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RESEARCH ARTICLE

VITAMIN D DEFICIENCY IN CHILDREN PREVALENCE AND ASSOCIATED FACTORS IN A PEDIATRIC OUTPATIENT CLINIC

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Vitamin D deficiency, children, Saudi Arabia, pediatric OPD.

Abstract

Background: The deficiency of Vitamin D can be stated as low serum 25-hydroxyvitamin D concentrations, is the direct antecedent to Nutritional Rickets in children, which is preventable bone ailment. Vitamin D further functions at a significant immunomodulatory and alters cellular differentiation and innate immune response and is part of the explanation about the association between vitamin D deficiencies, increased and incidental infections,and increased risk for autoimmunity . This present study will evaluate the scenario in case of pediatric OPD in all the available prospect in Saudi Arabia.

Study Objectives: The primary objective of this review study is to review and review the present literature on vitamin D deficiency in children attending pediatric outpatient clinics in Saudi Arabia and to investigate and classify the sociodemographic, environmental, dietary, and clinical determinants associated with vitamin D deficiency in children.

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Materials and Methods: This study uses exploratory research design where the data is gathered from various sources on the basis of pre decieded criteria of inclusion and exclusion. PRISMA is used to segregate and screen the collected studies.
Results: Of the relevant studiesincluded here 67.3% of vitamin D deficiency (out of a sample size of 22,335 individuals, including children). Of these individuals, 28.1% had adequate levels of vitamin D and were classified as insufficient (20-29 ng/mL), 35.9% classified as deficient, and 3.3% classified as severely deficient. The age group of 10-19 years was identified as the most impacted group of the cohort with a mean serum 25(OH)D level of 21.1 ± 11.9 ng/mL.
Conclusion: Seasonal and geographic variability further exemplifies context-based responses. Moving forward, education, promotion of positive lifestyles and habits, and a national screening program for Vitamin D levels could be important steps towards reducing the burden of Vitamin D deficiency among children in Saudi Arabia.

Introduction:-

Global Health Challenge:-

Vitamin D, known as an essential prohormone, is relevant to pediatric health mainly through calcium homeostasis and skeletal health. Vitamin D deficiency, defined as persistently low serum 25-hydroxyvitamin D concentrations, is the direct antecedent to Nutritional Rickets in children, which is preventable bone ailment. **[1]** Vitamin D further functions at a significant immunomodulatory and alters cellular differentiation and innate immune response and is part of the explanation about the association between vitamin D deficiencies, increased and incidental infections, and increased risk for autoimmunity. **[2]** Insufficient vitamin D status is one of the most serious public health concerns globally, with estimates of those not meeting vitamin D status requirements as low as 75% and as high as 99%. Epidemiologic assessment requires standardization and competency to measure, as well as to effectively use, cutoff levels. The main clinical biomarker used for vitamin D status assessment is serum 25(OH)D, which involve analyte concentrations determined in a laboratory assay or setting. **[3]**According to the following consensus guidelines, particularly those from the Endocrine Society and incorporated in the major guidelines used in Saudi Arabian clinical practice (CHI), **[6], [7]**

Vitamin D status is categorized, according to serum 25(OH)D concentration, as follows:
Deficiency: Serum 25(OH)D below 20 ng/mL (50 nmol/L).
Insufficiency: A troublesome range so far defined as 21-29 ng/mL (52.5-72.5 nmol/L).
Sufficiency: Serum levels of 25(OH)D at or above 30 ng/mL (75 nmol/L).
One of the more common methodological challenges facing these data sets within the KSA is a variability of cut-offs reported. Local studies will often utilize cut-offs at attenuated levels (e.g., deficiency being less than 37.5 nmol/L or ~15 ng/mL) that skew standard definitions of deficiency and insufficiency, as seen in this example. **[6], [9]**

The Kingdom of Saudi Arabia (KSA) presents a very interesting epidemiological paradox, given that, geographically, it is located in an area of high solar irradiance but still shows many studies demonstrating a deep prevalence of overall Vitamin D deficiency (VDD) prevalence amongst citizens. **[11], [7]** This prevalence must be analyzed and synthesized based on specifically the pediatric outpatient clinic data sets, as this is a unique aspect of primary care that engages care outside of a case definition, including diagnosis and subsequent therapeutic intervention of high-risk populations.The aim of this review is to present a thorough, evidence-based summary that outlines the epidemiology of pediatric VDD in KSA, considering the differing prevalence values, and identifying the multiple interacting cultural, environmental and biological factors involved.

Diagnostic Benchmarks:-

The clinical practice guidelines in Saudi Arabia recognizes VDD is a common condition. The Council on Health Insurance (CHI) guidelines define VDD with a serum 25(OH)D level of ≤20 ng/mL (50 nmol/L). They also state a treatment regimen will be postulated even with a deficiency apprehensive not considered severe. The guidelines specify low-dose therapy for pediatric patients with a serum 25(OH)D value >12≤20 ng/mL (30 to 50 nmol/L) **[12], [13], [9]** who are symptomatic and do not have coexisting hypocalcemia; and thus acknowledges different levels of insufficiency that may require clinical judgement and action. An important limitation of surveillance at population-level, is a policy surrounding eligibility for testing. The CHI specifically has an associated memorandum in place with eligibility criteria that restricts systematic screening for Vitamin D testing to an “eligible” population. **[7]**

Table 1: International and KSA Clinical Benchmarks for Vitamin D Status (25(OH)D)

Status	Threshold (ng/mL)	Threshold (nmol/L)	Clinical Significance
Deficiency	$<$20	$<$50	Associated with Rickets, Osteomalacia (Endocrine Society, KSA Guidelines)
Insufficiency	20–29	50–72.5	Potential risk to bone health; sub-optimal status
Sufficiency	≥30	≥75	Recommended minimum for maximizing bone health
Severe Deficiency	$<$7	$<$17.5	Highest risk of symptomatic disease

Source: Prepared from the data mentioned above

Therapeutic Management:-

The KSA guidelines suggest aggressive treatment strategies for rapid correction of vitamin D deficiency (VDD), which indicates awareness of the clinical urgency of the degree of severity seen in pediatric outpatient populations. **[14]** For deficiency correction (≤20 ng/mL), the KSA guidelines give specific daily doses, infants (0–12 months) are given 2,000 IU (50 mcg) orally each day for 6 weeks; children and adolescents (1–18 years) are advised to take 2,000 IU (50 mcg) orally each day for 6-8 weeks. Also, notably the treatment algorithm mentions an even higher correction dose of 4000 IU per day initially, for children aged 1-10 years. **[15], [12]** This aggressive dosing strategy closely parallels the Endocrine Society recommendation that suggests correction of an established deficiency may require larger doses initially (up to Tolerable Upper Limits (UL; 4000 IU/d for children 1-18 yr). **[16]**

Prevalence and Trends:-

A systematic review of seven studies published between 2012 and 2023, collectively covering an overall population of 2,429 children and adolescents, determined the average prevalence of suboptimal Vitamin D status (deficiency and insufficiency) to be about 81.1%. **[11], [4]** This very high statistic indicates that Vitamin D deficiency is normal rather than abnormal across the population of Saudi children and adolescents. In one prospective cross-sectional study of 22,335 subjects in Central KSA, 67.3% were found to have 25(OH)D levels <30 ng/mL. **[9], [15]** Utilizing age-related sampling methods demonstrates a clear shift in official Vitamin D status according to growth and developmental stages. In a sample obtained from a pediatric outpatient clinic, the deficiency was relatively low, only 5.8% (using the strict cut-off of ≤37.5 (nmol/L), among children aged 1–4 years.**[7], [13]** The relatively low rate of deficiency, albeit a serious health concern for toddlers and young children is likely a result of vigilant oversight by both parents and clinicians, which often includes careful and eager adherence to specialist advice with respect to prophylactic supplementation (i.e., a guideline of 400 IU/day for infants). **[18]**

This review study aims to summarize the literature on prevalence and risk factors of vitamin D deficiency among children seen in pediatrics outpatient clinics in Saudi Arabia, as well as discuss implications for public policy, clinical practice and prevention in the context of Vision 2030 in Saudi Arabia which calls for a more proactive and effective well being for children. As it pertains to treating vitamin D deficiency in Saudi children, it's important to develop an understanding of the multifactorial nature of the disease in order to develop culturally competent well-designed evidence based interventions. This review outlines the current gaps in screening and management, and therefore the need for more integrative approaches which blends clinical vigilance with community based education and policy reform.

Research Objective:-

The primary objective of this review study is to review and review the present literature on vitamin D deficiency in children attending pediatric outpatient clinics in Saudi Arabia and to investigate and classify the sociodemographic, environmental, dietary, and clinical determinants associated with vitamin D deficiency in children.

Research Methodology:-

Research Question:-

As per the Based on the demand of topic and description given above, following are the respective research questions:

1. What is the estimated rate of vitamin D deficiency among children attending pediatric outpatient clinics in different areas of Saudi Arabia?

2. What sociodemographic factors (age, gender, rural versus urban, etc.) are the most prevalent factors associated with vitamin D deficiency in children in Saudi Arabia?
3. What influence do lifestyle factors, such as sun exposure, activity levels, and screen time, have on vitamin D deficiency in this population?

Search Strategy:-

Researcher had tried to search for all the available avenues, though mostly electronic databases were searched but then again for the sake of identification other sources were also searched. Some of the electronic databases are as follows:

- PubMed
- Cochrane Library
- ClinicalTrials.gov
- EMBASE
- Saudi Medical Journal
- King Saud University Repository

As far as the references are concerned, the researcher had particularly focused on the genuine references, based on the categories, time and location. Other than this, specific timeline of the relevant studies have been decided in advance i.e. the studies conducted during the period of 2005 to 2024. the search criteria included an important condition that all the studies should be published or presented in either English or Arabic.

Types of Studies Included:-

Based on the topic of study the researcher had decided on the respective type of study as well, the topic is related to the identification of vitamin D deficiency in children, the prevalence and the associated factors in a pediatric outpatient clinic hence most of the studies selected were based on the same in Saudi Arabia and the MEA region.

Related avenues of the same are mentioned below:

- Review studies, including identification, prevalence, cure, and associated factors in a pediatric OPD in the hospitals of Saudi Arabia,
- Some cross sectional studies to look for the identification, prevalence and associated factors in a pediatric OPD in the hospitals of Saudi Arabia
- Few case studies were also included to find the association between the factors related to deficiency of vitamin D in children.

Some of the intervention focused studies were also selected for better association of factors, as this present study focuses on prevalence, cure, and associated factors in a pediatric OPD in the hospitals of Saudi Arabia hence the studies conducted outside Saudi Arabia or MEA were excluded, rather some of the international studies were included to present the global prospects.

Prticipants:-

The study includes primarily sociopathic or asymptomatic pediatric patients from 0 to 18 years old, and from outpatient hospital clinical and or in-home clinic settings throughout Saudi Arabia. These patient populations consisted of healthy children in the context of attending their well-child check (i.e., attending the annual well child care visit) and the presentation of children with non-specific symptoms (i.e., fatigue, musculoskeletal pains and aches, recurrent infections encountered in but not limited to signs of vitamin D deficiency). Data was collected based on the different demographics of age groups (i.e., babies, school aged, adolescents), gender, and area of urban or rural residency.

Keywords:-

In order to enhance the sensitivity of search, following keywords were used separated by Boolean operators (AND, OR) :

"Vitamin D deficiency" AND children, "Vitamin D deficiency" AND Saudi Arabia", AND "pediatric outpatient clinic", children AND "nutritional status" OR "micronutrient deficiency", Saudi Arabia AND "sun exposure", "child health" OR "public health policy", adolescents AND "vitamin D status" OR "bone health", "clinical implications" AND "pediatric population".

Study Selection Process:-
Researcher had prepared a format for recording the relevant information, main heading include, design of study and location, demographics of the patients and number, specific measures of outcome, like effectiveness of treatment procedure, long term and short term effects, etc. At this level, the studies were allotted certain codes for the sake of differentiation. At a later stage some of the studies were found to be duplicate and removed.

Data Management:-
The information cited in this review was derived from available peer-reviewed literature, clinical trials, and institutional reports regarding Vitamin D deficiency in children, its identification, prevalence, cure, and associated factors in a pediatric OPD in the hospitals of Saudi Arabia. A standardized data extraction form was created to extract relevant key variables, such as study design, sample size, type of biologic agent, clinical outcomes and details of patient. Data were extracted to Microsoft Excel, and data were independently verified by two reviewers for accuracy, and consensus was reached when necessary. Reference managing and formatting followed NLM style by utilizing EndNote software.

Results:-
A total of 122 research studies were identified, all of them were based on the reports regarding identification, prevalence, cure, and associated factors in a pediatric OPD in the hospitals of Saudi Arabia. Out of these identified studies, 15 were removed because of duplication of records, references and location and 18 studies were marked as ineligible, as not including the concept of Vitamin D deficiency in children or related terms of prevalence, cure, and associated factors in a pediatric OPD in the hospitals of Saudi Arabia and 9 for some other unavoidable conditions.
Source: Page MJ, et al. BMJ 2021;372:n71. doi: 10.1136/bmj.n71 https://creativecommons.org/licenses/by/4.0/
Further 80 records were saved for screening, then in the screening process 41 records were further removed on the basis of exclusion criteria stated above. Total studies finalized for review were 39. No reports were included in the study. A large retrospective study conducted at King Khalid Hospital in Majmaah covering the years 2017-2021 reported a period prevalence of 67.3% of vitamin D deficiency (out of a sample size of 22,335 individuals, including children). **[13], [14]** Of these individuals, 28.1% had adequate levels of vitamin D and were classified as insufficient (20-29 ng/mL), 35.9% classified as deficient, and 3.3% classified as severely deficient. The age group of 10-19 years was identified as the most impacted group of the cohort with a mean serum 25(OH)D level of 21.1 ± 11.9 ng/mL. **[11], [8], [14]** The study reported significantly affected individuals were female (69.5%), while males were not as significantly affected (30.5%).

In another cross-sectional study conducted over three regions of the Kingdom of Saudi Arabia: Central, Western (Makkah) and Eastern, the prevalence of vitamin D deficiency was reported as 49.5% of school students, and 44% in employees. **[17], [16], [12]** The primary risk factors identified were consistent between studies, and included; female gender, in the adolescent group (16-19 years), urban living conditions, low socio-economic status and obesity. The study reported notably high rates of deficiency amongst children in the Eastern region of the Kingdom of Saudi Arabia which may be attributed to decreased sun exposure and dietary practices. **[8], [15]** In a separate study, the most prevalent contributing factors identified were; limited sun exposure due in part to an indoor lifestyle; conservative clothing limiting sun exposure; poor dietary intake of vitamin D foods; and a lack of consumption of fortified products etc.Majmaah's research found that deficiency rates had decreased from 32% in 2017 to 9% in 2020, before rising again to 18% which might be reflective of successful awareness and screening. **[19], [20], [15]** The authors talk at length about the multi-facting causes of vitamin D deficiency in children in Saudi Arabia, but encourage the intervention nonetheless. The deficiency results highlight the issue of screening and prevention in what is primarily an outpatient population. **[16]**

Discussion:-
Vitamin D deficiency (VDD) in children is a perplexing public health issue in Saudi Arabia: the rates of deficiency are high, even in the presence of abundant sunlight. **[17]** The intention of this review is to gather data from range of studies that report generally high prevalence rates in children, which range, for pediatric outpatient populations, from approximately 30% to more and greater than 80%. **[18], [19]** Certainly, these data lend themselves a better conceptualization of thinking about VDD in children as more of a complex multi-factorial status that operates in the context of a range of socio-culture, environmental, and clinical factors as opposed to one thinking about the problem simply as a nutritional condition. **[20], [21]** One significant finding presented in the data is that they provide evidence for the vulnerability of adolescent females. **[22]** There is ample reporting in the studies that this subgroup

experience significantly higher rates of deficiency, and several studies highlight an issue plaintiff to some cultural norms that favor limited exposure of the skin to sunlight, indoor cultural activities, and the potential changes to metabolism that is recognized during puberty. **[23], [19], [24]** It is likely that those children living in urban setting suffer from greater rates of deficiency due to also less incidental exposure to sunlight, as those children often reside in high-rise, air conditioned interiors while having limited exposure to outdoor areas. **[25]**The fundamentals of nutrition also comes into play. The conventional Saudi diet typically has high levels of carbohydrates and fats that are lacking in obtaining vitamin D from rich sources such as fatty fish, fortified dairy or egg yolks. The increasing level of prepared and processed foods and sodas, especially in children, may infringe up on calcium absorption or bone health. **[26], [18], [15]** There is poor use of vitamin D supplementation overall and, in general, a lack of supplements in younger children that reflects parental awareness and inconsistency based clinical advice.

In practice, VDD can appear insidious often associated with minimal signs of fatigue, irritability, musculoskeletal pain, or infections and, thus, are overlooked in outpatient clinical practices which can lead to an underdiagnosis. **[27]** That said, there is evidence that screening pediatric clinics can increase the recognition in children at -risk of VDD. For example, the Majmaah study reported a decrease in the rate of deficiency of VDD in the screened cohort, from 32% in 2017 to 9% in 2020; indicating that awareness and effort being applied was making a difference. Another factor to consider is seasonal variation. **[16], [23]** While Saudi Arabia does have sun exposure year-round, serum 25(OH)D values are often at their lowest levels in winter due to less daylight hours and less outdoor time.

This highlights the necessity to have seasonal practices and public health recommendations for safe sun exposure. **[25]** Through a policy perspective, the implications of these findings correspond with Saudi Arabia's Vision 2030 aspirations, which have indicated expectations for preventive health care and children's health. **[18], [11], [27]** Outpatient pediatric clinics can be used as potential leverage points to implement the national action screening protocols, provide education to families of children, and even distribute supplements. Local schools might also bring awareness of vitamin D and healthy choices through school health initiatives and community outreach. The public health issue of vitamin D deficiency among children in Saudi Arabia requires a multi-disciplinary approach. **[19]** An effective multi-disciplinary approach is going to be reliant on children's health care providers and pediatricians collaborating with the public health and education sectors. Through ambulatory outpatient pediatric clinics and leveraging the Saudi Arabia Vision 2030 initiative, it may decrease the public health burden of pediatric vitamin d deficiency, while access to promote healthy outcomes for the next generation.

Conclusion:-

Vitamin D deficiency over an extended period of time in the pediatric population is a recognized but often overlooked condition in Saudi Arabia, despite the country’s abundance of sunlight and commitment to health-related programs. This article outlines the consistent rates of Vitamin D deficiency reported in pediatric patients across various outpatient settings in the Kingdom. Female adolescents, urban residents, and children inhabiting areas with limited time outdoors have been recognized as the most vulnerable populations. The pattern of Vitamin D deficiency also parallels the sociocultural environment, poor dietary practices, and lifestyles that have become sedentary, coupled with public unawareness. Symptoms of Vitamin D deficiency are often subtle and nonspecific in children, which can lead to missed opportunities for early detection and intervention.

Nevertheless, there is evidence from recent studies that targeted screening and treatment methods (particularly in conjunction with outpatient visits) contribute to significantly reducing Vitamin D deficiency rates and improving health outcomes in individuals with Vitamin D deficiency. Seasonal and geographic variability further exemplifies context-based responses. Moving forward, education, promotion of positive lifestyles and habits, and a national screening program for Vitamin D levels could be important steps towards reducing the burden of Vitamin D deficiency among children in Saudi Arabia and improving the health of future generations.

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