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DEPARTMENT OF PUBLIC HEALTH

Vitamin D Deficiency and Associated Factors among Patients Presenting with Nonspecific Musculoskeletal pain and Neurologic Symptoms: A Cross-sectional Study in Asella Town Hospitals, Ethiopia, 2025

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A thesis submitted to the Department of Public Health, College of Health Sciences, Arsi University, in partial fulfillment for the requirement of Master of Public in General Public Health.

JUNE, 2025

ASSELLA, ETHIOPIA.

ARSI UNIVERSITY

COLLEGE OF HEALTH SCIENCES DEPARTMENT GENERAL PUBLIC HEALTH.

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Title of the research project	Vitamin D Deficiency and Associated Factors among Patients Presenting with Nonspecific Musculoskeletal pain and Neurologic Symptoms in Asella Town Hospitals, Ethiopia, 2025
Duration of project	June 1, 2025 to November 30; 2025
Study area	Assela Rhobot general hospital and Arsi university referral and teaching hospital medical and neurology follow up clinic
Total cost of project	44,000 ETB
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Acknowledgement

Above all, I thank Almighty God, the architect of my life, whose grace and guidance made this work possible. I would also like to express my sincere appreciation to Arsi University, College of Health Sciences, Department of Public Health, for accepting my research proposal and giving me the opportunity to pursue this study. My deepest gratitude goes to my advisors, Dr. Gebi Husein and Mr. Tewodros Desalegn, for their invaluable guidance, encouragement, and constructive feedback throughout the development of this research project.

I would also like to extend my heartfelt thanks to the two study hospitals namely Asella Teaching and Referral Hospital and Asella Rehoboth Hospital for their cooperation and support during data collection. My sincere appreciation goes to the OPD nurses at neurology and rheumatology OPDs from both hospitals who diligently served as data collectors and contributed greatly to ensuring high-quality data. Special thanks are also due to the senior laboratory technologists of Asella Teaching and Referral Hospital and Asella Rehoboth Hospital, whose professionalism and technical expertise in processing and analyzing serum samples played a crucial role in the accomplishment of this study.

Acronyms and Abbreviations

1, 25 (OH) 2 D: 1, 25-dihydroxy vitamin D

25OHD: 25-hydroxy vitamin D

ALP: Alkaline phosphatase

ARH-Assela Rehoboth hospital

ARTH-Assela referral and teaching hospital

BMI: Body man index

ELISA: Enzyme-Linked Immunosorbent Assay

FGF-23: fibroblast growth factor 23

IGF1: insulin like growth factor 1

IGFBP3: insulin like growth factor binding protein 3

PTH: parathyroid hormone

RANKL: receptor associated nuclear factor κβ ligand

SOP: standard operational procedure

TRPV6: transient receptor protein cat ion channel subfamily V member 6

UV: ultraviolet

VDBP: vitamin D binding protein

VDCC: voltage dependent calcium channel

VDRE: vitamin D response elements

VDR: vitamin D receptor

WC: waist circumference

Abstract

Background: Vitamin D deficiency; an established contributor to nonspecific musculoskeletal and neurological symptoms; is increasingly reported even in tropical regions such as Ethiopia despite abundant sunlight. However, little is known about its burden among adults presenting with these symptoms in southeast Ethiopia. This study addresses this gap by assessing the prevalence of vitamin D deficiency and its associated factors among adults attending hospitals in Asella Town with these symptoms.

Methods: A cross-sectional study was conducted among 200 adults presenting with nonspecific musculoskeletal pain or neurological symptoms at Assela Referral Hospital and Rehoboth General Hospital. Participants were selected using convenience sampling, enrolling eligible adults who presented to the study hospitals from June 1 2025 to October 30, 2025. Data were collected using a structured, Kobo-based questionnaire administered by trained data collectors. Serum 25-hydroxyvitamin D levels were measured using an ELISA assay following standard procedures. Data were exported, cleaned, and analyzed in SPSS version 26. Descriptive statistics summarized participant characteristics and vitamin D deficiency prevalence using frequencies, percentages (for categorical variables) and means with standard deviations (continuous variables). Bivariate analysis identified crude associations, and variables with $p < 0.25$ were included in a multivariable analysis model. Statistical significance was determined using adjusted odds ratios (AOR), 95% confidence intervals (CI), and p-values < 0.05.

Results: Among 200 adult participants, 129 (64.5%; 95% CI: 57.6–71.4%) had vitamin D deficiency (<20 ng/ml) and 60 (30%; 95% CI: 23.8–36.7%) had insufficiency (20-30 ng/ml). After adjustment, Participants exposed to sunlight for ≤30 minutes per day had more than 4 times odds of Vitamin D deficiency compared with those exposed to >30 minutes per day (AOR = 4.42; 95% CI: 1.04–8.77). Individuals who rarely consumed vitamin D–rich foods (fish, eggs, dairy) had almost 4-fold increased likelihood of Vitamin D deficiency (AOR = 3.83; 95% CI: 1.57–9.32). Participants who did not engage in physical activity were nearly 3 times likely to be Vitamin D deficient (AOR = 2.81; 95% CI: 1.52–5.59). Sunscreen use (AOR = 2.74; 95% CI: 1.14–6.54), higher BMI (AOR = 1.18 per 1 kg/m²; 95% CI: 1.01–1.37), and greater pain severity (AOR = 3.63 per 1-point increase; 95% CI: 2.11–5.91) are significant independent predictors.

Conclusion: prevalence of Vitamin D deficiency was high among study participants and was primarily related to modifiable behavioral factors such as inadequate sunlight exposure, obesity, and sunscreen use and poor intake of vitamin d rich foods. Public health interventions emphasizing safe sun exposure, healthy body weight, and dietary vitamin D intake are recommended to mitigate the burden of vitamin D deficiency and its impacts.

Keywords: Vitamin D deficiency, risk factors, nonspecific musculoskeletal pain, Ethiopia

1. Introduction

1.1 Background

Vitamin D is a fat-soluble vitamin that promotes calcium and phosphorus absorption in the gut, thereby maintaining normal serum calcium and phosphate concentrations and enabling normal bone mineralization, bone growth, and remodeling (1) . Vitamin D is cholesterol resembling an important micronutrient molecule that physiologically regulates Calcium, Phosphorous, and bone metabolism and regulates many other cellular functions. The VDR is nearly universally expressed in nucleated cells (2). Once vitamin D is ejected out of the plasma membrane into the extracellular space, it binds to the vitamin D binding protein. Soluble essential vitamin that regulates calcium homeostasis and is crucial for human health across all ages (3 ,4).

Vitamin D is gained from exposure of skin to sunlight, diet, and dietary supplements. Humans receive 80 – 90% of their vitamin D supply through ultraviolet B sunlight exposure of the skin and the rest through vitamin D-containing foods (4). Exposure of human skin to solar UVB radiation leads to the conversion of 7-dehydrocholesterol to previtamin D_3 in the skin. Previtamin D_3 is then rapidly converted to vitamin D_3 by UVB radiation which is the most important and main source of vitamin D for the body(5).

Many foods and dietary supplements contain vitamin D naturally, and it can be produced endogenously through vitamin D synthesis when the skin is exposed to the ultraviolet rays of sunlight (6). Vitamin D2 can only be supplied through certain foods naturally containing vitamin D in significant amounts including oily fish such as salmon, sardines and tuna, and oils of the liver of some fish or supplements of animal origin (e.g. cod liver oil, oily fish, egg yolk), fortified foods, and supplements(7). Fortified foods with vitamin D3 at different levels include fortified breakfast cereals, fortified butter, fortified cheeses, fortified margarine, fortified milk, fortified orange juice, fortified yogurts, infant formulas and fortified breakfast cereals (8). Vitamin D2 and vitamin D3 are available as oral over-the-counter supplements like Vitamin D2 50,000 IU/capsule and Multivitamin 1000 IU vitamin D3 supplements(9).

Research suggests that vitamin D deficiency may contribute to muscle weakness, fatigue, and an increased risk of falls in older adults. Supplementing with vitamin D has been shown to improve muscle performance and reduce the incidence of musculoskeletal injuries in various populations

(10). A serum concentration of less than 30 nmol/L of 25(OH) D, which is the best indicator of vitamin D levels, is considered inadequate for the general health and wellbeing of adults. Vitamin D deficiency is defined as a 25(OH) D below 20 ng/ml (50 nmol/liter), and vitamin D insufficiency as a 25(OH) D of 21–29 ng/ml (525–725 nmol/liter. Vitamin D deficiency can be considered as Severe deficiency when serum 25(OH) D is < 12ng/ml(11).

1.2. Statement of the problem

The prevalence of Vitamin D deficiency in the world is estimated to be between 25% and 50 % among patients with musculoskeletal disorders (12). It has been reported that 30-50% of both children and adults in the United States, Canada, Europe, Australia, New Zealand, and Asia are vitamin D-deficient(13). Despite the important role of sunlight in vitamin D synthesis, recent studies have shown that the rate of vitamin D deficiency is also higher in the sunniest areas of the world, including the Middle East countries, such as Saudi Arabia, Qatar, and United Arab Emirates, Turkey, India, and Iran because of low exposure to sun due to cultural factors (14). Dark-skinned ethnic groups within Europe are also worryingly at much increased risk of vitamin D deficiency compared to their white counterparts in the range 28–65%, depending on the country and the ethnic group (15).

The relationship between vitamin D deficiency and musculoskeletal pain has been well-documented in the literature(16). Vitamin D deficiency appears to be more prevalent among patients with chronic musculoskeletal pain. In 2016 musculoskeletal disorders are the second cause of disability worldwide with back pain as the most frequent condition. The disability due to musculoskeletal condition has increased by 19% from 2006 to 2016 and is expected to rise in sedentary and aging people(17).

A large cross-sectional study in Turkey found that 74% of 14,925 patients with widespread musculoskeletal pain had vitamin D deficiency(18). Cross-sectional study in the Pakistan reported that 93% of 150 patients with persistent musculoskeletal pain had vitamin D deficiency (19) . A meta-analysis of observational study published in 2015 by Ming-Yen Hsiao and colleagues summarized that there was significantly higher risk of vitamin D deficiency in patients with chronic widespread pain than the control group(20) .

Despite ample sunshine throughout the year, one-third to one half of individuals living in Sub-Saharan Africa and the Middle East have serum 25-hydroxyvitamin D levels <25 nmol/l (21). A systematic review done in 2018 reported varying rates of vitamin D deficiency across different regions in Africa, with a significant proportion of patients presenting with musculoskeletal and neurologic symptoms (22). Studies conducted in Nigeria and South Africa, have shown a higher prevalence of musculoskeletal pain among individuals with low vitamin D levels(23),(24) .

Musculoskeletal conditions produce severe long-term pain with prolonged untreated or under-treated chronic pain can have significant negative physical impacts like long term activity limit, sleep disturbance and physical fatigue, psychological impacts like pain related anxiety and fear (25). Vitamin D status has become an essential aspect of primary care. Vitamin D deficiency and insufficiency can be both corrected and prevented safely through supplementation (26). Vitamin D deficiency in its chronicity may lead to osteomalacia and a compensatory secondary hyperparathyroidism(27) . Vitamin D deficiency itself has been reported to cause muscle pain and bone pain (28).

Vitamin D exerts its genomic effect on target tissues including intestine, bone, kidneys and Parathyroid gland and other non-classical tissues through the body that express its receptor in muscle and neurons (29). The direct effect of 1, 25(OH) 2D on muscle cells, neurons, neutrophils, prostaglandin and nitric oxide is also another mechanism(30). Adult bones undergo a constant state of remodeling. Decreased levels of 25(OH) D facilitate osteoclast genesis with consequent increased bone resorption. Bone pain and proximal muscle weakness with gait instability are characteristic of osteomalacia. Decreased levels of 25(OH)D have been shown to be directly related to low bone density in the hip (31).

In resource limited countries like Ethiopia, it is difficult to screen for vitamin D deficiency for every individual but screening for at least patients with symptoms of vitamin deficiency can identify patients with nonspecific musculoskeletal pain symptoms who can benefit from vitamin D supplementation (32).Vitamin D deficiency and its associated risk factors among patients with nonspecific musculoskeletal pain symptoms are largely under-studied in Africa despite the continent having a high burden of vitamin D deficiency (33). Despite Ethiopia being rich with 13 months of sunshine there is a high prevalence of vitamin D deficiency in the general population, with studies indicating that up to 70% of individuals may be deficient in this essential

nutrient(34) .Limited numbers of institutional based studies in Ethiopia done in Addis Ababa reported 88 % prevalence of vitamin D deficiency among patients presenting with musculoskeletal and neurologic symptoms ((28),(36)) Therefore, assessing prevalence of vitamin D deficiency in different cultured communities and associated risk factors among patients with nonspecific musculoskeletal pain symptoms is crucial in southeast Ethiopian context to get specific data from those coming from rural areas of the country.

1.3 Significance of the study

Measuring vitamin D among patients with nonspecific musculoskeletal pain symptoms is important to identify patients who can benefit from vitamin D supplementation therapy. Vitamin D is measured rarely in Ethiopia in spite of suggestions by Endocrine society guidelines to screen for vitamin D deficiency for individuals at risk of deficiency. The data generated from this research will show the prevalence of vitamin D deficiency and its associated risk factors in patients with nonspecific musculoskeletal pain symptoms from participants coming from all over Arsi and nearby areas. Therefore, determining prevalence and risk factors of Vitamin D deficiency will alert clinicians and health policy makers to give attention to this problem and initiate the need for further research, appropriate intervention and its inclusion as part of routine diagnosis in patients with nonspecific musculoskeletal pain symptoms. This information can guide healthcare providers in developing targeted interventions to improve vitamin D status and overall health outcomes in this patient population. Furthermore, the finding of this study will also provide data for future research among this population with a large sample size

2.Literature review

2.1. Overview of Vitamin D and its Deficiency

Vitamin D maintains bone health by involving both in bone formation and resorption processes. To maintain serum calcium homeostasis vitamin D is also involved in mobilization of Ca and P from bone by stimulating osteoclast genesis (35). Vitamin D plays a crucial role in the regulation of calcium, phosphorus, bone health, and muscle function (36). The active form of vitamin D, calcitriol, facilitates the absorption of calcium and phosphorus in the intestines by up regulating the expression of calcium-binding proteins and phosphate transporters. This process ensures adequate mineralization of bones and teeth, as well as proper neuromuscular function (37). Deficiencies in vitamin D can lead to impaired calcium and phosphorus absorption, resulting in skeletal abnormalities such as rickets in children and osteomalacia in adults (38).

Cross sectional study in the USA by Gregory A. *et al* reported prevalence of vitamin D as 93 % among patients with persistent, nonspecific musculoskeletal pain(39). Another systematic review and meta-analysis of 29 studies published in the year 2017 by Joshua Zadro and colleagues summarized that there is strong association between vitamin D deficiency and low back pain (40). Gorter EA *et al* conducted a cross-sectional study in Netherland from 2012 to 2013 which showed out 527 participants with fracture, 31 % had insufficient and 40 % had a vitamin D deficiency, of whom 11 % of the total group had a severe vitamin D deficiency(41).

A cross-sectional study on 174 Switzerland chronic patients by Von Känel P *et al* reported 92% of the participants had vitamin D level below 30ng/ml from which 71% were vitamin D deficient and 21% vitamin insufficient (42). Of 218 premenopausal women with common musculoskeletal pain and unknown etiology studied by Halim Yilmaz and colleagues in Turkey, 79.8% were detected with vitamin D deficiency (43). Another cross-sectional study by Muharrem Çidem and colleagues Turkey patients with widespread musculoskeletal pain showed the prevalence of vitamin D deficiency of 73.9% while it was 90%) for vitamin D inadequacy; 70% deficiency and 20% had insufficiency (44). Different descriptive analytic study performed on adult patients with musculoskeletal pain symptoms showed vitamin D deficiency in 95.4 % of Iran patients, 85.35% of Iraq patients, 80% -88.4% of Pakistan patients, with mean levels of 15.855± 4.918 ng/ml (45).

A meta-analysis of observational study published in 2015 by Ming-Yen Hsiao and colleagues which included twelve studies comprising 1,854 patients with chronic widespread pain summarized that there was significantly higher risk of vitamin D deficiency than the control group (46). The association between vitamin D concentration and pain: a systematic review and meta-analysis by Z Wu *et al* in 2018 from Eighty-one observational studies with a total of 50,834 participants concluded the odds of vitamin D deficiency was increased for arthritis, muscle pain and chronic widespread pain, but not for headache or migraine, compared with controls (47).

Demiryurek BE and Gundogdu AA. in their case control study included 36 patients with mild carpal tunnel syndrome and 40 without carpal tunnel syndrome in 2016 found significantly lower vitamin D levels in the mild carpal tunnel syndrome patients than those electro-physiologically normal subjects (48). Noha T. Abokrysha studied 30 women diagnosed with fibromyalgia in Saudi Arabia in 2011 showed mean vitamin D level of 4.76 +/- 1.46 ng/mL and significant negative correlation between vitamin D level and widespread pain index (49).

A study done in south Australia by Jill Benson and colleagues in 2005 on eight cases with muscle pain and eight age and sex matched controls showed that all the eight patients with muscle pain had lower vitamin D levels than those without muscle pain (50). A systematic review and meta-analysis by Mauro *et al* (2022) found a significant correlation between vitamin D deficiency and musculoskeletal pain in various patient populations, including individuals with fibromyalgia, chronic widespread pain, and nonspecific musculoskeletal pain(51),(54).

Among Ethiopian studies Vitamin D Levels in Patients Presenting with non-Specific neuromuscular Pain and Fatigue in Ethiopia by Guta Zenebe reported all of the study participants had vitamin D deficiency, in which more than half of them had severe hypovitaminosis D (52). A cross-sectional study was conducted among patients with nonspecific musculoskeletal pain symptoms from March to May 2018 at TASH by Amanuel Dubale showed that among the total 75 study participants with nonspecific musculoskeletal pain symptoms, 66 (88%) had vitamin D deficiency(53).

2.2. Factors associated with vitamin D deficiency

The literature review revealed several key risk factors associated with vitamin D deficiency on a global scale. These include limited sunlight exposure due to factors such as urbanization, air

pollution, and indoor lifestyles. Other risk factors include dark skin pigmentation, older age, obesity, malabsorption disorders, inadequate dietary intake, chronic kidney disease, medication use, and geographic location in regions with limited sunlight exposures (54).

2.2.1 Socio-Demographic Factors

The amount of vitamin D production in the skin depends on the incident angle of the sun and thus on latitude, season and time of the day. It is highest when the sun is at the zenith and a flattening of the incident angle leads to a reduced vitamin D production (55). Other factors influencing cutaneous vitamin D production adversely are an increase in skin pigmentation, aging, especially age >65 years and the topical application of a sunscreen (56). Screening for vitamin D levels in patients presenting with musculoskeletal pain symptoms may help identify individuals at risk of deficiency and guide appropriate treatment strategies (57).Supplementing with vitamin D, either through sunlight exposure, dietary sources, or supplementation, may alleviate musculoskeletal pain or improve overall musculoskeletal health (58).

Factors associated with vitamin D deficiency includes mostly due to decreased sunshine exposure, deprivation of sunlight, decline in coetaneous synthesis of vitamin D due to aging, decrease in renal hydroxylation, melanin pigmentation, solar length angle, latitude, season and time of the day(59).The other factors for vitamin D deficiency includes low intake of foods fortified with vitamin D, obesity, smoking, pollution, exercise, use of drugs (e.g. anti-epileptic drugs and antituberculosis drugs or diseases that accelerate vitamin D metabolism, renal insufficiency, mal-absorption syndromes, and chronic liver diseases (60). The elderly and people with dark skin need increased sunlight exposure time (twofold to 10-fold) for vitamin D synthesis compared with fair-skinned young individuals (61). A review by A. Mithal *et al* summarized as older age; female sex; darker skin pigmentation; factors that determine sunlight exposure, such as clothing and cultural practices; dietary habits; and national policies of vitamin D fortification are risk factors for vitamin D deficiency(61).

A study by done in India also showed significantly high vitamin D deficiency among females, (AOR) of 2.8 (95% CI: 1.9–4.2), indicating that females were nearly three times more likely to be deficient compared to males(62) .A retrospective study done in 2023 showed that there was significant mean vitamin D difference between females and males (63). Similarly, Fadheela T,

Al- Mahroos and colleagues conducted a study in Bahrain, which demonstrated that individuals with high income had an AOR of 1.6 (95% CI: 1.1–2.4) for vitamin D deficiency (64).

2.2.2 Behavioral and Lifestyle Factors

Smoking was associated with an AOR of 1.7 (95% CI: 1.1–2.5)(65), lack of sun exposure with an AOR of 2.2 (95% CI: 1.5–3.3), and a high body mass index (BMI ≥30) with an AOR of 1.9 (95% CI: 1.2–3.0) for vitamin D deficiency(66). A randomized controlled trial by Ellis *et al.* (2018) demonstrated that vitamin D supplementation improved pain scores and physical function in patients with nonspecific musculoskeletal pain compared to placebo (67). Paul S. McCabe *et al.* recruited 3369 men aged 40–79 between 2003-2005 from eight European centers for a longitudinal study of male ageing and after adjustment for cofounders those in the lowest quintile of vitamin D were more likely to develop chronic widespread pain (68). A cross-sectional study on Under 18-year-old children by Christy B. Turer and colleagues showed Vitamin D deficiency is highly prevalent in overweight and obese children and severely obese (69).

A systematic search of the literature was conducted to identify relevant articles focusing on risk factors associated with vitamin D deficiency in Ethiopia. Those individuals above the age of 50 years, housewives and those on antiepileptic medications tended to have a more severe vitamin D deficiency(32). Feleke *et al* reported that a greater proportion of people in Ethiopia had vitamin D deficiency despite abundant sun availability. The authors also explained low vitamin D among Ethiopians, likely related to the dressing habit, as most people; especially women tend to cover most of their body parts. Vitamin D insufficiency appears to be common among several other populations, including: dark skinned, obese, hospitalized, institutionalized, and individuals who consistently use sun screens and wear protective clothes (33).

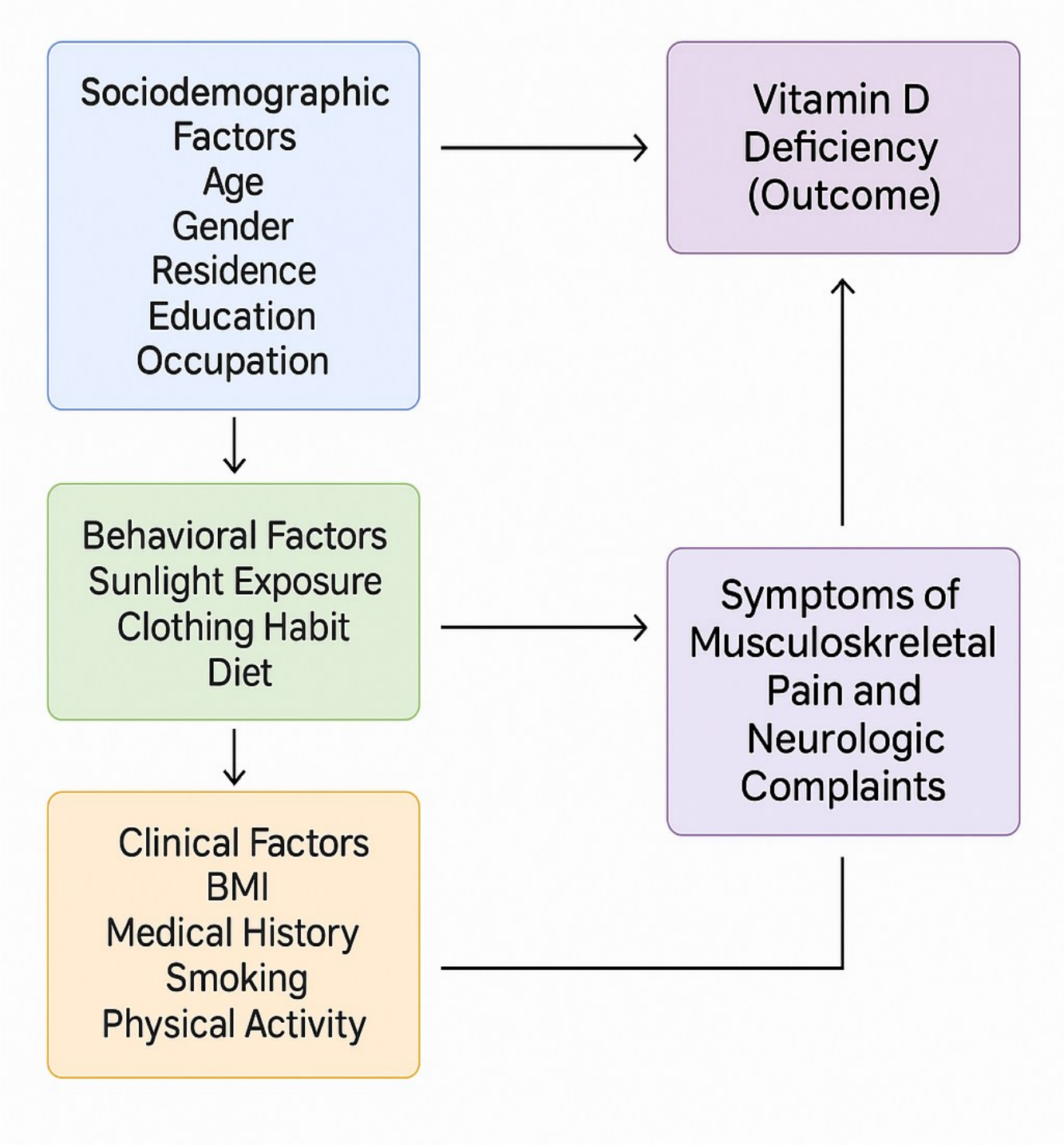

Figure 1 : Conceptual Framework of Factors Associated with Vitamin D Deficiency Among Adults with Nonspecific Musculoskeletal Pain (modified from advisors, *et.al* (70)

3. Objective

3.1. General objective

To assess Vitamin D Deficiency and associated factors among Patients Presenting with nonspecific musculoskeletal pain and neurologic symptoms in Asella Town Hospitals, Ethiopia,2025

3.2. Specific objectives

To assess vitamin D deficiency among patients with nonspecific musculoskeletal and neurologic pain symptoms in Asella Town Hospitals, Ethiopia, 2025.

To determine factors associated to vitamin D deficiency among patients with nonspecific musculoskeletal and neurologic symptoms in Asella Town Hospitals, Ethiopia, 2025.

4. Methods and materials

4.1 Study Area

One of the study hospitals was Arsi University Referral and Teaching Hospital, which was founded in 1964; renovated in 1992 by Ethio-Italian cooperation; and starting from 2014, it is a teaching hospital for the newly founded Arsi University, situated in Asella Town, 175 km southeast of Addis Ababa. The hospital has 321 beds and acts as a medical referral center for a population of over 3.5 million inhabitants in the Arsi Zone and its surroundings(71,72). The outpatient service includes a number of clinics from each clinical department. Under the department of Internal Medicine, there are a number of medical outpatient clinics and senior referral follow-up clinics. The medical follow-up services of ARTH are organized into two main parts: The General OPD, which operates five days a week. A Neurology Follow-up Clinic, which operates two days per week and manages over 100 patients weekly.

The other study area was e Asella Rehoboth General Hospital, which was established in the year 2000 GC. Since 2014, Rehoboth General Hospital has served as a teaching hospital for the newly established Asella Rehoboth and Harme College. The hospital is located in Asella Town, approximately 175 km southeast of Addis Ababa. Asella Rehoboth General Hospital has a capacity of 125 beds and functions as a referral center for over 3.5 million people living in the Arsi Zone and surrounding areas(73). Its outpatient services include a variety of specialized clinics including neurology and rheumatology clinics which are working five days per week with 2 seniors,2 general practitioners and three nurses serving about 60 patients weekly.

4.2 Study Period

This study was conducted from June 1, 2025 to November 30; 2025

4.3 Study Design

A Cross-sectional study design was used.

4.4.1 Source population

All patients who visited neurology and rheumatology clinics was included in the study.

4.4.2 Study population

All adult patients who visited ARH and ATRH neurology and rheumatology clinics for nonspecific musculoskeletal pain symptoms during the study period and meet the inclusion criteria were our study populations.

4.4.2.1 Exclusion and inclusion criteria

4.4.1. Inclusion criteria

All adult patients who came with nonspecific musculoskeletal pain symptoms in ARTH and Rehoboth neurology and rheumatology clinics are capable of independent communication to give informed consent with none of the following exclusion criteria.

4.4.2. Exclusion criteria

Patients with age of less than 18 years old

Patients on vitamin D supplementation therapy

Patients on calcium supplementation therapy

Patients on multivitamin therapy

Patients with known rheumatologic diseases, trauma and anatomic skeletal malformations.

4.4.3 Sample size determination

The actual sample size for this study was calculated using the single population proportion formula, assuming a 5% margin of error (d = 0.05), a 95% confidence level (Zα/2 = 1.96), and a proportion (p) of 88% based on a previous cross-sectional study conducted at Tikur Anbessa Specialized Hospital (TASH) from March to May 2018 by Amanuel Dubale. In that study, 66 out of 75 patients (88%) presenting with nonspecific musculoskeletal pain symptoms were found to have vitamin D deficiency (74). Using the standard formula: $N= Z^2 \cdot p \cdot q / d^2$

where: Z=1.96 (for 95% CI), p=0.88 (proportion of vitamin D deficiency), q=1−p=0.12 d=0.05

Substituting the values'$N= \frac{(1.96)^2 \cdot (0.88) \cdot (0.12)}{(0.05)^2} = 183$

By adding a 10% non-response rate, the final sample size was adjusted to **200** participants to ensure adequate statistical power and compensate for potential data loss or incomplete responses.

4.5 Sampling method

Participants were selected using convenience sampling, enrolling eligible adults who presented with nonspecific musculoskeletal pain and/or neurologic symptoms with all inclusion criteria and none of the exclusion criteria at the selected two hospitals during the study period until the desired sample size was reached.

4.6 Dependent and independent variables

4.6.1. Dependent variables

Vitamin D deficiency

4.6.2. Independent variables

Sociodemographic factors like age, sex, residence, educational level, Occupation, Monthly income, Clinical Factors like duration of musculoskeletal pain, Presence of neurologic symptoms, BMI, Chronic illness, Lifestyle and Behavioral Factors like, sunlight exposure (duration and time of day), Physical activity level, dietary habits, use of sunscreen, smoking status, alcohol consumption. Supplementation and Medication like Vitamin D supplements, Use of medications affecting Vitamin D metabolism (anticonvulsants, glucocorticoids)

4.7 Operational definitions

Nonspecific musculoskeletal pain refers to pain affecting muscles, bones, joints, ligaments, or tendons for which no identifiable specific cause such as trauma, infection, inflammatory disease, tumor, fracture, or structural abnormality can be established after clinical evaluation(75).

Neurologic symptoms are defined as subjective sensory or cognitive complaints reported by the participant, including numbness, tingling (paresthesia), fatigue, headache, dizziness, or difficulty concentrating, without an immediately identifiable neurologic diagnosis at presentation(76,77).

BMI is calculated as weight (kg) / height (m^2) and classified based on WHO standards as Underweight: <18.5 kg/m^2, Normal: 18.5–24.9 kg/m^2, Overweight: 25–29.9 kg/m^2 and Obese

when BMI ≥30 kg/m² (75,76). WC is measured at midpoint between last rib and iliac crest. Normal WC is when it is ≤94 cm and Central Obesity is considered when it is >94 cm(78).

Vitamin D Deficiency is defined by a serum 25-hydroxyvitamin D [25(OH)D] level of less than 20 ng/mL (50 nmol/L), while vitamin D Insufficient is defined by serum vitamin D level 21–29 ng/mL and it considered as Sufficient if serum vitamin D is ≥30 ng/mL(79).

Sunlight exposure refers to direct sun exposure between 10:00 AM and 3:00 PM for at least 30 minutes per day, occurring on ≥3 days per week. The daily exposure ≤30 minutes/day is considered as low exposure (80).

Physical activity is defined as engaging in moderate-intensity physical movement for at least 150 minutes per week, consistent with the WHO recommendations for adults (81).

Dietary intake of vitamin D–rich foods (including fish, eggs, and dairy products) was categorized according to the participants' reported frequency of consumption. Intake was classified as "Often" when these foods were consumed≥3 times per week, "Sometimes" when consumed one to two times per week, and "Rarely" when consumed less than once per week or not at all(82).

Chronic illness was defined as a self-reported or physician-diagnosed condition lasting ≥3 months, such as diabetes, hypertension, kidney disease, or other long-term health problems (83) .

4.8 Data collection Tools and procedures

Data was collected using a structured questionnaire designed to capture information on demographic characteristics, medical history, dietary habits, sun exposure, and symptoms related to musculoskeletal pain and neurologic conditions. The tool was adapted from previously validated instruments used in similar studies conducted in low- and middle-income countries, including Ethiopia (70). The questionnaire content was refined through expert review by a panel of public health, clinical, and research professionals at Arsi University to ensure content validity and cultural appropriateness.

A digital, paper-free approach was employed using Kobo Collect, a mobile-based platform that supports structured and secure offline data collection. The pre-programmed questionnaire was deployed on tablets or Android smartphones and administered by three trained degree-level nurse

professionals. Data collectors were given one-day training session. One experienced supervisor from pupil health was overseen daily activities, verified form completeness, and was troubleshooting technical issues.

Venous blood samples (5 mL) were collected aseptically and processed by trained laboratory technologists from each participant at the main laboratory of Rehoboth General Hospital. Serum was separated by centrifugation and stored at –20°C until analysis. Vitamin D levels were measured using the Enzyme-Linked Immunosorbent Assay method, following the manufacturer's protocol. Results were reported in ng/mL, and vitamin D status was classified based on the Endocrine Society Clinical Practice Guidelines. Data collection was done June 1, 2025 to October 30, 2025, during routine follow-up visits at medical clinics.

4.9 Data quality control

Data quality was controlled by rechecking the questioner to avoid duplications, incomplete information and invalid information before data collection. Regular checkup for completeness and consistency of the collected data was done using a checklist by the supervisor. All laboratory analyses included internal quality controls provided with the ELISA kits. External quality control was performed by re-analyzing 10% of randomly selected samples. Pretests were done at Adama hospital on 5% of the study participants before starting data collection to assess the quality of the questioner.

4.10 Data processing and analysis

Data was checked for completeness and consistency after collected electronically using Kobo Toolbox via mobile devices in the hospitals. Then was subsequently be exported to SPSS version 26.0 for cleaning, coding, and analysis. Prior to statistical analysis, the distribution of continuous variables was assessed for normality through both visual inspection of histograms and statistical tests, including the Kolmogorov-Smirnov and Shapiro-Wilk tests. A p-value ≥ 0.05 will indicate normal distribution.

Descriptive statistics was used to summarize all variables. Categorical data was reported as frequencies and percentages, while continuous data was presented as mean ± standard deviation (SD) for normally distributed variables and as median with interquartile range (IQR) for skewed

distributions. Pearson's correlation was used for parametric data, and Spearman's correlation for non-parametric data. To identify factors associated with vitamin D deficiency, binary logistic regression analysis was performed. Variables with a p-value < 0.25 in the bivariate analysis were included in the multivariate model to control for confounding. The strength and direction of associations was interpreted using Adjusted Odds Ratios (AORs) with corresponding 95% confidence intervals.

4.11 Ethical considerations

Ethical approval for the study was obtained from the Institutional Review Board (IRB) of Arsi University, College of Health Sciences. Approval and support letters were submitted to the Departments of Neurology and Rheumatology at Asella Robot Hospital and Asella Teaching and Referral Hospital. Written informed consent was obtained from all participants prior to data and blood sample collection. Participation was entirely voluntary, based on eligibility criteria, with no coercion or discrimination. Confidentiality was strictly maintained using coded identifiers. Participants were informed of their right to withdraw at any time without consequence. The only minimal risk involved was minor discomfort from venipuncture and time spent during data collection. Individuals diagnosed with vitamin D deficiency was referred for appropriate clinical management. All biological samples were safely disposed of following laboratory waste disposal protocols.

4.12 Dissemination of results

The findings of this study will be disseminated through multiple channels to maximize their impact and utility. A comprehensive report will be submitted to the participating hospitals (both private and governmental) in Asella Town to inform clinical practices and policy recommendations. Results will also be presented at local and national scientific conferences and stakeholder meetings to reach healthcare professionals and public health authorities. Furthermore, the study will be published in peer-reviewed medical or public health journals. A summary of the key findings will be shared with the community in simplified language to promote awareness about Vitamin D deficiency and its risk factors.

5. Results

5.1 Socio-demographic Characteristics

A total of 200 adult participants were included in the study, with a mean age of 46.46 ± 15.40 years. More than half were female 109(54.5%) and the majority were urban residents 112(56%). The mean BMI was 23.6 with SD ± 3.9 kg/m². Farmers constituted the largest occupational group 90(45%), followed by merchants 52(26%) and government employees 46(23%). For analysis farmers and merchants were categorized as outdoor workers, representing 142 (71%) of the participants, while the remaining were classified as indoor workers 58(29%) (Table 1).

Table 1: Socio-demographic and anthropometric characteristics of study participants at ARH and ATRH neurology and rheumatology clinic from June to October 2025 (n=200)

Variable	Category	Frequency (%)
Sex	Female	109 (54.5%)
	Male	91 (45.5%)
Residence	Rural	88 (44.0%)
	Urban	112 (56.0%)
Occupation	Government employee	46 (23.0%)
	NGO employee	12 (6.0%)
	Farmer	90 (45.0%)
	Merchant	52 (26.0%)
Age (years)	18–35	53 (26.5%)
	36–55	97 (48.5%)
	56–99	49 (24.5%)
Monthly income (ETB)	< 4,500	82 (41.0%)
	4,501–14,000	107 (53.5%)
	> 14,001	10 (5.5%)

BMI category	Underweight	11 (5.5%)
	Healthy weight	131 (65.5%)
	Overweight	48 (24.0%)
	Obese	10 (5.0%)
Waist circumference	Normal	165 (82.0%)
	Central obesity	35 (18.0%)

5.2. Life style and clinical characteristics of study participants

The lifestyle and clinical characteristics of the 200 study participants in the two-hospital was analyzed and majority of participants reported limited daily sunlight exposure, with 159**(**79.5%) receiving less than 15 minutes of sunlight per day. Only 21(10.5%) had 15–30 minutes of exposure, and 20(10.0%) exceeded 30 minutes daily. Similarly, 74(37.0%) reported using sunscreen.

Regarding clothing practices, 108(54.0%) wore fully covered clothing while 92(45.5%) were partially covered. About 137 (68.5%) of participants reported no physical activity, while just 73(31.5%) engaged in 1 or more days of activity per week. Dietary practices also showed Only 25(12.5%) reported consuming vitamin D–rich foods like fish, eggs, or dairy products often, while 118(59.0%) consumed them rarely. Lifestyle habits revealed that only 8(4.0%) were current smokers and189(94.5%) were never smokers. Alcohol consumption was also assessed and 167(83.5%) reporting no alcohol consumption.

Most participants 164 (82.0 %) reported no history of chronic illness. Among those 36(18.0%) participants with chronic condition, hypertension14 (7.0%), diabetes 7(3.5%), Chronic respiratory disease 7(3.5%) were the leading known chronic illness. Pain characteristics showed that 92.5% experienced generalized pain, while only 7.5% reported localized pain. 166(88.0%) of participants experiencing pain for more than one month. Neurological symptoms reported by 195(97.5%) of the participants. Pain intensity was assessed bay VAS pain scale and resulted moderate pain for 144(71.5%) participants and severe pain for 56(27.5%) participants (Table 2).

Table 2 :Lifestyle, Clinical, and Behavioral Characteristics of Participants at ARH and ATRH neurology and rheumatology clinics from June to October 2025 (n=200)

Variable	Category	Frequency (%)
Daily sunlight exposure (per day)	<15 min	159 (79.5%)
	15–30 min	21 (10.5 %)
	>30 min	20 (10.0%)
Sunscreen use	No	126 (63.0%)
	Yes	74 (37.0%)
Type of clothing	Fully covered	108 (54.0%)
	Partially covered	92 (46.0%)
Physical activity (days/week)	None	137 (68.5%)
	1–2 days	48 (24.0%)
	≥3 days	15 (7.5%)
Dietary intake of vitamin D–rich foods (fish, eggs, dairy)	Often	25 (12.5%)
	Sometimes	57 (28.5%)
	Rarely	118 (59.0%)
Cigarette smoking	No	189 (94.5%)
	Yes	8 (4.0%)
	Stopped	3 (1.5%)
Alcohol consumption	No	167 (83.5%)
	Yes	28 (14.0%)
	Stopped	5 (2.5%)
History of chronic illness (Any)	No	164 (82.0%)
	Yes	36 (18.0%)
Types of chronic illness	Hypertension	14 (7.0%)
	Diabetes mellitus	7 (3.5%)
	Chronic respiratory disease	7(3.5%)
	Chronic kidney disease	3 (1.8%)
	Other chronic conditions	5 (2.2%)
Nature of pain	Generalized	185 (92.5%)
	Localized	15 (7.5%)
Duration of pain	1–4 weeks	24 (12.0%)
	>1 month	176 (88.0%)
Neurological symptoms	Yes	195 (97.5%)
	No	5 (2.5%)
Pain severity (VAS Scale)	Moderate pain	144 (71.5%)

Variable	Category	Frequency (%)
	Severe pain	56 (27.5%)

5.3 Prevalence of Vitamin D Deficiency

The mean serum 25(OH)D concentration among the 200 adult participants with nonspecific musculoskeletal pain symptoms was 18.53 ± 7.05 ng/mL (95% CI: 17.55–19.51 ng/mL), indicating a high overall burden of vitamin D deficiency. Vitamin D deficiency (<20 ng/mL) was present in 129 participants (64.5%) with a 95% CI of 57.6–71.4%, while 60 participants (30.0%) were vitamin D insufficient (20–29 ng/mL) with a 95% CI of 24.0%–36.5%. Only 11 participants (5.5%) had sufficient vitamin D levels (≥30 ng/mL) (95% CI: 3.1%–9.7%) (table 3).

Comparing hospitals, the first 100 participants from Assela Robot Hospital (private) had a mean serum vitamin D level of 18.31 ± 6.65 ng/mL (95% CI: 16.99–19.63 ng/mL), while the second 100 participants from Asella Teaching and Referral Hospital (government) had a mean level of 18.73 ± 7.48 ng/mL (95% CI: 17.26–20.20 ng/mL).

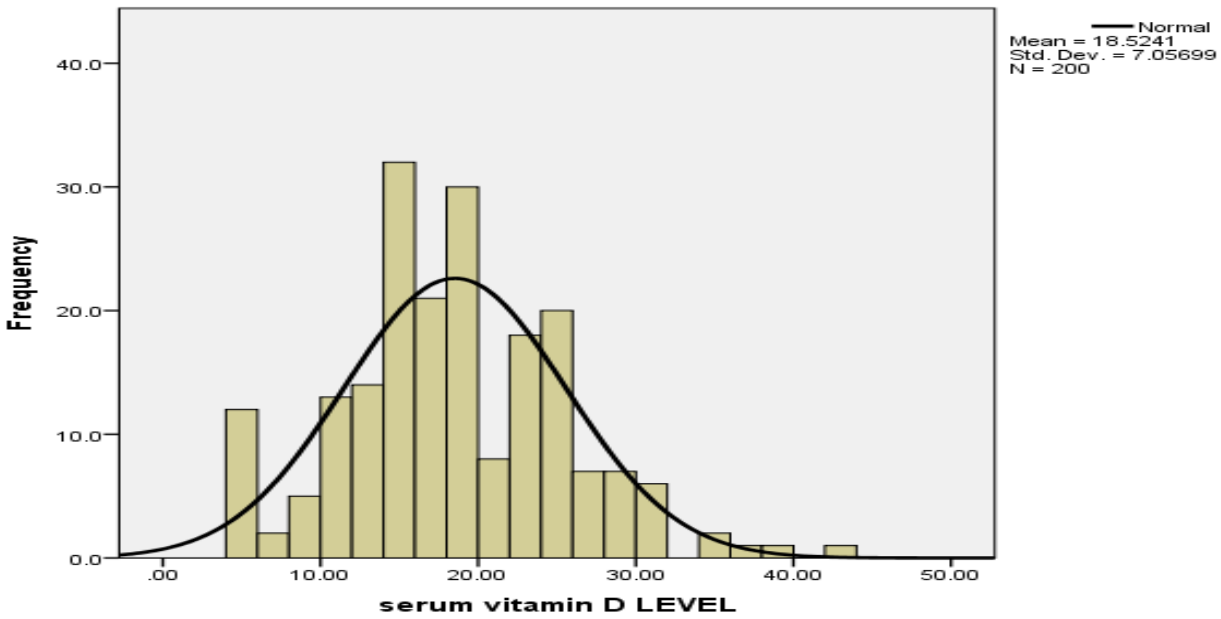

Figure 2: Serum 25(OH)D level distribution among participants with nonspecific musculoskeletal pain at ARH and ATRH neurology clinics from June to October 2025 (n=200).

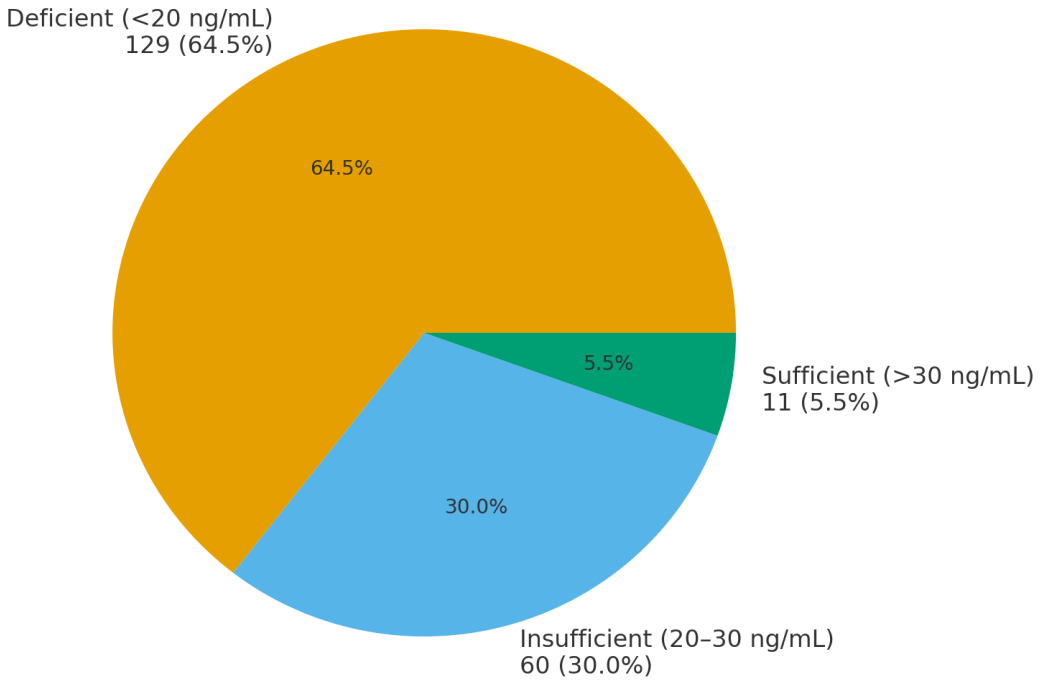

Figure 3: Distribution of study participants by vitamin D status showing the proportion of deficient, insufficient, and sufficient levels among participants with nonspecific musculoskeletal pain at ARH and ATRH neurology clinics from June to October 2025 (n=200.

5.4 Factors associated with Vitamin D deficiency

In the bivariate analysis, Vitamin D status (deficient vs non-deficient) was examined against the following independent variables: daily sunlight exposure (≤30 min vs. >30 min per day), dietary intake of vitamin D–rich foods (rarely vs. often/sometimes), type of clothing (fully vs. partially covered), sunscreen use (yes vs. no), physical activity (none vs. any (1–2 or ≥3 days/week)), BMI (per 1 kg/m²), waist circumference (≤94 vs. >94 cm), occupation (indoor vs. outdoor), age (per 1 year), sex (female vs. male), and VAS pain severity (per 1-point increase).

Candidate Variables qualified for the Multivariable Model Using a screening cutoff of $p < 0.25$, were entered into the multivariable logistic regression model were daily sunlight exposure,

dietary intake of vitamin D–rich foods, type of clothing, sunscreen use, physical activity, BMI, waist circumference, occupation, age, sex, and pain severity by VAS scale.

In the final multivariable logistic regression model, six variables remained statistically significant independent predictors of Vitamin D deficiency. Participants with ≤30 minutes of daily sunlight exposure had over four times higher odds of vitamin D deficiency compared with those exposed for longer periods (AOR = 4.42; 95% CI: 1.04–8.77). Individuals who rarely consumed vitamin D–rich foods such as fish, eggs, or dairy were at almost four-fold higher risk for vitamin D deficiency when compared with those who consumed at least sometimes and often (AOR = 3.83; 95% CI: 1.57–9.32). Sunscreen users had nearly threefold higher odds of vitamin D deficiency than non-users (AOR = 2.74; 95% CI: 1.14–6.54).

Participants with no physical activity had about three times greater odds of deficiency compared with those active at least once weekly (AOR = 2.81; 95% CI: 1.52–5.59). Higher body mass index contributed significantly; each 1 kg/m² increase in BMI raised the odds of deficiency by 18% (AOR = 1.18; 95% CI: 1.01–1.37). Finally, greater VAS pain severity was strongly associated with deficiency, with each 1-point increase corresponding to more than a threefold rise in odds (AOR = 3.63; 95% CI: 2.11–5.91) (Table 3, figure 4).

The Pearson correlation analysis was used to examine the relationship and direction between serum vitamin D levels and selected continuous variables. Pearson correlation analysis showed that age had a weak and non-significant negative relationship with serum vitamin D levels ($r = -0.082$, $p = 0.249$). Monthly income demonstrated a small but statistically significant inverse correlation ($r = -0.168$, $p = 0.018$), indicating a modest tendency for higher-income participants to have lower vitamin D levels. BMI showed a significant negative association ($r = -0.274$, $p < 0.001$), and waist circumference demonstrated a similar inverse relationship ($r = -0.199$, $p = 0.005$), both suggesting reduced vitamin D levels with increasing their values. Pain severity (VAS score) exhibited the strongest negative correlation ($r = -0.486$, $p < 0.001$), indicating that individuals with lower vitamin D levels tended to report more intense musculoskeletal pain.

Table 3 :Final model of variables with vitamin d deficiency among study participants at ARH and ARTH neurology and rheumatology clinic from June to October 2025 (n=200).

Variable	Category / Unit	Vit D deficient n = 129	Not deficient n = 71	Crude OR (95% CI)	Adjusted OR (95% CI)	p-value (AOR)
Daily sun exposure	>30 min	1	19	1.00 (ref)	1.00 (ref)	
	<=30 min	128	52	12.67 (5.96–35.11)	4.42 (1.04–8.77)	**0.047**
Dietary intake of Vit D-rich foods	Often/S/times	36	46	1.00 (ref)	1.00 (ref)	
	Rarely	93	25	4.75 (2.56–8.84)	3.83 (1.57–9.32)	**0.003**
Type of clothing	Fully covered	90	21	1.00 (ref)	1.00 (ref)	
	partly cover	39	50	0.18 (0.10–0.34)	0.47 (0.19–1.16)	0.103
Sunscreen use	No	52	50	1.00 (ref)	1.00 (ref)	
	Yes	77	21	3.62 (1.94–6.74)	2.74 (1.14–6.54)	**0.024**
Physical activity (days/week	Any	28	35	1.00 (ref)	1.00 (ref)	
	None	101	36	3.87 (1.44–9.71)	2.81 (1.52–5.59)	**0.015**
Body mass index (BMI)	Per 1 kg/m² increase	129	71	1.15 (1.05–1.25)	1.18 (1.01–1.37)	**0.032**
WC (CM)	≤94	100	63	1.00 (ref)	1.00 (ref)	
	>94	29	8	2.05 (0.87–4.80)	1.42 (0.33–6.09)	0.636
Occupation	Outdoor	91	21	1.00 (ref)	1.00 (ref)	
	Indoor	38	50	2.74 (1.15–6.57)	1.29 (0.50–3.33)	0.592
Age (years)	Per 1-year increase	129	71	1.01 (0.99–1.03)	1.00 (0.97–1.03)	0.868
Sex	Female	75	34	1.00 (ref)	1.00 (ref)	
	Male	54	37	0.65 (0.36–1.16)	1.63 (0.61–4.34)	0.328
VAS pain severity	Per 1-point increase	129	71	5.50 (3.07–8.95)	3.63 (2.11–5.91)	**<0.001**

Note: OR = odds ratio; CI = confidence interval; ref = reference category. Adjusted ORs are from a multivariable logistic regression model including all listed variables.

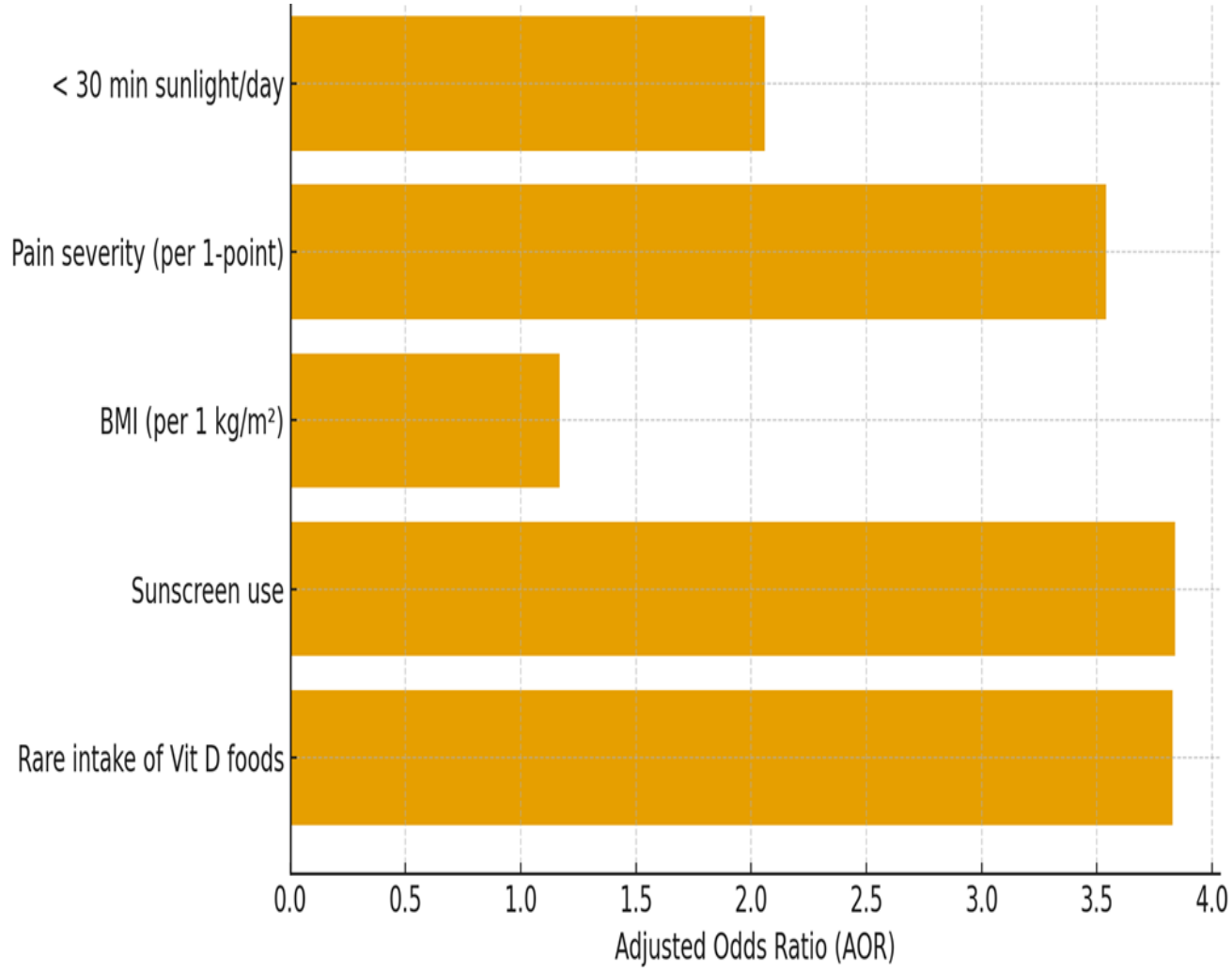

Figure 4 :Horizontal bar chart for Significant Predictors of Vitamin D Deficiency with adjusted odd ratios among all study participants at ARH and ATRH neurology and rheumatology clinics from June to October 2025 (n=200).

6. Discussion

This study assessed the prevalence of vitamin D deficiency and its associated factors among 200 adults presenting with nonspecific musculoskeletal pain and neurologic symptoms at ARH and ATRH hospitals in Asella Town, Arsi Zone, Oromia Region, southeastern Ethiopia. Conducted in 2025, it represents the first investigation of its kind in this population and provides important baseline evidence on the magnitude and determinants of vitamin D deficiency among symptomatic adults in this setting.

This study found a high prevalence of vitamin D deficiency among adults presenting with nonspecific musculoskeletal pain at ARH and ATRH hospitals, with 64.5% (95% CI: 57.6–71.4%) classified as deficient and an additional 30% (95% CI: 23.6–36.4%) as insufficient. These findings are consistent with an institutional-based cross-sectional study conducted in three public hospitals in Addis Ababa by Libsework *et al*. (2025), which reported a similar deficiency rate of 68.1% (95% CI: 63.1%–72.7%) among adults with musculoskeletal pain(84). Tolassa Wakayo *et al.* similarly reported 61.8% deficiency among symptomatic urban students central Ethiopia, a country with "thirteen months of sunshine (85).

Comparable patterns have been reported in other high-sunlight regions. Studies from Cairo (63.5%), Nigeria (65%), and South Africa (68%) demonstrated similar deficiency rates among adults with musculoskeletal complaints(86–88).A study from Sudan reported an even higher prevalence (82.6%) among symptomatic women, likely due to cultural clothing practices leading to reduced UVB exposure, whereas in our mixed-gender sample, 70% of women were deficient—still high, but not as extreme because men were also included(89)

Studies from Asia and the Middle East echo these findings. Heidari *et al*. (2010) in Iran (63.4%), Vaidya *et al.* (2014) in Nepal (62.5%), and Mohammad Ali (2022) in Bangladesh (~60%) all reported deficiency levels comparable to our results (90–92).Similarly, large cohort data from Turkey indicated a 74% deficiency rate among 15,000 patients with widespread musculoskeletal pain (93). Indian studies like Bansal *et al*., 2015: 66% and more recent findings from Dr. Garvi (62.5%) also mirror our results(94,95). Collectively, these studies reinforce the global pattern that nonspecific musculoskeletal pain frequently coexists with vitamin D deficiency.

The final multivariable logistic regression model in our study identified six statistically significant independent predictors of vitamin D deficiency which were limited sunlight exposure, poor intake of vitamin D–rich foods, physical inactivity, sunscreen use, higher BMI (per 1 kg/m² increase), and greater pain severity (per 1-point VAS increase).

Participants with <30 minutes of daily sunlight had 4.42 times higher odds of vitamin D deficiency than those with >30 minutes. This finding highlights the centrality of UVB exposure, which accounts for 80–90% of vitamin D synthesis(80). Similar associations have been documented in studies done in Ethiopia by Gebreegziabher ,2013(96), Sudan by Husain *et al.,*2019(89), Nigeria by Owo *et al.*,2025 (87), Al-Mahroos *et al.,*2013(97), Qatar by Badawi *et al*. (2012)(98) and Indian by Bansal *et al*. (2015)(94), where indoor occupations, heat avoidance, and cultural clothing substantially limit sun exposure despite high solar intensity.

Sunscreen use was also identified as an independent predictor of vitamin D deficiency in this study, with sunscreen users showing significantly nearly three times odds of deficiency compared to non-users. This finding is consistent with findings from the Sun-D Trial, which confirmed that daily sunscreen application substantially reduces cutaneous vitamin D production(99). Similar associations have been documented in other studies: research from Australia and the United States has shown that regular use of high-SPF sunscreen can lower serum 25(OH)D levels, particularly among individuals who spend limited time outdoors(100). Studies from Cameroon and Nigeria further support this relationship, reporting higher rates of vitamin D deficiency among women and indoor workers who frequently use sunscreen or cosmetic skin-lightening products that contain UV-blocking agents(87,101). A retrospective analysis from a cosmetic dermatology center in South India by Divyalakshmi *et al*. (2022) similarly reported a higher prevalence of vitamin D deficiency among sunscreen users compared to non-users(102).

In our study Dietary intake was another strong predictor of deficiency: individuals who rarely consumed vitamin D–rich foods had nearly four -fold higher odds of deficiency. This aligns with evidence that natural dietary sources such as fatty fish, eggs, and fortified dairy are essential populations without routine fortification programs(103). Similar associations between poor dietary intake and vitamin D deficiency have been reported in studies from Sudan, where low

consumption of vitamin D–containing foods was strongly linked to deficiency among adults despite abundant sunlight exposure(104). This study was also supported by the study done Andrade *et al.* in 2021, USA showed participants rarely or never consuming foods high in vitamin D such as fish and dairy products had significantly higher odds of being vitamin D deficient than who takes it sometimes or often (0.17, CI 95% 0.05–0.08; $p < 0.001$)(105).

Participants with physical inactivity had nearly three times higher odds of vitamin D deficiency compared with those who engaged in activity at least once per week. inactive individuals have fewer opportunities for incidental sun exposure and may also experience lower musculoskeletal function, which can worsen vitamin D-related symptoms(106). Finding in this study aligns with studies from Qatar and Turkey, which similarly reported lower vitamin D levels among individuals with minimal activity ((98,107)). Evidence from other studies further supports this association includes studies from Saudi Arabia by Al-Othman *et al. (*2012)(106), Bangladesh Nahar *et al*., 2014(108), Indian study by Dr. Garvi (2025)(95), and multi-country European cohorts by Lips *et a*l. (2019) all identified physical inactivity as an independent predictor of vitamin D deficiency.

BMI remained an independent predictor of vitamin D deficiency with each 1 kg/m² increase in BMI raised the odds of deficiency by 18% in our study. This result is consistent with well-established biological evidence that adipose tissue sequesters vitamin D, thereby reducing its bioavailability in circulation mechanism demonstrated in metabolic studies such as Wortman *et al*. (2018)(109). Evidence from African settings shows similar patterns: studies from Ethiopia and South Africa have documented significantly lower serum 25(OH)D concentrations among adults with elevated BMI, independent of sunlight exposure patterns(74,110). Large epidemiologic studies from the United States (111)), as well as investigations conducted in Bahrain, South Korea, and several Middle Eastern countries have consistently shown higher prevalence of vitamin D deficiency among individuals with overweight or obesity ((88,92,112).European research, including UK Biobank analyses, likewise demonstrates an inverse relationship between BMI and vitamin D status, further reinforcing that increasing adiposity is a universal risk factor(113). A study from the Netherlands by Araghi *et al*. (2015) further supports this relationship, reporting a significant inverse association between BMI and serum vitamin D levels among adults(114).

In our study Pain severity (VAS score) showed a robust and statistically significant association with vitamin D deficiency, with each 1-point increase in VAS score corresponding to nearly a fourfold rise in the odds of deficiency. This finding is biologically plausible, as vitamin D plays a key role in neuromuscular function, nociception, and muscle performance; therefore, inadequate levels may heighten pain perception and worsen functional impairment(115). Our results are consistent with those of Hsiao *et al.* (116) , who reported greater musculoskeletal pain, paresthesia, and fatigue among individuals with low serum vitamin D levels. Similar associations have been documented by Plotnikoff and Quigley(117), Straube *et al.* (118), and Shipton & Shipton (119), all of whom found evidence that supports an inverse relationship between serum vitamin D concentration and chronic or unexplained musculoskeletal pain severity.

Conversely, socio-demographic variables like sex, age, and residence were not significantly associated with vitamin D deficiency in our study. This contrasts with studies where older age and female sex predicted lower vitamin D levels ((120),(112)). Several factors likely explain this difference: the relative homogeneity of the population, shared cultural and occupational patterns, and the overwhelming influence of behavioral factors (sun exposure, diet, physical activity), which may mask more subtle demographic effects. Additionally, as a hospital-based sample of symptomatic adults, many individuals were already at high risk, reducing observed variability

7. Strengths and Limitations

A major strength of this study is its inclusion of a diverse set of behavioral, dietary, and clinical predictors, allowing for comprehensive multivariable analysis. Standardized laboratory measurement of 25(OH)D improved reliability, and the study provides the first evidence on this topic in southeastern Ethiopia.

Limitations include the cross-sectional design, which restricts causal inference; reliance on self-reported behavioral data; and limited generalizability due to hospital-based convince sampling from hospital settings. Additionally, the absence of parathyroid hormone and bone density measurements restricted assessment of downstream metabolic effects.

Conclusion

This study reveals a high prevalence of vitamin D deficiency among adults presenting with nonspecific musculoskeletal pain in Asella Town hospitals, despite the region's abundant year-round sunlight. The analysis shows that deficiency is driven primarily by modifiable lifestyle and clinical factors including limited daily sun exposure, infrequent consumption of vitamin D–rich foods, physical inactivity, sunscreen use, higher BMI, and greater pain severity rather than socio-demographic characteristics.

After controlling for confounders, these behavioral and clinical predictors remained significant, while variables such as sex, age, and residence showed no independent association with deficiency. These findings underscore the importance of lifestyle-focused prevention strategies and targeted clinical interventions to address the substantial burden of vitamin D deficiency in this population.

Recommendations

Based on the findings of this study, coordinated actions at multiple levels are recommended;

At the population and Primary Health Care Unit (PHCU) level, community awareness should be strengthened to promote safe and regular sunlight exposure, increased physical activity, and consumption of vitamin D–rich foods. Because deficiency was associated with higher BMI, community programs should integrate messages on healthy weight management and activities.

Within health facilities and among health workers, routine assessment of vitamin D status should be considered for adults presenting with chronic musculoskeletal or neurologic symptoms, particularly those with high BMI, limited sun exposure, or sedentary behaviors. Health professionals should provide individualized counseling on safe sunlight exposure and dietary diversification to include vitamin D–rich foods. Integrating vitamin D screening and counseling into chronic pain clinics helps early detection of vitamin D deficiency and reduce sever nonspecific musculoskeletal and neurologic pains.

At the woreda and zonal health office levels, nutrition-sensitive and lifestyle-focused programs should be reinforced to promote adequate sunlight exposure and outdoor physical activity. Local health authorities should support initiatives that improve access to vitamin D–rich foods and consider affordable supplementation for vulnerable groups.

For partners working in nutrition and chronic pain health, collaborative efforts are needed to expand food-based strategies, increase the availability of vitamin D–rich foods, and implement culturally tailored public health campaigns. Partners can also support capacity-building for frontline health workers and fund research exploring determinants of vitamin D deficiency.

At the regional health bureau and Ministry of Health (MoH) levels, national strategies should consider incorporating vitamin D supplementation guidelines for high-risk groups into primary health care services and exploring feasible food fortification options.

Finally, future research should include longitudinal and community-based studies to clarify causal pathways and seasonal patterns of vitamin D deficiency, as well as examine genetic influences and interactions with chronic nonspecific musculoskeletal and neurologic pains patients for prevention and early management strategies of vitamin d deficiency.

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ANNEX I: Information sheet

Arsi University Referral and Teaching Hospital, Department of Public health individual consent form for the study on: To assess Prevalence of Vitamin D Deficiency and Associated Risk Factors Among Patients with Nonspecific Musculoskeletal Pain and Neurologic Symptoms Attending Assela teaching and referral hospital and Robot General Hospital, Assella, Ethiopia from June 1, 2025 to October 30: 2025.G.C.

My name is _____. I am working with the research team of Arsi University Referral and Teaching Hospital. We would like to assure you your name will not be mentioned in the questionnaire and the information that you will give us will be kept confidential and only used for research purposes. You have full right to refuse to take part or to interrupt the interview at any time. But the information that you will give us is quite useful to achieve the objective of the study and to bring change in atrial fibrillation management.

Are you willing to participate in the study? 1- Yes 2 - No

If the answer is yes, thanks! Conduct the interview. If the answer is no, Thanks!

Don't force or reinforce an individual to participate in the survey

Interviewer's: name ---------- signature -------

Date of interview ---------- date ----------month/**:** 2024 G. C.

Checked on ---------- date----------month/: 2024 G.C

Complete 1 Incomplete 2 other (specify) ----------

ANNEX II-Consent form- English version

In signing this document, I am giving my consent to participate in the study titled with **to assess Prevalence of Vitamin D Deficiency and Associated Risk Factors Among Patients with Nonspecific Musculoskeletal Pain and Neurologic Symptoms Attending Assela referral and teaching hospital and Rehoboth General Hospital, Assella, Ethiopia from June 1, 2025 to October 30,2025**.

If you agree to participate, you will be asked questions about your health and lifestyle. A small amount of blood will be collected to measure your Vitamin D level. The process will take approximately 15–20 minutes. There is minimal risk of feeling slight pain during blood collection. All procedures will be performed safely by trained professionals. There is no financial compensation for participating in this study.

I have understood that participation in this study is entirely voluntary. I have been told that my answers to the questions will not be given to anyone else and no reports of this study ever identify me in any way. I have also been informed that my participation or non-participation or my refusal to answer questions will have no effect on me. I understood that participation in this study does not involve risks other than minimal pain when sample taken. I understood that Dr. Diress Molla is the contact person if I have questions about the study or about my rights as a study participant.

Investigator: Dr.Diress Molla

Cell phone: +251 909262342

E-mail:molladiress@gmail.com

Participant’s signature and date: _____

ANNEX III. Data Collection Format (English Version

Part I – Patient interview Date _____Card number _____

Section 1 – Sociodemographic and clinical data

1. Age of the patient in years _____

2. Sex: A. Male ☐ Female ☐

3. Occupation - 1. Farmer ☐ Merchant ☐

4. 3.Employee in governmental institutio ☐ 4. Employee in non-governmental ☐

5. Residence -1. Urban ☐ 2. Rural ☐

6. Level of income per month_____

Section 2: Lifestyle and Behavioral Factors

7. Daily sunlight exposure (hours/day): <15 min ☐ 15–30 min ☐ >30 min ☐

8. Do you use a sun screen? A. Yes B. No

9.Type of clothing: Fully covered ☐ Partially covered ☐

10. Physical activity (days/week): None ☐ 1–2 ☐ 3+ ☐

11. Dietary intake of Vitamin D-rich foods (fish, eggs, dairy): Rarely ☐ Sometimes ☐

Often ☐

12. Have you ever smoked cigarettes? A. Yes B. No C. Stopped

13. If yes, for how long? _____years

14. If yes, how much _____/day (quantify)

15. Do you drink alcohol? A. Yes B. No C. Stopped

Section 3: Clinical Information

16. Body Mass Index (BMI): _____kg/m²

17. Waist circumference_____

18. History of chronic illness (e.g., liver/kidney disease): Yes ☐ No ☐

19. Medication affecting Vitamin D metabolism (e.g., steroids, anticonvulsants): Yes ☐ No ☐

Section 4: Investigation results

20. 25(OH)D Level (ng/mL): _____

- ☐ <20 (Deficient)
- ☐ 20–30 (Insufficient)
- ☐ >30 (Sufficient)

21. Serum Calcium (if measured): _____

22. Other relevant blood work (optional): _____

Section 5: Neurological and Musculoskeletal Symptoms

23. Nature of musculoskeletal pain: Generalized ☐ Localized ☐

24. Duration of pain: <1 week ☐ 1–4 weeks ☐ > 1 month ☐

25. Neurological symptoms (numbness, tingling, weakness): Yes ☐ No ☐

26. Severity of symptoms (VAS scale 1–10): _____

የመረጃ ስብስብ ቅፅ (Amharic Version)

ክፍል I – የታካሚው መረጃ

ቀን: _____ **ካርድ ቁጥር:** _____

ክፍል 1 – የሕይወት ሁኔታ እና የሕክምና መረጃ

1. እድሜ (በዓመት) _____
2. ፆታ: አ. ወንድ ቢ. ሴት
3. ሥራ:
    1. ገበሬ
    2. ነጋዴ
    3. የመንግሥት ሰራተኛ
    4. የግል ድርጅት ሰራተኛ
4. የመኖሪያ ቦታ:

    ከተማ _____ ገጠር_____

5. ወርሃዊ ገቢ: _____

ክፍል 2 – የኢኗኗር እና የባህላዊ አውድ

6. የቀኑ የፀሐይ መጋለጫ (በሰአት):

- ----<15 ደቂቃ -----15–30 ደቂቃ _____>30 ደቂቃ

7. የፀሐይ መከላከያ ተጠቃሚ ነህ/ሽ? አ. አዎ ቢ. አይ
8. የልብስ አይነት:

- _____ሙሉ እንደተሸፈነ _____በከፊል እንደተሸፈነ

9. የአካል እንቅስቃሴ (በሳምንት ቀናት):

- ___አንድም አይደለም____1–2 ቀናት _____3 ወይም ከዚያ በላይ

10. የቫይታሚን D የሚያበረታታ ምግብ (አሳ፣ እንቁላል፣ የወተት ምርቶች) በምሳ:

- _____ከበቂ በታች _____አንዳንዴ _____በተደጋጋሚ

11. ሲጋራ ታጨሳለህ? አ. አዎ ቢ. አይ ግ. ቆሟል

12. አዎ ካለ ስንት ዓመት? _____

13. በቀን ስንት? _____

14. አልኮል ትጠጣለህ? አ. አዎ ቢ. አይ ግ. ቆሟል

ክፍል 3 – የሕክምና መረጃ

15. BMI: _____ ኪግ/ሳሜ^2

16. የወገብ አካባቢ መለኪያ: _____

- ሕመም ታሪክ (ለምሳሌ፡ የኩላሊት፣ የጉበት ችግር)፡ አ. አዎ ቢ. አይ

- በቫይታሚን D ላይ የሚነኩ መድሃኒቶች (ለምሳሌ፡ የእፒለፒስዩ፣ ስተሮይድ):አ. አዎ ቢ. አይ

ክፍል 4 – የምርመራ ውጤት

19. 25(OH)D የደም መጠን: _____

- <20 (እጥረት) .... 20–30 (ዝቅ ያለ) .....>30 (በቂ) .....

20. የካልሲየም መጠን: _____ሌላ የደም ምርመራ: _____

ክፍል 5 – የጡንቻ ፣የመገጣጠምያ እና ኑሮሎጂካል ምልክቶች

22. የህመም አይነት

- የተሰራጨ..... አንድ ቦታ.....

23. የህመም ጊዜ:

- <1 ሳምንት..... 1–4 ሳምንት ..... 1 ወር ....።

24. የነሮሎጂካል ምልክቶች: አ. አዎ ቢ. አይ

25. የህመም ደረጃ (VAS መለኪያ 1–10): _____

Daataa Walitti Qabuu (Afaan Oromoo)

Kutaa I – Odeeffannoo Hirmaataa

Guyyaa: _____ Lakkoofsa Kaardii: _____

Kutaa 1 – Odeeffannoo Haala Hawaasummaa fi Fayyaa

1. Umuriin Hirmaataa (waggaa): _____
2. Saala: A. Dhiira B. Dubartii
3. Hojii:

A. Qonnaan Bulaa C. Hojjetaa Mootummaa

B. Daldalaa D. Hojjetaa Dhaabbata Hojii Dhunfaa

4. Teessoo:

A. Magaalaa B. Baadiyyaa

5. Galii ji'aa: _____

Kutaa 2 – Haala Jireenyaa fi Hirmaannaa Qaamaa

6. Sa'aatii yeroo guyyaa ifa aduu arguu:

- <15 daqiiqaa_____--15–30 daqiiqaa_____>30 daqiiqaa_____

7. Makaa Ifaa (Sun screen) fayyadamtaa? A. Eeyyen B. Lakki

8. Akaakuu uffannaa:

- Guutumaan guutuutti uffame_____ Gariin qaamaa mul'atu_____

9. Sochii qaamaa torbanitti guyyaa meeqa?

- Homaa------- 1–2------, 3 fi isaa oli-------

10. Nyaata Vaayitaamiin D qabaatu (foollee, handhuura, aannan):

- Yeroo Tiqqaaa_____ Yeroo muraasa_____Yeroo hunda_____

11. Sigaarrii hojjetteetta? A. Eeyyen B. Lakki C. Dhaabde

12. Waggaa meeqa? _____

13. Guyyaa meeqa? _____

14. Alkoolii ni dhugda? A. Eeyyen B. Lakki C. Dhaabde

Kutaa 3 – Odeeffannoo Fayyaa

15. BMI: _____ kg/m²

16. Cimaa garaa: _____

17. Dhukkuba dheeraa (kan akka dhukkuba sombaa/kidneeyii): A. Eeyyen B. Lakki

18. Dawaa Vitamin D irratti dhiibbaa qabu fayyadamta? A. Eeyyen B. Lakki

Kutaa 4 – Bu'aa qorannoo

19. Vitamin D (25(OH)D) Fkn: _____

- <20 (Hanqina cimaa)____20–30 (Hanqina giddu galeessa)_____>30 (Gahaa)_____

20. Qorannoo Kaalsiyemii: _____ Odeeffannoo qorannoo biroo: _____

Kutaa 5 – Mallattoo Hafuuraa fi Hidhii

22. Dhukkuba Hidhii:

- Bu'uura-------Adda baafame-------

23. Yeroo dhukkubsataa turte:

- <1 torbee---- 1–4 torbee------,1 ji'a-------

24. Mallattoolee Niyurolooji: A. Eeyyen B. Lakki

25. Sadarkaa dhukkubbii (Sakatta'a VAS 1–10): _____

Thesis approval sheet

Thesis Approval Sheet

This is to certify that the thesis entitled with **Vitamin D Deficiency and Associated Factors among Patients Presenting with Nonspecific Musculoskeletal pain and Neurologic Symptoms: A Cross-sectional Study in Asella Town Hospitals, Ethiopia, 2025**: submitted by Diress Molla yirdaw, ID No.0490/2015 has been reviewed and approved by the undersigned, based on the comments and suggestions provided during the thesis defense.

Student Declaration

I, the undersigned, declare that I have incorporated the comments and suggestions of my advisors and examiners into the final version of my thesis proposal.

Name of Student: Dr. Diress Molla

Signature: _____ Date: 10/12/2025

Advisors' Approval

1. Name: Gebi Husen (PhD) Signature: _____ Date: 10/12/25
2. Name: Tewodros Desalegn Signature: _____ Date:

Examiners' Approval

1. Name: _____ Signature: _____ Date:
2. Name: _____ Signature: _____ Date:

Department Head Approval

I hereby confirm that the student has submitted the final version of the thesis duly signed by the advisors and examiners.

Name: _____ Signature: _____ Date: _____