Electronic Health Record Analysis for Personalized Medicine: Predicting Malnutrition-Related Health Outcomes and Secondary Neuropsychiatric Health Concerns

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Malnutrition poses risks regarding cognitive, behavioral, and physical well-being. The aim of this study was to investigate the prevalent health issues associated with malnutrition by utilizing electronic health records (EHR) data. The IBM Watson Health, Explorys platform was used to access the EHR data. Two cohorts were created by two queries; patients with a history of malnutrition (n=5180) and patients without a history of malnutrition diagnosis (n= 413890). The log odds ratio and $\chi 2$ statistic were used to identify the statistically significant differences between these two cohorts. We found that there were 35 terms that were more common among the cohort with the malnutrition diagnosis. These terms were categorized under developmental anomalies, infectious agents, respiratory system issues, digestive system issues, pregnancy/prenatal problems, mental, behavioral, or neurodevelopmental disorders, diseases of the ear or mastoid process, diseases of the visual system, and chromosomal anomalies. The management of malnutrition in children is a complex problem that can be addressed with a multifactorial approach. Based on the key themes emerging from among the commonly prevalent terms identified in our study, infection prevention, education in appropriate nutritional solutions for digestive health issues, supportive services to address neurodevelopmental needs, and quality prenatal healthcare would constitute beneficial prevention efforts. Improving our understanding of malnutrition is necessary to develop new interventions for prevention and treatment.

Keywords: Malnutrition, mental health, developmental anomalies, Electronic Health Records

1. Background

1.1. *Malnutrition as a Public Health Issue*

Malnutrition is a global health concern with long-lasting negative health implications regarding children's mental and physical well-being. The World Health Organization [1, 2] defines malnutrition as "deficiencies, excesses, or imbalances in a person's intake of energy and/or nutrients "with pediatric undernutrition accounting for about 45% of all child deaths globally. Severe malnutrition increases the risk of serious illness and death as well as acute infectious diseases for children with malnutrition [3]. Malnutrition is a critical public health problem in many parts of the world. Every form of malnutrition poses a significant threat to health and well-being and consequently improving nutrition is an important global health priority [1, 2].

Protein-energy malnutrition (PEM) is a global problem present in both developing and industrialized countries. In developing countries, malnutrition is often associated with several risk factors, including social and environmental factors such as poverty, poor education, limited access to health care, and a polluted environment. Living in areas with high rates of infectious diseases such as respiratory infections, diarrheal diseases, human immunodeficiency virus (HIV), tuberculosis, and nutritional factors such as acute and chronic food shortages and suboptimal feeding practices are also associated with malnutrition [3, 4]. In industrialized countries, malnutrition frequently observed in the form of micronutrient deficiencies in childhood can have long-term effects on health and productivity in adulthood. Not only detection and prevention of severe malnutrition but also subclinical deficiencies can be important to reverse the adverse effects of these deficiencies (especially iron and B vitamins) on the social, cognitive, and physical well-being of children [5].

Although malnutrition is a major global health problem that threatens human well-being, until recently there was no consensus on diagnostic criteria [6]. Many researchers used international growth standards to diagnose and treat severe malnutrition. The 2021 edition of the Joint Child Malnutrition Estimates (JCME) published by the UNICEF/ World Health Organization / World Bank Group provided country-level assessments regarding types of malnutrition including stunting and wasting among children under the age of five [7]. Children who are affected by stunting are too short for their age. Stunting is associated with irreversible physical and cognitive deficits. It is expected that the coronavirus disease 2019 (COVID-19) pandemic will also impact rates of malnutrition negatively. Based on the JCME, the global number of children affected by undernutrition is expected to have increased by up to 15% due to the negative impact of COVID-19 on household income, access to nutritious food, and essential nutrition services [7].

Children need good nutrition to grow, learn, play, and participate. A review study conducted in 1995 found that children with a history of early childhood malnutrition were likely to have lower cognitive functioning, school performance, and more behavioral problems as compared to matched controls and their siblings [8]. A recent systematic review found that children with a history of early childhood malnutrition were likely to have impaired cognition and higher levels of behavioral problems during childhood and adolescence [9]. However, the causal pathways linking malnutrition to neurodevelopment, cognition, behavior, and mental health are not clearly identified by the previous research due to shared environmental complexity with a multitude of risk factors including poverty, socioeconomic adversity, risk of infectious disease, lack of parental engagement, and school truancy [9]. The same systematic review concluded that studies examining the effects of malnutrition on children's mental health are inconclusive. It was indicated that only a few studies have examined specific areas of mental health, such as depression, and that more research is needed to investigate the long-term care needs of children with a malnutrition history and to investigate the prevalent health concerns co-occurring with malnutrition to improve patient outcomes.

2. Methods

2.1. *Motivation*

Utilizing big data in the form of Electronic Health Records (EHR) is a relatively recent approach to conducting research regarding mental and physical health with various significant knowledge discovery implications. However, big data has been rarely used to study the implications of malnutrition on human development particularly in industrialized countries such as the U.S. and Canada. Given the lack of current evidence on this increasingly important topic, in this study, we aim to identify the health correlates that are highly prevalent among patients with a diagnosis of malnutrition using large-scale EHR data. The objective of this study is to investigate EHR data to explore the associations between malnutrition and negative health outcomes. We hypothesized that malnutrition diagnosis will be adversely linked to mental and physical health outcomes among participants in the EHR data from the US and Canada.

2.1.1. *Data-Source*

Data for this study was pulled through IBM Watson Health, Explorys EHR platform. Explorys is a commercial platform that provides access to EHR data on clinical health information. It provides data from various hospital-affiliated providers from 40 acute care facilities, from more than 400,000 providers and Physicians, from 2.0 billion patient visits, and 4.4 million emergency care visits (IBM Explorys, 2020). It utilizes the Systematized Nomenclature of Medicine (SNOMED) via the International Classification of Diseases (ICD), one of the designated standards for use in EHRs, to systematically structure medical terms. The data is accessed through queries. Quarries produce data for the frequencies of selected medical diagnostic terms. It is also possible to select a subset of patients from the system. For example, the Explorys platform has been successfully used to investigate associations between multiple sclerosis and COVID-19 [10], colorectal cancer [11], and substance use and mental health concerns [12].

2.2. *Sample*

In this study, cohorts were created by two queries in the late fall of 2021, i) all patient records containing malnutrition diagnosis and ii) all patient records not containing malnutrition diagnosis. In the present study, malnutrition is a clinician-based diagnosis that is coded through ICD10 into the patient chart. The IBM Explorys data provides these patient cohorts based on the diagnosis. Although there is no consensus on the diagnostic criteria, many clinicians in the US and Canada use the Global Leadership Initiative on Malnutrition's (GLIM) criteria for the diagnosis of malnutrition [6]. Specifically, a two-step methodology is frequently used in the diagnosis of malnutrition, the initial stage involves screening individuals to identify those who are at risk by utilizing validated screening tools followed by the subsequent stage, where the assessment is conducted to diagnose the condition and determine its severity. The diagnosis of malnutrition can often be made through a comprehensive assessment of physical observations and a thorough history of the patient's dietary and health status by taking into account the notably non-volitional weight loss, low body mass index, and diminished muscle mass (i.e., phenotypic criteria), in addition to reduced food intake and occurrences of inflammation or disease burden (i.e, etiologic criteria).To diagnose malnutrition at least one phenotypic criterion and one etiologic criterion should be present. Healthcare practitioners additionally may conduct a body mass index (BMI) or a child's arm circumference assessment. The following terms were used in diagnostic decision-making by the clinicians: Deficiency of macronutrients, Disease Malnutrition (calorie), Nutritional deficiency disorder, Nutritional disorder, and Undernutrition. Clinicians also included their observations such as body measurements, pediatric percentile measurement, body mass index, chemistry hematology, cell fractions/differential myeloid cells, and pediatric weight percentile. If feasible, a blood sample is procured for the purpose of examining the potential problems in specific micronutrients. In the present study, the malnutrition cohort had 5180 patient records and the cohort with no malnutrition had 413890 patient records. The majority of the patient records in the malnutrition cohort were children; 40% were younger than 4 years of age, 35% were between 5 to 9 years of age, 25% were between 10 to 14 years of age, and 5% were older than 18 years of age. Fifty-six percent of the malnutrition cohort were males.

2.3. *Analysis*

We conducted the analysis at the level of frequencies. Our analytical strategy is addressing this difference based on unequal group sizes. Specifically, we use odds ratio statistics to investigate the proportional prevalence rate of the health concerns. This statistical framework has been used in other research publications including traumatic brain injury [TBI, 13] intimate partner violence [14], and mental health predictions [15]. The odds ratio takes into account the expected observation in larger cohorts as compared to observation in smaller cohort sizes.

Two statistical analyses, namely the log odds ratio and the $\chi 2$ statistic, were utilized in this study. Specifically, the log odds ratio was utilized to compute the logarithm of the ratio between the frequencies of Malnutrition and No Malnutrition. The $\chi 2$ statistic was utilized to determine if there is a significant association between observed and expected frequencies of diagnostic terms in the two cohorts. We ranked the terms based on both the log odds ratio and $\chi 2$ statistic. Two rankings based on frequencies were produced, and the highest rank allocated to every term was established. Subsequently, diagnostic terms were ranked based on the premise that a term could only attain a high ranking if it satisfied the criteria in both the log odds ratio and $\chi 2$ statistic rankings. Furthermore, one-tailed z-tests ($p<0.05$) were conducted as a conservative approach to reduce the likelihood of Type 1 errors to evaluate the extent of the evidence against the null hypothesis. Using the extent of the standard deviations and the sample mean's distance from the population mean, we concentrated the inferences concerning the diagnostic terms grounded in sample data with higher confidence.

To conduct a one-tailed z-test for an odds ratio, we first calculated the log odds ratio (logOR), the standard error of the logOR, and then we compared the calculated z-score to a critical value-based $p<.05$ significance level and the direction of our hypothesis (one-tailed test) to determine if the observed odds ratio is statistically significant. To make this calculation we used a commercially available statistical package (IBM SPSS Statistics).

Null Hypothesis (H0): The odds ratio is equal to 1 (no association between malnutrition and non-malnutrition cohorts).
Alternative Hypothesis (Ha): The odds ratio is greater than 1 (testing for a positive association between malnutrition diagnosis and health concerns).

In order to calculate the z-score, SPSS uses Log OR to SE ratio: $z = (\text{logOR}) / (\text{SE})$.

2.4. *Tables*

For more information about the sample characteristics see Table 1.

Table 1. Characteristics of Study Population

Variables	**Malnutrition n (%)**	**Non- Malnutrition n (%)**
Race		
Caucasian	1865 (36%)	289723 (70%)
African American	829 (16%)	74500 (18%)
Asian	104 (2%)	4139 (1%)
Hispanic/Latino	52 (1%)	4139 (1%)
Native American/Alaskan Native	0 (0%)	0 (0%)
Multi-racial (race)	207 (4%)	12417 (3%)
Other (race)	207 (4%)	8278 (2%)
Gender		
Female	2279 (44%)	215223 (52%)
Male	2901 (56%)	198667 (48%)
Vitals		
Severely underweight body mass index <16.49	2849 (55%)	53806 (13%)
Underweight body mass index 16.5< x <18.49	1968 (38%)	95195 (23%)
Prehypertension sys. 120-139 dias. 80-89	1295 (25%)	322834 (78%)

3. Results

The age of a patient was utilized to categorize them into one of the 3 age groups; juniors (i.e., younger than 18), adults (i.e., between 18 and 65), and seniors (i.e., older than 65). Ninety-five percent of the records were those from juniors majority of whom were younger than 4 years of age. The majority of the records with no malnutrition diagnosis were from patients who were adults older than 50 years of age. Investigation of the most frequently observed diagnostic terms among those diagnosed with malnutrition indicated that; attention deficit hyperactivity disorder, deficiency of macronutrients, developmental disorder, a developmental disorder of motor function, disorder by body site, disorder of body system, disorders of attention and motor control, malnutrition (calorie), the mental disorder usually first evident in infancy, childhood AND/OR adolescence were among the most frequently observed terms for those in that cohort under the age of 4.

Our comparison of the malnutrition cohort to no malnutrition background cohort indicated that 35 terms were significantly more prevalent among the malnutrition cohort (See Table 2). Identified terms were classified into broader categories based on ICD 11 classification system, and SNOMED. We present the distribution of the 35 terms into these categories in Table 2. These broader parent codes include developmental anomalies, infectious agents, respiratory system, digestive system, pregnancy/prenatal problems, mental, behavioral, or neurodevelopmental disorders, diseases of the ear or mastoid process, diseases of the visual system, and chromosomal anomalies (See Figure 1).

Table 2. Comparison of the malnutrition cohort to no malnutrition background

Diagnostic Terms	**Malnutrition Frequency n=5180 n (%)**	**Non-Malnutrition Frequency n= 413890 n (%)**	**Log Odds Ratio**	**p**	**Z score**
Infective laryngitis	370 (7%)	380 (0.09%)	3.50	<0.001	47
Coxsackie virus infection of oral cavity	250 (5%)	260 (0.06%)	3.32	<0.001	37
Enlargement of tonsil or adenoid	200 (4%)	210 (0.05%)	3.22	<0.001	32
Tonsil and/or adenoid hypertrophy	200 (4%)	210 (0.05%)	3.22	<0.001	32
Infection of larynx	370 (7%)	390 (0.09%)	3.20	<0.001	43
Arterial malformation	250 (5%)	270 (0.07%)	3.02	<0.001	34
Developmental speech disorder	580 (11%)	630 (0.15%)	3.01	<0.001	51
Congenital anomaly of pulmonary artery	110 (2%)	120 (0.03%)	2.95	<0.001	22
Congenital anomaly of tricuspid valve	110 (2%)	120 (0.03%)	2.95	<0.001	22
Deletion of part of autosome	80 (2%)	90 (0.02)	2.81	<0.001	18
Tracheitis	80 (2%)	90 (0.02%)	2.81	<0.001	18

Condition in fetus originating in the perinatal period	460 (9%)	530 (0.13%)	2.76	<0.001	42
Disorder of psychological development	840 (16%)	980 (0.24%)	2.75	<0.001	56
Cow's milk protein sensitivity	70 (1%)	80 (0.02%)	2.75	<0.001	16
Fetal disorder	310 (6%)	360 (0.09%)	2.72	<0.001	34
Disorder of fetus or newborn	1020 (20%)	1220 (0.29%)	2.70	<0.001	60
Acute suppurative otitis media without spontaneous rupture of ear drum	450 (9%)	530 (0.13%)	2.69	<0.001	41
Abnormal ventriculoarterial connection	120 (2%)	140 (0.03%)	2.69	<0.001	22
Congenital biliary atresia	60 (1%)	70 (0.02%)	2.68	<0.001	15
Disease caused by Adenovirus	60 (1%)	70 (0.02%)	2.68	<0.001	15
Disease caused by Poxviridae	60 (1%)	70 (0.02%)	2.68	<0.001	15
Disease caused by unassigned Poxviridae	60 (1%)	70 (0.02%)	2.68	<0.001	15
Molluscum contagiosum infection	60 (1%)	70 (0.02%)	2.68	<0.001	15
Coxsackie virus disease	280 (5%)	330 (0.08%)	2.67	<0.001	32
Alternating esotropia	50 (1%)	60 (0.01%)	2.60	<0.001	13
Hypoplasia of the optic nerve	50 (1%)	60 (0.01%)	2.60	<0.001	13
Inflammation of bronchiole (Human metapneumovirus)	50 (1%)	60 (0.01%)	2.60	<0.001	13
Neuromuscular scoliosis	50 (1%)	60 (0.01%)	2.60	<0.001	13
Anomaly of jaw size	90 (2%)	110 (0.03%)	2.56	<0.001	13
Disease caused by Enterovirus	90 (2%)	110 (0.03%)	2.56	<0.001	13
Overriding aorta	90 (2%)	110 (0.03%)	2.56	<0.001	18
Right ventricular hypertrophy	90 (2%)	110 (0.03%)	2.56	<0.001	18
Tetralogy of Fallot	90 (2%)	110 (0.03%)	2.56	<0.001	18
Congenital anomaly of muscle AND/OR tendon	130 (3%)	160 (0.04%)	2.54	<0.001	18
Congenital anomaly of skeletal muscle	130 (3%)	160 (0.04%)	2.54	<0.001	18

4. Discussion

The aim of the study was to examine prevalent health issues related to malnutrition diagnosis and associated neuropsychiatric health issues utilizing EHR data available for the U.S. and Canada. The EHR platform utilizes the Systematized Nomenclature of Medicine (SNOMED) via the International Classification of Diseases (ICD), one of the designated standards for use in EHRs, to systematically structure medical terms [16]. The study underscores the importance of bridging the gap between imaging for malnutrition and the early detection of malnutrition signs, particularly in children. By supporting clinical insights that focus on predicting risks and outcomes, this approach aims to prevent secondary neuropsychiatric illnesses that can arise from nutrition-related problems. This paper explores the challenges and solutions involved in translating findings from electronic health records (EHRs) into actionable insights for personalized medicine, ultimately facilitating informed clinical decisions at the individual level.

Building on the consensus criteria established by the European Society of Clinical Nutrition and Metabolism (ESPEN)—which include weight loss, reduced BMI, and reduced fat-free mass index (FFMI)—this research emphasizes the limitations and regional variations in the prevalence of malnutrition [6]. In North America, where rates of moderate and severe stunting and wasting are classified as low and very low, respectively, the study suggests that these disparities in malnutrition outcomes may be even more pronounced in regions characterized by higher food insecurity and political instability [17]. This highlights the need for context-specific analyses and the integration of diagnostic imaging and biomarker criteria in addressing malnutrition across diverse populations.

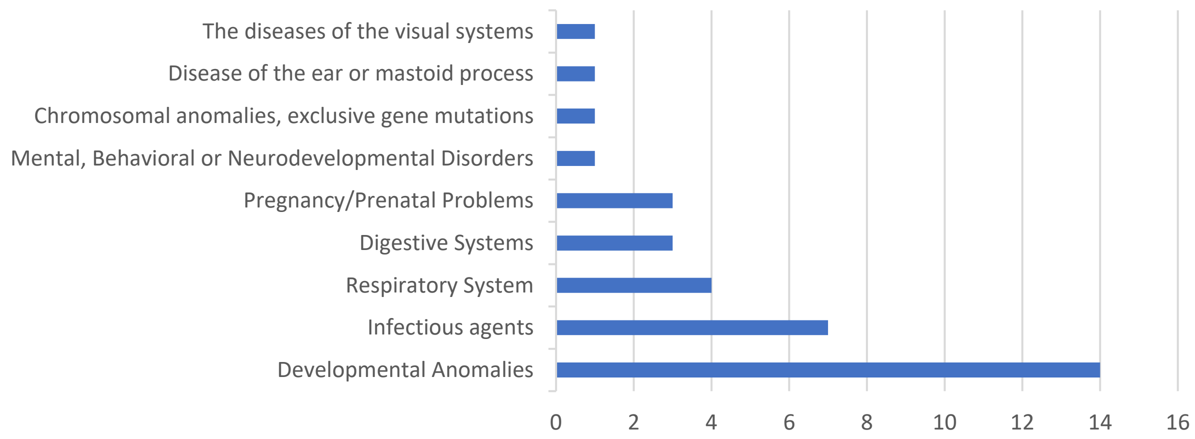

Figure 1. Distribution of Significant Terms into Broader Categories
This figure provides information regarding the 35 terms that were significantly more prevalent in the malnutrition cohort classified into broader categories based on ICD 10 classification system, and SNOMED. These broader categories were developmental anomalies, infectious agents, respiratory system, digestive system, pregnancy/prenatal problems, mental, behavioral, or neurodevelopmental disorders, diseases of the ear or mastoid process, diseases of the visual system, and chromosomal anomalies.

Our results showed that 35 health correlates were significantly more common among the undernourished cohort. Key themes emerging from among the commonly prevalent terms included developmental anomalies, infectious agents, respiratory system problems, digestive system problems, pregnancy/prenatal problems, mental, behavioral, or neurodevelopmental disorders, diseases of the ear or mastoid process, diseases of the visual system, and chromosomal anomalies.

Prevalence of these diagnostic themes could be due to various reasons, including (i) terms such as mental, behavioral, or neurodevelopmental disorders are a direct consequence of current malnutrition (ii) terms such as chromosomal abnormalities and pregnancy/prenatal problems are risk factors that increase the vulnerability to malnutrition (iii) terms such as frequent infections, respiratory system issues, gastrointestinal system issues might be more prevalent in the demographics such as regions with climate inequality, among malnourished children (iv) terms such as ear or mastoid disorders and visual system disorders are associated with the occurrence of malnutrition and linked to a potentially long-term consequence.

Examination of the most frequently observed diagnostic terms in a cohort aged 0-4 years diagnosed with malnutrition revealed that this cohort was also frequently diagnosed with attention deficit hyperactivity disorder and macronutrient deficiencies. Past research children with ADHD were also found to have lower levels of protein intake and lower levels of vitamins B1, B2, and C and lower levels of zinc, iron, and calcium in comparison to typically developing children in the control group [17]. Significant terms might also have potentially indirect mental and social developmental effects such as musculoskeletal disorders. Neuromuscular scoliosis is one of the terms that was observed as significantly more prevalent among malnourished children. Multiple surgeries (traditional growing rods) during the treatment process in combination with the condition itself might have a negative impact on the mental health of children resulting in lower self-esteem, depression, and anxiety [18].

Previous studies have also emphasized potential ethnic and racial differences in malnutrition and their impact on biological reference intervals. For instance, Colantonio et al. (2012) investigated the impact of ethnicity on biochemical markers of health and disease in a healthy cohort of 179 multi-ethnic and racially diverse Canadian children and adolescents [19]. The study found variations in levels of ALT, iron, total cholesterol, triglycerides (TG), and SHBG. Additionally, Vitamin D levels were higher in Caucasian pediatric participants compared to Black, Asian, and Hispanic participants. These biochemical markers play a critical role in diagnosing and understanding the manifestations of malnutrition. Therefore, establishing accurate reference intervals is essential for detecting the true extent of these health concerns in developing children, which is vital for improving health equity [20].

Social, political, and economic factors can be linked to chronic infections play an important role in the emergence of malnutrition through systemic and individual interactions [21]. In our data from the US and Canadian hospital systems, we observed that boys are slightly more likely to have a history of malnutrition [22]. A recent systematic review found that there are sex differences regarding undernutrition with boys more likely than girls to be wasted, underweight and stunted [22]. The occurrence of secondary malnutrition in developed countries is linked to abnormal nutrient loss, increased energy expenditure, or decreased food intake, often associated with chronic diseases such as cystic fibrosis, chronic renal failure, childhood malignancies, congenital heart disease, and neuromuscular disease.

The extent to which early impairments in neurodevelopment due to malnutrition impact future cognition and function, and the extent to which other relevant environmental factors such as prenatal nutrition, family characteristics, and infectious diseases influence these findings are unclear. Therefore, future research comparing the health effects of malnutrition while controlling for these interactions can help us better understand the impact of malnutrition [22, 23].

Imaging Genetics and Neuropsychiatric Illnesses and Future Research. Nutritional biomarkers serve as objective indicators of normal biological or pathogenic processes and are categorized into three main types: biomarkers of exposure, biomarkers of status, and biomarkers of function [24]. These biomarkers are assessed through a variety of methods, ranging from traditional dietary exposure assessments, such as self-reports, to the evaluation of biological fluids, tissues, or urine, which reflect the body's total nutrient reserves or the degree of nutrient depletion [24]. Functional biomarkers provide insights into physiological and behavioral variations and nutrient imbalances, such as enzyme activity or the presence of abnormal metabolic by-products, signaling early signs of subclinical deficiencies [24]. As an emerging field, functional biochemical markers underscore the significance of studying alterations in DNA, gene expression, and immune function caused by malnutrition [24]. Key laboratory biomarkers frequently discussed in the literature for diagnosing malnutrition, assessing nutritional risk, and monitoring the efficacy of nutritional interventions include albumin, pre-albumin, transferrin, C-reactive protein, α1-acid glycoprotein, hemoglobin, cholesterol, and lymphocyte count [20]. These biomarkers are often used in combination, such as albumin, pre-albumin, cholesterol, and lymphocyte count, or albumin, hemoglobin, and total lymphocyte count, to provide a comprehensive assessment of nutritional status [20].

There is limited research utilizing neuroimaging to document the effects of malnutrition on the brain. Among the most commonly utilized neuroimaging methods examining this impact are Electroencephalogram (EEG), Functional Near-Infrared Spectroscopy (fNIRS), and Nuclear Magnetic Resonance (NMR). Research utilizing the EEG method to study malnutrition reveals alpha wave disturbances that are linked to neurodevelopmental delays in children [25]. The fNIRS is another neuroimaging technique that can be particularly valuable for assessing brain functionality among young children [26, 27, 28]. Studies using this technology found that cerebral blood flow in malnourished children is a biological marker of cognitive functional difficulties [29]. Due to the challenges regarding the affordability of NMR technology, this method has not been utilized often. The majority of the limited number of studies utilizing this methodology are case studies with small samples and no controls. Nonetheless, available evidence so far demonstrates the significant potential of NMR technology in early diagnosis and prevention of long-lasting impacts of malnutrition on cognitive function [30].

In a recent review of neuroimaging studies, Ayaz et al. (2023) documented cerebral atrophy of malnourished children, with or without ventricular dilation [31]. The extent of atrophy or ventricular dilation were not assessed in any of the studies reviewed. Consequently, the authors emphasized the need for a universal scoring system to quantify the extent of brain atrophy and correlate it with the severity of malnutrition that would enable healthcare providers to better assess the impact of nutritional interventions [31].

Whole brain mapping, an emerging technology for investigating the functional impact of neurocircuitry in specific regions and neural networks, holds significant promise for understanding the effects of malnutrition on neuropsychiatric concerns [32, 33]. This approach is particularly valuable for studying mechanistic pathways such as the blood-brain barrier, glial cell proliferation, and brain-body interactions [32, 33]. Additionally, gene ontology analyses offer promising mechanistic insights, including pathways related to oxidative stress, myeloid interactions with the immune system, and stress-related responses [32, 33, 34].

Limitations and Future Research. There are limitations due to the nature of this type of data. We utilized an established statistical framework to analyze the EHR data to address these limitations. Although malnutrition is a significant global health concern posing a threat to well-being, until recently there was no consensus on the diagnostic criteria. The lack of such diagnostic criteria hinders progress regarding the design and implementation of successful interventions. Children who are affected by wasting are too thin for their height either due to recent rapid weight loss or failure to gain weight are often diagnosed with malnutrition. Another limitation of the current study is that, due to the nature of the available data, it was not feasible to calculate the effects across all BMI ranges. The extent to which early impairments in neurodevelopment due to malnutrition impact future cognition and function, and the extent to which other relevant environmental factors such as prenatal nutrition, family characteristics, and infectious diseases influence these findings are unclear. Therefore, future research comparing the health effects of malnutrition while controlling for these interactions can help us better understand the impact of malnutrition [22, 35, 36].

Malnutrition is a global health concern with long-lasting negative health implications regarding children's mental and physical well-being and children living in high-income countries are not immune to this impact. Utilizing big data in the form of Electronic Health Records (EHR) is a relatively recent approach to conducting research regarding mental and physical health with various significant knowledge discovery implications. We found that for the malnourished cohort, the terms that were more significantly common were grouped under the following categories: developmental anomalies, infectious agents, respiratory system issues, digestive system issues, pregnancy/prenatal problems, mental, behavioral, or neurodevelopmental disorders, diseases of the ear or mastoid process, diseases of the visual system and chromosomal anomalies. Our findings underscore the significance of prevention strategies such as providing support during pregnancy, educating primary caregivers and family members on general child nutritional needs, basic health, and hygiene; as well as a community-based approach including affordable access to basic health services [7, 19].

In conclusion, the management of malnutrition in children is a complex problem that can be addressed with a multifactorial approach. Health policies on prevention of malnutrition such as educating primary caregivers and family members on general child nutritional needs, basic health, and hygiene might be helpful in improving children's health [21, 22]. A community-based approach including access to affordable healthy and nutritious food, basic health, water, hygiene, and sanitation services, and opportunities for safe physical activity can be beneficial to address the issue of malnutrition among children under 5 years of age [35, 36].

Furthermore, our findings underscore the importance of ensuring adequate nutrition before and during pregnancy as one of the vital pathways to improving the health and well-being of children [7]. Infection prevention, education in appropriate nutritional solutions, supportive services and quality prenatal healthcare would constitute beneficial prevention efforts.

4.1. *Footnotes*

The IBM Explorys Therapeutic Dataset is used in this manuscript in the form of aggregate statistics (number of records) in a specified population. The data is unidentified and aggregated, and no individual records were used due to privacy concerns. The study is considered an exempt study.

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