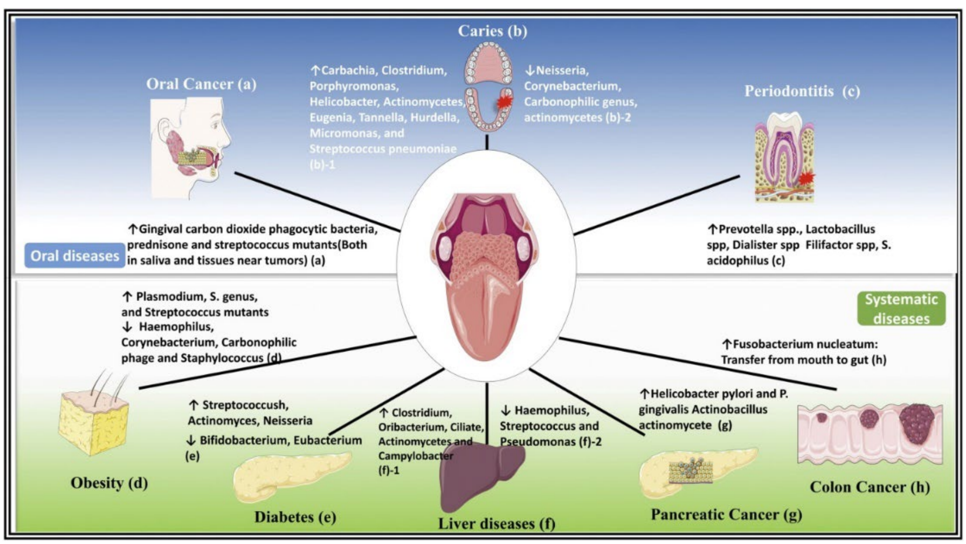

Figure 1. Oral microbiota is related to oral and systematic diseases

METHOD

Study Area

Oral microbes in Sokoto specialty hospital inpatient children are studied from the Northwest state of Nigeria's 36th state, Sokoto, borders Niger. Sokoto is Nigeria's capital and largest city. Sakkwato, Arabic for "market," gives Sokoto its name. Birnin, Shehu da Bello, and Sakkwato are other names. Nigeria's Islamic educational complex houses the caliphate's headquarters. Since 1976, Sokoto has covered Nigeria's northwest portion. Rijiya A, Sokoto South Local Government, Sokoto State, houses the Public Sokoto Specialist Hospital. The Nigeria Ministry of Health's Secondary Health Care Centre, Sokoto Specialist Hospital, was created on January 1, 1986, and operates 24/7. Sokoto Specialist Hospital is open 24/7, Monday through Sunday. Secondary Healthcare Centre with infrastructure, staff, and services make up Nigeria's health system. Malnourished patients at the Specialist Hospital, Sokoto State, were given aseptic oral swabs for microbiological examination. Hospitalised sample donors were surveyed. The patient was urged to forgo eating, drinking, brushing their teeth, and using mouthwash for 30 minutes before the swab. Puritan PurFlock Ultra (25-3606-U) swabs were repeated rapidly. Trial participants had a sterile swab run down the front two-thirds of their tongues. Swabs scarcely bend. To gather samples, the swab was spun across the mouth for 15 seconds to 20 seconds. Self-sealing polythene bags carry specimen containers. To avoid altering results, specimens are sent to the lab immediately. Local storage guidelines apply if specimens cannot be relocated quickly. Isolation used nutrient, sorbitol, and nutrient broth agars. Gram staining and biochemical testing detected nutritious agar-spread plate microorganisms. A colony was put on a clean slide with sterile water and dried to make a bacterial culture smear. The slide's back burned repeatedly. Smears are cleaned after 60 seconds. The smear was stained with Gramme's iodine for 60 seconds, drained, and stored in 95% ethanol until the crystal violet stain faded for 10 seconds to 15 seconds before washing with water. 30 seconds of safranin counterstain. The slide was held in water, dried, and examined under a microscope with an oil immersion objective lens (×100). Indole, Motility, Methyl Red Reaction, Voges Proskauer, Urease, Oxidase, Citrate Utilisation, Coagulase, and TSI tests were done.

RESULTS

In the mouths of malnourished children, researchers found *Haemophilus influenzae*, *Staphylococcus aureus*, *Escherichia coli*, *Streptococcus pyogenes*, *Cronobacter condimenti*, *Photorhabdus luminscenes*, *Klebsiella aeroginosa*, *Bacillus tequillensis*, *Yersinia molderath*, and *Bacillus megaterium*. *Cronobacter condimenti* in the mouth was 25%. Oral samples had 4.5% *Bacillus tequillenses*, *Yersinia molderath*, and *Bacillus megaterium*. *Klebsiella aeroginosa*, *Haemophilus influenza*, *Staphylococcus aureus*, *Escherichia coli*, and *Streptococcus pyogenes* had 9.1%, 12.5%, and 9.1%, respectively. Patients had 5% of *Bacillus megaterium*, 5% of *Cronobacter condimenti*, and 5% of *Bacillus tequillensis*. They also had 15% of *Klebsiella aeroginosa*, *Photorhabdus luminscenes*, *Haemophilus influenza*, *Staphylococcus aureus*, *Escherichia coli*, and *Streptococcus pyogenes*.

Haemophilus Influenzae

- Morphology: Gram-negative, rods or coccobacilli.
- Cultural traits: Chocolate agar colonies are smooth, grayish, and transparent.
- Biochemical characteristics: Positive for nitrate reduction, oxidase, alkaline phosphatase, catalase, acid generation from certain sugars.

Staphylococcus Aureus

- Morphology: Gram-positive, nonmotile, nonsporing cocci, clustered like grapes.
- Cultural traits: Opaque, yellowish colonies on blood agar, often hemolytic.
- Biochemical characteristics: Positive for catalase, coagulase, DNase, acid generation from various sugars.

Escherichia Coli
- Morphology: Gram-negative, straight *bacilli* or *coccobacilli*, non-spore-forming.
- Cultural traits: Smooth colonies on nutrient agar, glossy, complete edges.
- Biochemical characteristics: Positive for nitrate reduction, catalase, acid generation from certain sugars.

Streptococcus Pyogenes
- Morphology: Gram-positive, ovoid or spherical cells, often found in chains.
- Cultural traits: Beta-haemolytic, facultative anaerobes, ideal growth at 37°C.
- Biochemical characteristics: Positive for alkaline phosphatase, acid generation from various sugars.

Cronobacter Condimenti
- Morphology: Gram-negative rods, non-motile, non-spore-forming.
- Cultural traits: Opaque, round, yellow colonies on TSA.
- Biochemical characteristics: Positive for arginine di-hydrolase, citrate utilization, DNase, acid generation from various sugars.

Photorhabdus Luminescens
- Morphology: Gram-negative rods with peritrichous flagella.
- Cultural traits: Polymorph, yellow, orange, or brown colonies.
- Biochemical characteristics: Positive for catalase, esculin hydrolysis, acid generation from certain sugars.

Klebsiella Aeruginosa
- Morphology: Gram-negative, non-motile, capsulated *bacilli*.
- Cultural traits: Glistening wet colonies with various stickiness.
- Biochemical characteristics: Positive for catalase, nitrate reduction, acid generation from various sugars.

Bacillus Tequillensis
- Morphology: Gram-positive, motile rods with endospores.
- Cultural traits: Smooth, round, yellowish colonies after 1 day at 37°C.
- Biochemical characteristics: Positive for oxidase, catalase, acid generation from various sugars.

Yersinia Molderath
- Morphology: Gram-negative bipolar rods.
- Cultural traits: Small, gray-white, opaque colonies after 24 hours.
- Biochemical characteristics: Positive for catalase, methyl red, acid generation from various sugars.

Bacillus Megaterium
- Morphology: Gram-positive, motile rods with endospores.
- Cultural traits: Round colonies, may become yellow, brown, or black.
- Biochemical characteristics: Positive for oxidase, catalase, acid generation from various sugars.

These bacteria exhibit different morphological, cultural, and biochemical characteristics. Some of them are known pathogens associated with various infections, while others are part of the normal flora of the human body. Proper identification and understanding of their characteristics are essential for managing infections and ensuring proper oral health.

DISCUSSION

Community, behaviour, and the environment affect health. According to the study, sub-Saharan African malnutrition was caused by poverty, chronic malnutrition, poor sanitation, contaminated water, and increased viral and bacterial infections. Malnutrition, immune dysfunction, and infection vulnerability are linked.

Other research in this region identified *Escherichia coli, Staphylococcus aureus, Haemophilus influenza, Streptococcus spp., Cronobacter condimentii, Klebsiella, Bacillus, Yersinia, Bacteroides*, and various aerobes and facultative anaerobes. *Haemophilus influenzae, Staphylococcus aureus, Escherichia coli*, and *Streptococcus pyogenes* were isolated. The patient's mouth had *Cronobacter condiment, Photorhabdus luminscenes, Klebsiella aeruginosa, Bacillus tequillensis*, and *Yersinia molderath*. Liesbeth (1999) isolated *K. pneumonia, K. Oxytoca, S. marcescens*, and *K. aeruginosa. Bacillus megaterium*, Saliva can spread enterobacteriaceae. Germs may be in the mouth. Hospitals, where most Enterobacteriaceae infections occur, need this. Diet affects oral microorganisms.

Three people had Haemophilus influenzae, Staphylococcus aureus, Escherichia coli, Streptococcus pyogenes, and *Cronobacter condimentii*.

Predominant bacterial isolate schematic 25% were *Cronobacter condimenti. Bacillus tequillenses, Yersinia molderath*, and *Bacillus megaterium* were 4.5% in oral samples, whereas *Klebsiella aeroginosa, Haemophilus influenza, Staphylococcus aureus, Escherichia coli*, and *Streptococcus pyogenes* were 9.1%, 12.5%, and 9.1%, respectively. *Staphylococcus aureus, Escherichia coli, Streptococcus pyogenes, Bacillus megaterium, Cronobacter condimenti*, and *Bacillus tequillensis* (5%).

Culture, morphology, and biochemistry characterised malnourished children's bacteria. These strategies isolate bacterial biological processes. Biochemical tests revealed two rods and one cocci among the three *Haemophilus influenza* isolates. Gramme-negative Voges praukes, glucose, lactose, and sucrose-positive bacteria *Staphylococcus aureus* isolate 2 displayed poor biochemical reactions. Gramme-positive and Cocci-shaped *Staphylococcus aureus* isolates Three Gramme-negative, rod-shaped *Escherichia coli* isolates are positive for Urea, catalyse, Sucrose, Citrate, and Voges praukes. Two isolates have urea. Both *Streptococcus pyogenes* isolates are positive for glucose, lactose, sucrose, and urea but negative for hydrogen sulphide, gas, and urea. This *Cronobacter* condiment isolate has rod morphology, a positive stain, and positive results for methyl Red, Hydrogen sulphide, Sucrose, Glucose, Lactose, and Gas. All six isolates had rod-shaped bacteria and the same biochemical reaction. No bacteria were citrate-negative. *Bacillus tequillensis* is Gramme-negative because it reacts poorly to stains and only favours catalyse Glucose, Voges praukes, and Citrate. Biochemicals, except hydrogen sulphide and urea, promote rod-shaped bacteria. Unlike other isolates, this rod-shaped, Gram-negative, Voges praukes-positive Yersinia molderath is positive for glucose. *Bacillus megaterium* dislikes stains. Methyl red, Lactose, Sucrose, and Fructose affect Gramme-negative bacteria, Rod-shaped bacteria. This study found that *Klebsiella aeruginosa*, which has similar results to Liesbeth (1999), has two isolates: one has a rod shape with a positive stain (Gramme positive) and is positive to all biochemical reactions except methyl Red, hydrogen sulphide, and urea with a negative result, and the other isolate has a bacillus shape and is positive to all biochemical reactions except methyl Red.

CONCLUSION

This study examines the oral microorganisms in malnourished children admitted to Sokoto Specialist Hospital in Nigeria. Sokoto is a state in the northwest of Nigeria with a predominantly Muslim population. Malnutrition encompasses under-nutrition illnesses. Obesity is frequent in wealthy nations, but under-nutrition is in Africa, Asia, and the Americas (World Health Organisation, 2021). Early childhood growth needs a strong immune system and food.

DECLARATIONS

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethics Approval and Consent to Participate

Ethical clearance was obtained from the Ethical Review Committee of Sokoto State Ministry of Health, Kebbi State University of Science and Technplpgy Aliero, And Sokoto Stte Specialist Hospital Sokoto. The objective and purpose of the study were explained to officials at the Kebbi Satate University of Science and Technology Aliero, Sokoto Ministry of Health, Specialist Hospital Sokotot (Smallest governmental administrative division) and written permission consent was obtained from the study participants.

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