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INSTITUTIONAL VARIATIONS IN VITAMIN D FORMULATION DISPENSING: A MULTI-CENTER STUDY OF JORDANIAN MILITARY HEALTHCARE FACILITIES

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ABSTRACT

1. Introduction: Vitamin D supplementation will continue to be fundamental in the prevention and treatment of many health disorders within any healthcare system. The proper dispensing and use of various vitamin D formulations, such as cholecalciferol (vitamin D3) and Alfacalcidol (1α-hydroxyvitamin D3) is essential for successful patient care and resource management. The Jordanian Royal Medical Services (JRMS) oversees multiple major hospitals catering to a large and vast population of patients each with unique patient demographics and clinical requirements. Analyzing the trends in vitamin D formulation dispensing among these institutions can yield significant information for healthcare planning and resource distribution.

2. Objective: This study will investigate the dispensing patterns of six distinct vitamin D formulations at three main military hospitals in Jordan over a four-year period (2020-2023) aiming to detect temporal trends, comprehend institutional variation, and produce insights to guide future procurement and distribution strategies in the military healthcare system. The study will assess the correlation between institutional specialization and preferences for vitamin D formulations, while examining the consequences for inventory management and standardization of clinical practices.

3. Methodology: The study will employ a retrospective analysis of dispensing records from the JRMS central medical stores to three military hospitals: King Al-Hussein Military Hospital, Farah Royal Rehabilitation Center, and Prince Rashid Ben Al-Hasan Military Hospital. The research will analyze monthly dispensing data for six vitamin D formulations: three strengths of Alfacalcidol (0.25 mcg, 0.5 mcg, and 1.0 mcg) and three of cholecalciferol (1000 IU, 5000 IU, and 50,000 IU). Monthly average dispensing quantities will be computed to address potential stock shortages and offer uniform comparison metrics. The analysis will concentrate on temporal trends, inter-hospital discrepancies, comparative usage patterns of various formulations, and annual fluctuations in dispensing quantities. The statistical study will encompass the calculation of mean monthly dispensing volumes, percentage variations between years, and comparative assessments among institutions. This thorough methodology will provide an in-depth analysis of vitamin D distribution trends and their ramifications for clinical practice and budget allocation within the military healthcare system.

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INTRODUCTION:

Vitamin D is a fat-soluble vitamin that plays a crucial role in maintaining calcium and phosphate balance, which is vital for bone health and various physiological functions. This compound is also involved in the modulation of immune function, the reduction of inflammation, and the regulation of cell growth [1]. Vitamin D deficiencies are linked to a wide range of health concerns, including rickets in pediatric populations, osteomalacia, and osteoporosis in adults. Additionally, these deficiencies may elevate the risk of infections, autoimmune disorders, and chronic illnesses such as cardiovascular disease and specific types of cancer [2]. Furthermore, recent findings indicate that vitamin D may offer protective benefits against metabolic disorders such as type 2 diabetes and obesity. Additionally, it may play a role in enhancing mental health by lowering the risk of depression and cognitive decline [3]. In addition to its role in the enhancement of muscle strength and the reduction of fall risk in older adults highlights its critical importance in preserving overall health and improving quality of life.

Considering its clinical importance, it is essential to ensure an adequate supply and appropriate use of vitamin D supplements within healthcare environments. The importance of addressing this issue is particularly pronounced in areas where there is a significant prevalence of vitamin D deficiency, often attributed to factors such as limited exposure to the sun, cultural practices, or inadequate dietary intake [4]. Effective management of vitamin D supplementation necessitates a comprehensive understanding of its biological roles, the various factors that lead to deficiency, and the potential consequences of inadequate levels for both individual and public health outcomes [5]. In healthcare systems, prioritizing vitamin D supplementation is consistent with preventive strategies designed to mitigate disease burden and healthcare expenditures, while simultaneously improving patient outcomes.

In clinical practice, two principal forms of vitamin D are frequently utilized: cholecalciferol (Vitamin D3) and Alfacalcidol (1-hydroxycholecalciferol). Cholecalciferol serves as a precursor that necessitates metabolic activation within the liver and kidneys to produce its biologically active metabolite, calcitriol [6]. In contrast, Alfacalcidol is a synthetic analog that is swiftly converted to calcitriol in the liver, effectively circumventing the renal activation process. The pharmacological distinction of Alfacalcidol renders it especially beneficial for patients suffering from chronic kidney disease or other conditions that compromise renal function. Furthermore, the use of Alfacalcidol facilitates enhanced regulation of active vitamin D concentrations, which can be especially beneficial in the treatment of conditions like secondary hyperparathyroidism and bone mineral disorders linked to renal impairment [7]. The selection of these formulations is contingent upon individual patient factors, encompassing the root cause of the deficiency, existing comorbidities, and practical considerations such as accessibility and expense [8].

The Royal Medical Services (JRMS) in Jordan manages a centralized healthcare system dedicated to delivering medical care to members of the military, their families, and other recipients. The process encompasses the procurement and distribution of pharmaceuticals, including vitamin D supplements, to the affiliated hospitals and healthcare centers [9]. It is essential to monitor the dispensing patterns of these supplements to gain insights into usage trends, identify potential supply chain challenges, and ensure equitable distribution. The centralized nature of JRMS offers a distinctive opportunity to conduct comprehensive analyses of extensive data regarding medication utilization. This can provide valuable insights into significant public health issues, such as vitamin D deficiency and its effective management. Moreover, employing data-driven strategies in inventory management can effectively reduce waste, avert stockouts, and guarantee that essential medications are delivered to patients promptly.

This research seeks to analyze the dispensing trends of two variants of vitamin D, specifically cholecalciferol and Alfacalcidol, sourced from the JRMS central medical stores to three prominent hospitals: King Al-Hussein Military Hospital, Farah Royal Rehabilitation Center, and Prince Rashid Ben Al-Hasan Military Hospital, spanning a four-year timeframe from 2020 to 2023. This study aims to identify trends, variations, and potential gaps in meeting clinical needs through a thorough analysis of the average monthly quantities dispensed. Comprehending these patterns is essential for tackling present healthcare issues and for

formulating strategic policies that enhance the distribution of vital medications. This analysis holds considerable importance in resource-constrained environments, where the effective management of medical supplies is crucial for upholding superior standards of patient care. Furthermore, the results of this research could extend their relevance to various healthcare systems, providing insightful lessons regarding the significance of effective supply chain management and the incorporation of data analytics in the decision-making framework.

This study underscores the variability observed in the dispensing patterns of vitamin D supplements among JRMS-affiliated hospitals, which is indicative of both clinical and operational dynamics. The findings illustrate the JRMS system's ability to adjust to evolving demands; however, they also highlight specific areas that necessitate enhancement to guarantee a consistent and equitable distribution. This variability highlights the impact of various factors, such as patient demographics, fluctuations in demand, and possible inconsistencies in inventory management practices. Furthermore, variations in clinical protocols and prescribing behaviors among healthcare professionals may play a significant role in the observed trends, underscoring the necessity for standardized guidelines to unify practices across different facilities.

By addressing these challenges, the JRMS will significantly improve its capacity to meet patient needs and maximize the utilization of resources. To attain this objective, it is essential to implement sophisticated inventory management systems that utilize real-time data to anticipate and adapt to variations in demand, effectively reducing the likelihood of shortages and excess stock scenarios. It is essential to implement periodic education courses for pharmacy and logistics personnel to guarantee compliance with best practices in inventory control and distribution. Enhancing communication and coordination between central medical stores and different healthcare facilities can significantly improve the responsiveness and efficiency of the supply chain. Furthermore, the integration of patient-centered strategies, including the customization of supply distributions according to the distinct requirements of hospital catchment areas, has the potential to enhance the overall efficacy of the system. By tackling these complex challenges, the JRMS can strengthen its position as a benchmark for resource management within the healthcare sector, guaranteeing that vital medications, such as vitamin D supplements, are accessible to all patients in need.

METHOD:

This research study utilized a retrospective descriptive design to analyze dispensing records from the JRMS main medical stores to three military hospitals: King Al-Hussein Military Hospital, Farah Royal Rehabilitation Center, and Prince Rashid Ben Al-Hasan Military Hospital, spanning a period of four years from 2020 to 2023. The investigation focused on six vitamin D formulations frequently utilized in the military healthcare system, with dispensing data gathered for all vitamin D formulations provided to the three hospitals throughout the duration of the study. The formulations comprised Alfacalcidol (One-Alpha) capsules available in strengths of 0.25 mcg, 0.5 mcg, and 1.0 mcg, as well as Cholecalciferol (Vitamin D3) capsules offered in strengths of 1000 IU, 5000 IU, and 50,000 IU. The monthly average dispensing quantities were determined by dividing the total annual quantities by twelve months. This approach accounts for potential stock shortages and facilitates standardized comparison metrics. The selection of this standardization method aims to mitigate the effects of temporary supply disruptions and fluctuations in inventory levels. The analysis concentrated on several critical aspects, including temporal trends in dispensing patterns throughout the four-year study period, inter-hospital differences in formulation preferences and utilization patterns, the relative usage of different vitamin D formulations within each institution, and year-over-year changes in dispensing quantities. The statistical analysis encompassed the calculation of mean monthly dispensing quantities, the assessment of percentage changes across years, and a comparative analysis among various institutions.

RESULTS:

The analysis demonstrated significant variability in the dispensing habits of vitamin D products among the three hospitals throughout the four-year duration. The dispensing of One-Alpha Capsules, specifically the 0.25 mcg dosage, has shown a significant reduction at King Al-Hussein Military Hospital. The average monthly quantity decreased from 32,434 in 2020 to 9,857 in 2022, with a

subsequent partial recovery to 16,125 in 2023. In contrast, the Farah Royal Rehabilitation Center exhibited a relatively stable pattern of dispensing for the same product, with quantities showing modest fluctuations between 9,526 in 2020 and 10,101 in 2023. At Prince Rashid Ben Al-Hasan Military Hospital, the observed trend was consistent with that of King Al-Hussein Military Hospital, showing a decrease from 18,383 in 2020 to 7,948 in 2022, subsequently followed by an increase to 11,452 in 2023 (Figure 1).

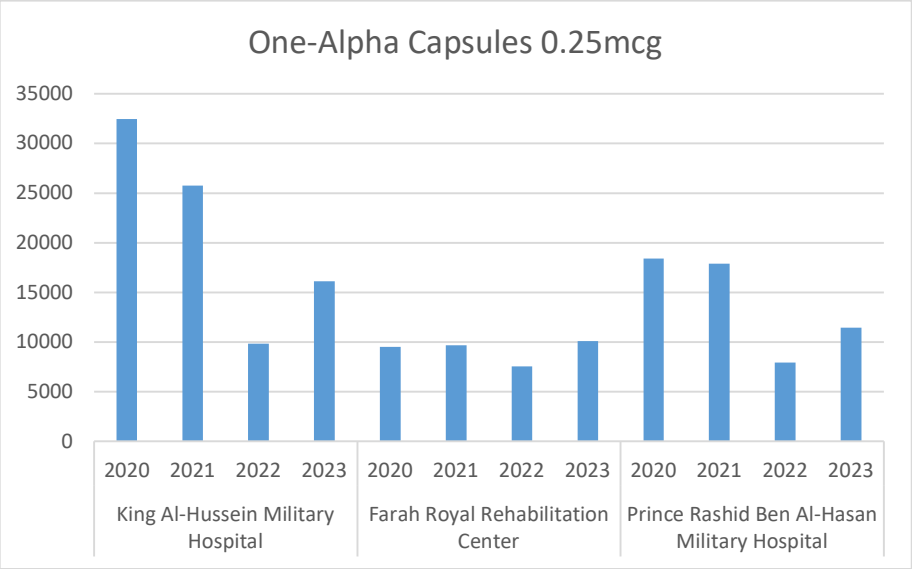

Figure 1: The frequency and distribution of One –Alpha Capsules in study hospitals per study years

The 0.5 mcg dosage of One-Alpha Capsules demonstrated irregular patterns, with significant variations observed at King Al-Hussein Military Hospital, where quantities reached a high of 11,015 in 2021, subsequently declining to 4,276 in 2023. Dispensing at Farah Royal Rehabilitation Center were confined to the year 2022. In contrast, Prince Rashid Ben Al-Hasan Military Hospital observed a rise in dispensing during 2022, followed by a significant decrease in 2023 (Figure 2).

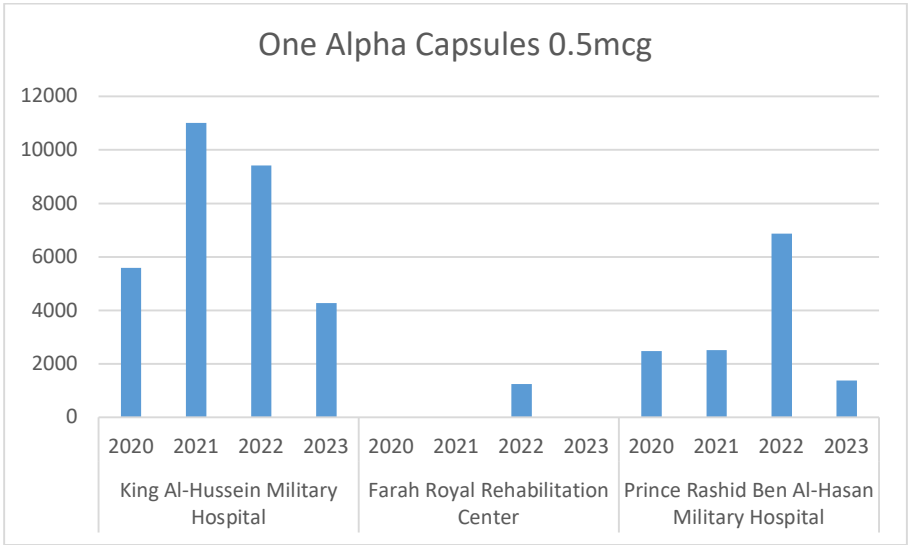

Figure 2: The variation in the frequency of One Alpha Capsule in study hospitals

The dispensing of One-Alpha Capsules at a dosage of 1.0 mcg was observed to be limited and inconsistent across all three hospitals. The average monthly quantities at King Al-Hussein Military Hospital experienced a decrease from 3,921 in 2020 to 1,900 in 2022, followed by an increase to 3,976 in 2023.

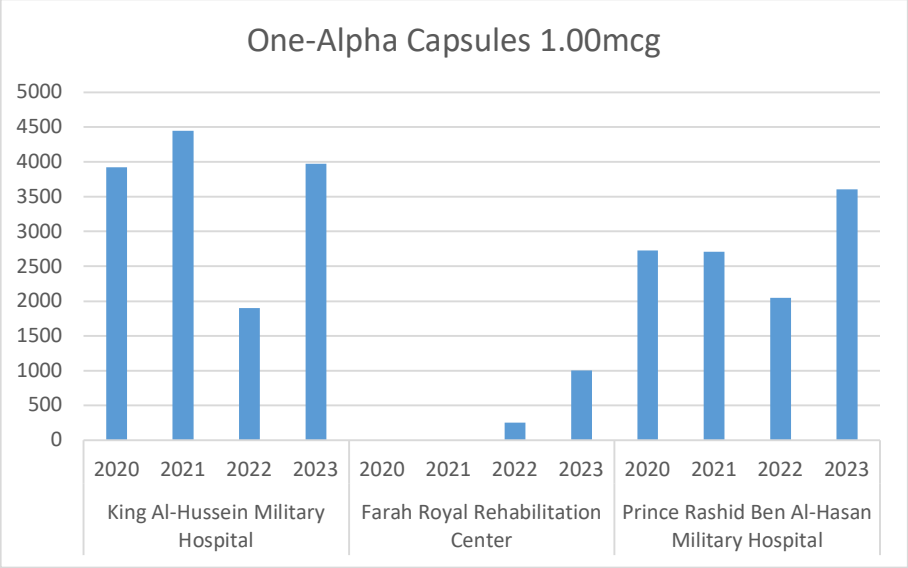

Fig 3(a): Prescription pattern of One Alpha Capsule

The administration of Vitamin D3 Capsules demonstrated notable variations in response based upon the dosage levels employed. The 1000 IU dosage demonstrated a steady increase at King Al-Hussein Military Hospital, rising from 3,901 in 2020 to 5,434 in 2023. Farah Royal Rehabilitation Center exhibited a comparable trend, with quantities increasing from 6,267 in 2020 to 6,977 in 2023. In contrast, the dispensing at Prince Rashid Ben Al-Hasan Military Hospital have been limited, with annual quantities varying between 400 and 500 units (Figure 3).

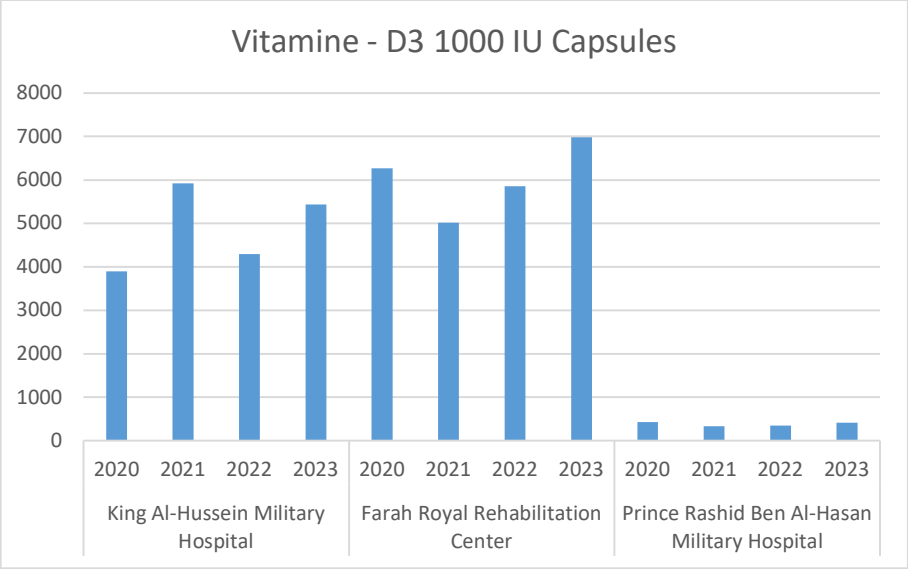

Figure 3(b): The frequency of prescribing Vitamin D3-1000 in study hospitals per year

The dispensing of 5000 IU Vitamin D3 Capsules observed a reduction across all three hospitals following initial peaks during the years 2020-2021. The Prince Rashid Ben Al-Hasan Military Hospital

has observed a significant decline, which is indicative of the overarching patterns seen in other healthcare facilities (Figure-4).

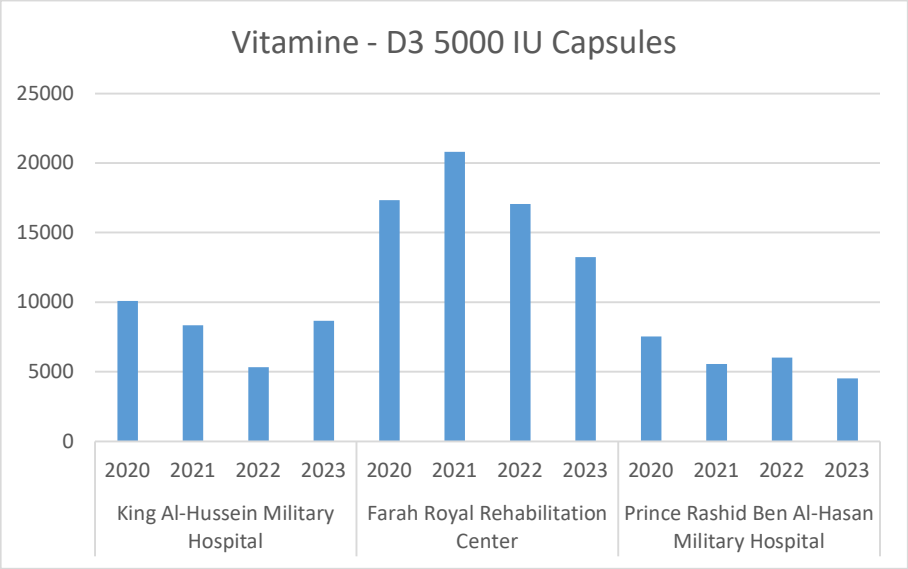

Figure 4: The frequency of prescribing Vitamin D3-5000 in study hospitals per year

The 50,000 IU dosage exhibited significant variability, with declining quantities across all hospitals over the study period (Figure 5).

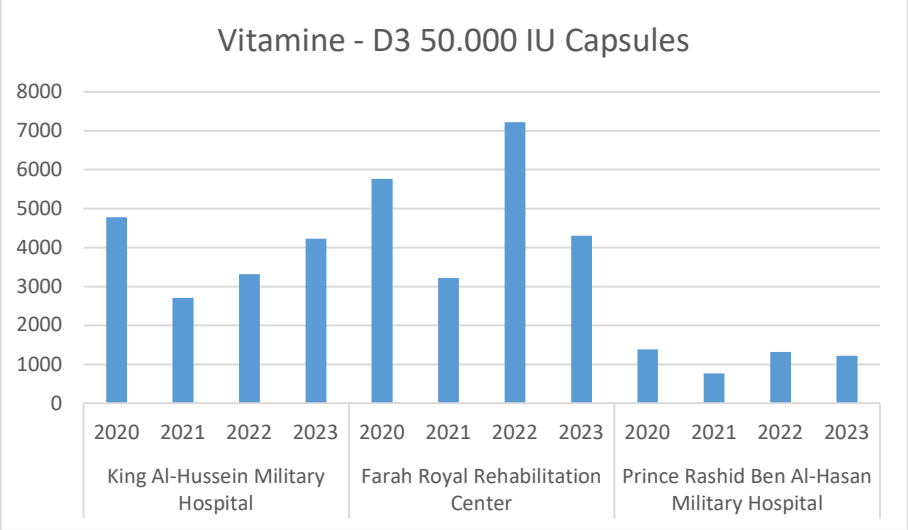

Figure 5: The frequency of prescribing vitamin D-50000 in study hospitals per year

DISCUSSION:

The examination of vitamin D dispensing habits within the three prominent military hospitals uncovers complex dynamics that warrant thorough investigation. The identified patterns demonstrate intricate relationships among institutional attributes, clinical requirements, prescriber tendencies, and healthcare system elements that together shape the utilization of vitamin D within the military healthcare context.

Institutional Variations and Clinical Practice Patterns: The observed discrepancies in dispensing practices across different institutions reveal significant insights that merit thorough investigation.

The consistent higher utilization of Alfacalcidol formulations, particularly the 0.25mcg strength, at King Al-Hussein Military Hospital indicates a concentrated approach for vitamin D supplementation. This pattern appears to be indicative of the hospital's tertiary care status and its approach to managing intricate cases that necessitate the use of activated vitamin D analogues. The substantial volume of Alfacalcidol dispensed may suggest a considerable patient demographic experiencing impaired vitamin D metabolism, renal dysfunction, or other medical conditions that require the use of pre-activated forms of vitamin D. The observed decrease in Alfacalcidol dispensing from 2020 to 2022, succeeded by a slight recovery in 2023, may indicate shifts in clinical guidelines or alterations in the demographics of the patient population.

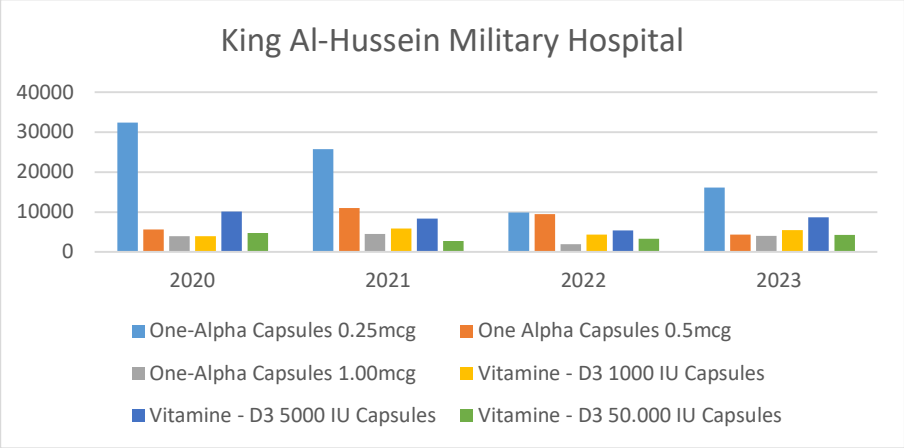

Fig 6: Prescription pattern in King Al-Hussein Military Hospital

Farah Royal Rehabilitation Center's notable emphasis on cholecalciferol preparations, especially in moderate (5000 IU) and high-strength (50,000 IU) formulations, is consistent with current approaches in rehabilitation medicine. This pattern indicates the incorporation of vitamin D supplementation into standardized rehabilitation guidelines, which may enhance musculoskeletal recovery, strengthen immune function, and promote overall health maintenance throughout prolonged rehabilitation phases [8]. The center's ongoing application of these formulations reflects a methodical strategy toward vitamin D supplementation, which could potentially serve as a benchmark for other rehabilitation facilities.

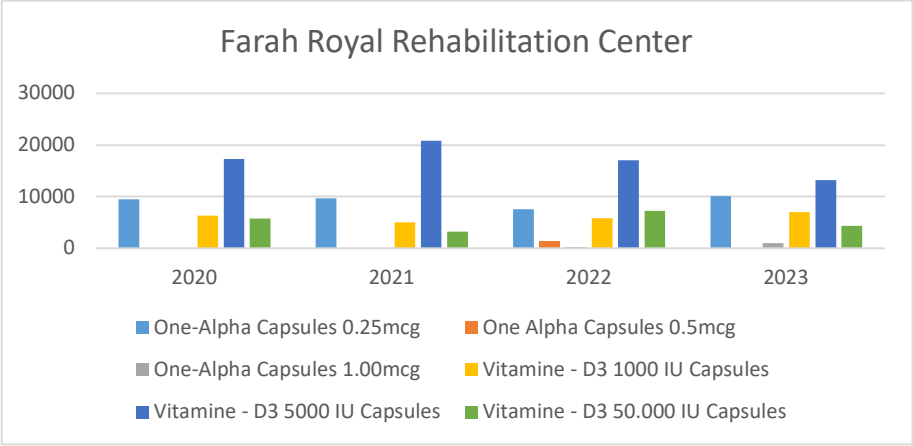

Fig 7: Prescription pattern in Farah Royal Rehabilitation Center

The dispensing volumes observed at Prince Rashid Ben Al-Hasan Military Hospital, characterized by their moderation and balance across various formulations, indicate a distinct approach to vitamin D supplementation. This may be attributed to the hospital's function as a general military facility catering to a diverse patient demographic. The observed dispensing patterns at this facility suggest

the presence of well-established prescribing protocols that effectively address diverse clinical needs while ensuring consistent inventory management practices.

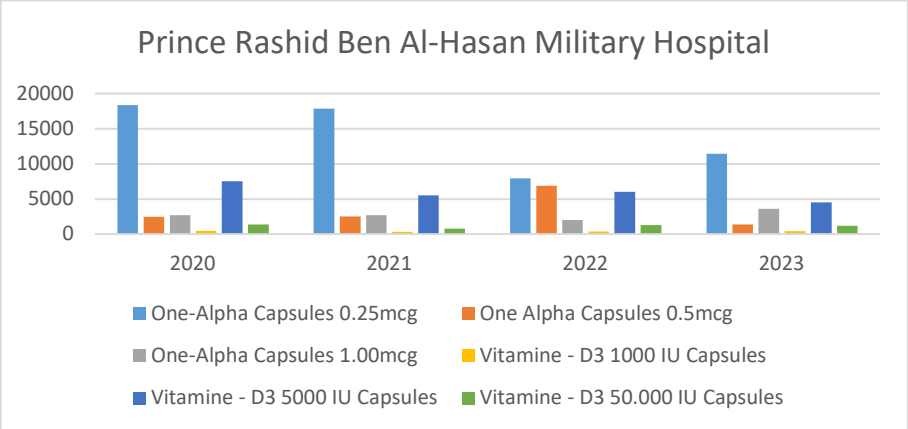

Fig 8: Prescription pattern in Prince Rashid Ben Al-Hasan Military Hospital

Temporal Trends and Healthcare System Implications: The observed temporal trends in vitamin D dispensing present significant implications regarding the continued development of medical practice within the military healthcare system. The observed decrease in Alfacalcidol utilization throughout various institutions from 2020 to 2022 may indicate several contributing factors. This trend may suggest a transition in clinical practice favoring the use of native vitamin D (cholecalciferol), aligning with the latest evidence and international guidelines. The observed rise in Alfacalcidol dispensing in 2023 may indicate a stabilization phase, during which healthcare professionals have developed more precise criteria for differentiating between activated and native forms of vitamin D. Furthermore, the discrepancies observed in dispensing patterns may indicate evolving patient demographics or shifting clinical requirements within the JRMS healthcare system. The consistent trends observed in cholecalciferol dispensing, especially at Farah Royal Rehabilitation Center, imply the presence of established procedures for general vitamin D supplementation. In contrast, the fluctuating patterns of Alfacalcidol dispensing may reflect the development of new strategies for addressing particular clinical conditions.

Resource Allocation and Inventory Management: The notable discrepancies in dispensing practices among various institutions and over different time frames carry substantial implications for the allocation of resources and the management of inventory within the military healthcare system. The results indicate a necessity for advanced, tailored strategies in stock management that take into account the creation of dynamic inventory systems capable of addressing both consistent baseline needs and fluctuating usage trends. The significance of this is especially pronounced for medications such as Alfacalcidol, where usage patterns exhibit notable variability. It is essential to implement evidence-based procurement tactics which consider institutional specialization while ensuring overall system efficiency. The unique patterns identified at each facility indicate that centralized procurement processes ought to integrate flexibility to address the specific needs of each institution.

Clinical Practice Standardization: The observed dispensing patterns offer valuable insights into potential avenues for standardizing clinical practices throughout the military healthcare system. In order to accommodate institution-specific requirements while ensuring consistency, several opportunities for standardization can be identified. These include the formulation of comprehensive system-wide guidelines for vitamin D supplementation that consider various clinical scenarios and diverse patient populations. The implementation of these guidelines may enhance the optimization of various vitamin D formulations, ensuring the preservation of clinical autonomy. Additionally, they facilitate the establishment of criteria for the selection of activated versus native vitamin D forms, tailored to individual patient characteristics and specific clinical indications. The differing patterns of Alfacalcidol and cholecalciferol usage indicate potential avenues for establishing more standardized methodologies in formulation selection.

Future Directions and Policy Implications: The results of this study present important considerations for future policy formulation and clinical implementation within the military healthcare system. This includes the necessity for continual monitoring of vitamin D dispensing habits to recognize emerging trends and evaluate the effects of any standardization measures that may be implemented. The implementation of this monitoring may provide valuable insights for future procurement strategies and the development of clinical practice guidelines. Additionally, it highlights the potential benefits of adopting electronic prescribing systems that integrate clinical decision support tools to facilitate the selection of appropriate vitamin D formulations. These systems have the potential to enhance utilization patterns while ensuring clinical effectiveness. Additionally, it is crucial to develop training workshops for healthcare providers that focus on optimal strategies for vitamin D supplementation. These programs have the potential to enhance evidence-based prescribing practices, taking into consideration the unique requirements of specific institutions and the diverse characteristics of patient populations.

CONCLUSIONS:

This study underscores the variability observed in the dispensing habits of vitamin D supplements among JRMS-affiliated hospitals, which is indicative of both clinical and operational dynamics. The findings illustrate the system's ability to adjust to evolving demands; however, they also highlight specific areas that necessitate enhancement to guarantee a consistent and equitable distribution. By addressing these challenges, the JRMS will significantly improve its capacity to meet patient needs while optimizing the utilization of resources.

Limitations of the Study: The study's dependence on aggregate dispensing data constrains its capacity to accurately reflect real-world usage patterns or patient outcomes. Furthermore, the analysis failed to consider external factors, including seasonal fluctuations in vitamin D requirements and disruptions in the global supply chain. The lack of qualitative data from medical care providers and patients significantly constrains the depth of interpretation.

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