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FACTORS INFLUENCING ANTI-OSTEOPOROTIC MEDICINE CONSUMPTION IN UZBEKISTAN: A DESCRIPTIVE ANALYSIS

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ABSTRACT
Background: Osteoporosis is an increasing public health burden in Uzbekistan, driven by demographic changes and limited access to timely diagnosis and treatment. This study aims to identify key determinants influencing the consumption of anti-osteoporotic medicines (AOMs). **Methodology:** A multifactor analytical approach was applied using descriptive, grouping, and correlational methods, as well as compound annual growth rate (CAGR) analysis. Because the annual series deviated from normality, associations between variables were assessed using Spearman's rank correlation coefficient (ρ). As CAGR is a descriptive indicator, the statistical significance of temporal change was additionally evaluated using Spearman's rank-based trend analysis. **Results:** Osteoporosis incidence increased by 95% between 2016 and 2024, with pronounced regional variability. The national CAGR was 9%, although the monotonic national time trend did not reach statistical significance ($\rho = 0.533$, $p = 0.139$). In RSSPMTO data, the correlation between annual population size and the combined number of osteoporosis/osteopenia cases was moderate when 2022 was included ($\rho = 0.60$, exact $p = 0.350$) and higher after exclusion of the 2022 peak ($\rho = 0.80$, exact $p = 0.333$). Still, neither association reached statistical significance, likely due to the small number of observations. **Discussion:** The findings indicate that medical, demographic, and technological factors, particularly limited diagnostic capacity and uneven regional detection, may influence AOMs consumption. **Conclusion:** Improving access to AOMs in Uzbekistan requires expanding densitometry services, implementing screening programs, and strengthening pharmaceutical policy through reference pricing, domestic production incentives, and price regulation.

INTRODUCTION

Osteoporosis is a systemic disorder of bone mass, strength, and microarchitecture that leads to increased bone fragility and represents a significant medical and socio-economic burden [1]. The disease develops over a prolonged period and has a substantial negative impact on health-related quality of life (QoL) due to factors such as pain, reduced physical activity, limitations in social functioning, and psychological disturbances [2]. It is projected that by 2050, more than 50% of osteoporotic

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fractures worldwide will occur in Asia, underscoring the problem's relevance for the region, particularly in Uzbekistan, where population growth and life expectancy are steadily increasing [3]. Against this background, osteoporosis represents an increasing public health burden in Uzbekistan. According to regional epidemiological estimates based on extrapolation of population-based data, approximately 1.4 million people in the country may be affected by osteoporosis. In 2015, an estimated 16,764 hip fractures occurred in Uzbekistan, and this number is projected to increase to 60,272 cases by 2050, representing a 360% increase associated with population aging and demographic changes [4]. Effective prevention of fractures and management of osteoporosis largely depend on the availability and accessibility of appropriate pharmacological therapy. In this context, many studies have analyzed specific aspects of the pharmaceutical market for anti-osteoporotic medicines and identified existing challenges in providing drugs to patients with osteoporosis [5,6]. At the same time, despite studies addressing individual segments of the pharmaceutical market, there remains a lack of comprehensive research on the factors influencing the anti-osteoporotic drug market. This gap is particularly relevant in the context of the Republic of Uzbekistan's pharmaceutical market. Therefore, this study aimed to identify and analyze the key medical, demographic, technological, and economic factors influencing the consumption of anti-osteoporotic medicines (AOMs) in Uzbekistan. The specific objectives were to

- Assess trends and regional variability in osteoporosis incidence during 2016–2024;
- Examine which demographic factors are most strongly associated with regional variability in incidence;
- Evaluate the role of diagnostic capacity in osteoporosis detection
- Analyze the structure of AOMs consumption and its pharmaceutical determinants.

This study provides a comprehensive multi-factor analysis of anti-osteoporotic medicine (AOM) consumption in Uzbekistan, integrating epidemiological, diagnostic, and pharmaceutical market data. It highlights the role of diagnostic capacity, demographic trends, and economic factors in shaping medicine use, and offers new country-specific evidence to support pharmaceutical policy and healthcare planning.

MATERIALS AND METHODS

A multifactor analytical approach was employed, incorporating statistical, analytical-synthetic, and correlational methods, as well as grouping techniques and compound annual growth rate (CAGR) analysis. CAGR was first calculated to describe the average annual growth in osteoporosis incidence. As CAGR is a descriptive measure and does not provide an inferential p-value, the statistical significance of temporal changes was additionally assessed using Spearman's rank-based trend analysis between calendar year and annual incidence values. Therefore, the p-values reported alongside CAGR reflect the significance of the underlying monotonic trend rather than the CAGR estimate itself.

For the Surkhandarya region, CAGR calculations were performed starting from 2017 due to the absence of official data for 2016. Osteoporosis incidence data were obtained from the Institute of Health and Strategic Development. Osteoporosis data according to the ICD-10 classification (codes M80–M82) were obtained from the Institute of Health and Strategic Development and recorded annually at the regional level.. Analyses of the growth in osteoporosis incidence (CAGR) and its relationship with population size were conducted for the period 2016–2024. The annual growth rates were calculated using the following formula:

$$\mathrm{CAGR} = \left(\frac{\mathrm{EV}}{BV}\right)^{\frac{1}{n}} - 1 \qquad (1)$$

where EV is the final value of the indicator at the end of the study period (2024); BV is the baseline value at the beginning of the study period (2016), n is the number of years in the study period [7].

Because the annual data series deviated from normality (Shapiro–Wilk p = 0.00002), parametric methods such as Pearson's correlation were considered inappropriate. Therefore, Spearman's rank correlation coefficient (ρ) was used to assess monotonic associations between variables. The coefficient was calculated using the standard formula:

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)} \quad (2)$$

where $d_i = R(x_i) - R(y_i)$. Here, $R(x_i)$ and $R(y_i)$ denote the ranks of the two analyzed variables, d_i is the difference between the paired ranks, and *n* is the number of observations.

For analyses based on annual observations, including the Republican Specialized Scientific and Practical Medical Center of Traumatology and Orthopedics (RSSPMTO) series presented in Table 4, exact two-sided p-values were used due to the small number of yearly observations. Data on the number of densitometric examinations were collected from the center's clinical examination registers for the period 2020–2024. The analysis was based on population data obtained from official statistical reports of the State Committee of the Republic of Uzbekistan on Statistics.

Statistical analyses were performed in Microsoft Excel and verified in Python 3.13.5 (SciPy 1.17.0). All statistical tests were two-tailed, and $p < 0.05$ was considered statistically significant. Consumption of AOMs was assessed using data from the Drug Audit pharmaceutical sales database for 2024, which provides information on medicine sales volumes and market value in Uzbekistan's pharmaceutical market.

RESULT

At the initial stage of the factor analysis, key medical determinants influencing AOMs consumption were examined. Particular attention was paid to trends in the incidence of osteoporosis in the Republic of Uzbekistan. A steady increase in the incidence of osteoporosis was observed from 2016 to 2021, followed by a decline in 2022–2023 and a subsequent rise in 2024 (Figure 1). Over the study period, the overall growth rate of osteoporosis incidence reached 95%.

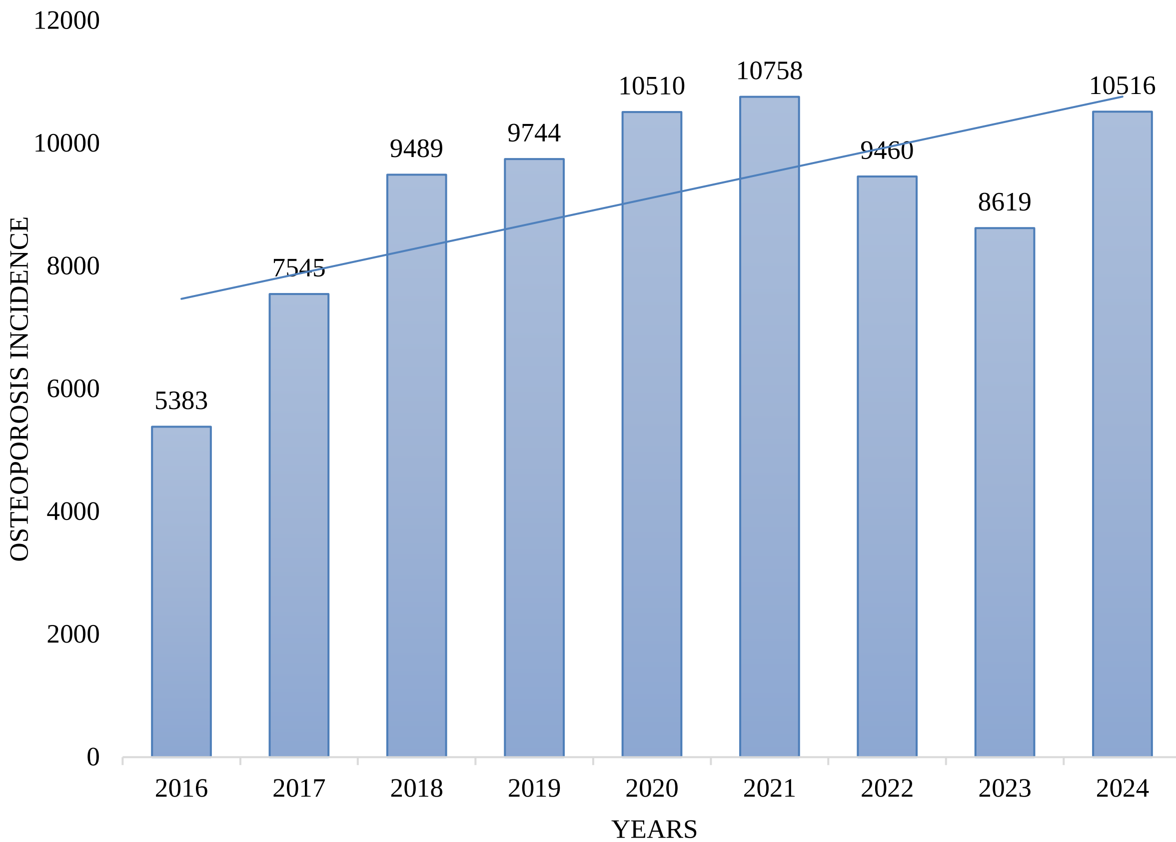

Figure 1: Dynamics of Osteoporosis Incidence in the Republic of Uzbekistan

A more detailed regional analysis revealed substantial variability between 2016 and 2024. An increasing trend in osteoporosis incidence was observed across most regions. To quantify temporal changes, CAGR was calculated for each region, and monotonic trends were assessed using Spearman's rank correlation. At the national level, the CAGR was 9%. However, the monotonic time trend did not reach statistical significance ($\rho = 0.533$, $p = 0.139$). Significant positive monotonic trends were identified in the Republic of Karakalpakstan, Andijan, Jizzakh, Navoi, Tashkent Region, and Khorezm. In contrast, Kashkadarya demonstrated a significant negative trend. The detailed regional dynamics of osteoporosis incidence and corresponding CAGR values are presented in Table 1.

To better understand the observed patterns, diagnostic capacity was further evaluated. According to available data, the number of dual-energy X-ray absorptiometry (DXA) devices in Uzbekistan was 0.16 units per 1 million population as of 2020 [4]. A total of 33 densitometers have been officially registered nationwide since 2014; However, information on their operational status is not publicly available. To evaluate the structure of diagnosed cases, data from densitometric examinations conducted at the RSSPMTO were analyzed. The results of densitometric examinations are presented in Table 2.

Table 1: Annual Growth Rates of Osteoporosis Incidence by Region

Region	2016	2017	2018	2019	2020	2021	2022	2023	2024	CAGR (%)
Republic of Uzbekistan	5383	7545	9489	9744	10510	10758	9460	8619	10516	9
Republic of Karakalpakstan	6	6	18	50	68	75	176	169	124	46
Andijan	54	78	99	159	281	289	293	268	1082	45
Bukhara	42	71	142	227	248	255	215	165	178	20
Jizzakh	72	87	127	151	162	168	92	178	568	29
Kashkadarya	452	323	367	328	327	335	248	192	102	-17
Navoi	7	11	41	24	81	92	246	47	144	46
Namangan	207	220	522	311	350	362	182	187	277	4
Samarkand	1195	2993	3624	3649	3345	3370	2152	1973	1390	2
Surkhandarya	-	514	761	686	516	550	521	576	365	-5
Syrdarya	278	270	288	298	245	258	211	290	550	9
Tashkent Region	543	629	1465	1834	1965	2010	2434	1951	2141	19
Fergana	71	106	124	167	173	180	107	165	169	11
Khorezm	234	355	410	414	636	656	748	813	868	18
Tashkent City	2222	1882	1501	1446	2113	2158	1835	1645	2558	2

Table 2: Indicators of Densitometry Results Among Examined Patients at the RSSPMTO

Categories of examined individuals	Years									
	2020		2021		2022		2023		2024	
Number of examinations (n, %)										
Urban population	2170 (57.5%)		3340 (58.6%)		2707 (36.4%)		3496 (46.9%)		3469 (45.0%)	
Rural population	1510 (40.0%)		2255 (39.5%)		4581 (61.6%)		3827 (51.3%)		4066 (52.7%)	
Foreign citizens	97 (2.5%)		109 (1.9%)		144 (2.0%)		134 (1.8%)		175 (2.3%)	
Total	3777 (100%)		5704 (100%)		7432 (100%)		7457 (100%)		7710 (100%)	
Number of Diagnosed Cases										
Severity of disease	OP*	OPN*	OP*	OPN*	OP*	OPN*	OP*	OPN*	OP*	OPN*
Total	1431	1598	1955	1792	2578	3347	1539	2676	1684	2185
Children	44	52	38	42	54	97	45	72	39	36
Adolescents	18	45	32	33	15	40	32	41	28	28
Adults	1369	1501	1885	1717	2509	3210	1462	2563	1617	2121
Man	446	632	632	685	545	1250	459	1115	416	896
Woman	923	869	1253	1032	1964	1960	1003	1448	1201	1225

Abbreviations: OP – Osteoporosis; OPN – Osteopenia.

The analysis of bone mineral density assessment results demonstrated that the highest prevalence of osteopenia and osteoporosis was observed in 2022. In subsequent years, however, the proportion of individuals with normal bone mineral density gradually increased, rising from 19.80% in 2020 to 49.82% in 2024. At the same time, the combined prevalence of osteopenia and osteoporosis remained consistently high, ranging from 50,18% to 80,20% annually.

To further investigate these trends, demographic factors affecting AOMs consumption were analyzed, including population size, level of urbanization, proportion of the elderly population, and gender distribution. Densitometric data obtained from the RSSPMTO were used to assess the relationship between population size and the number of osteoporosis and osteopenia cases identified during densitometric examinations.

An upward trend was observed over time in both diagnostic activity and the number of detected pathological cases, necessitating a comparison of the total number of identified cases with Uzbekistan's population size.

To ensure robustness of the analysis, correlation was assessed for the period 2020–2025, including and excluding the 2022 peak (Table 4).

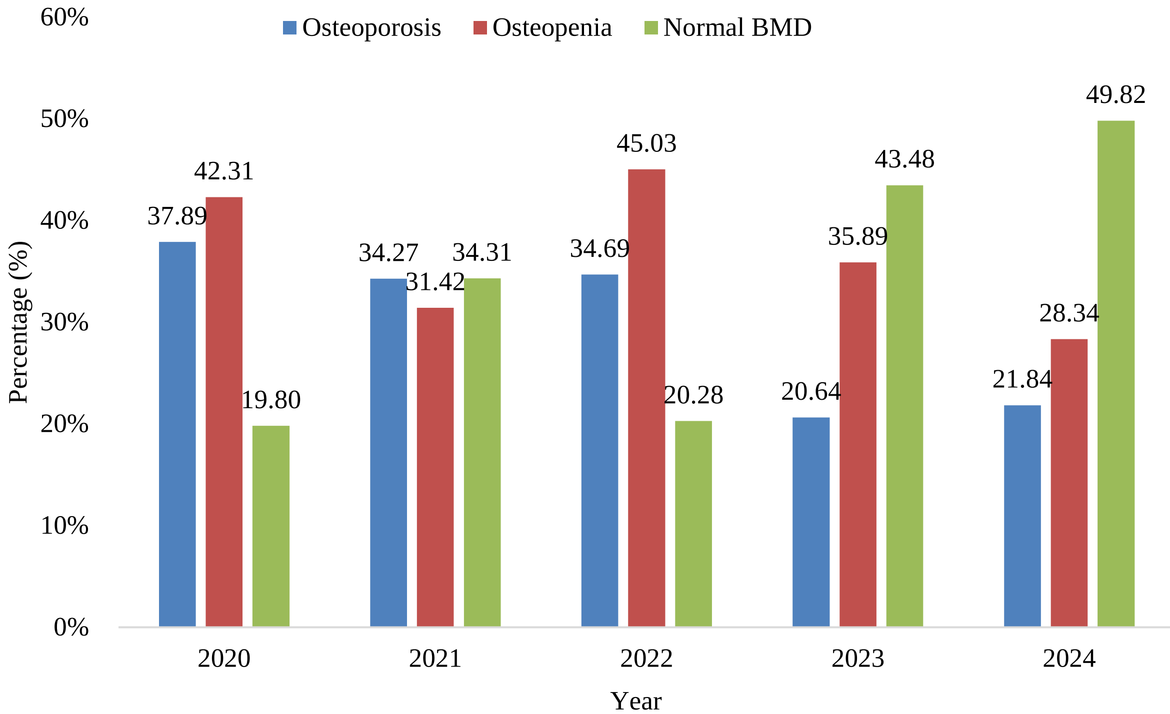

Figure 2: Distribution of Disease Severity According to Densitometric Data (% of Total)

Table 4: Correlation analysis of osteoporosis/osteopenia and population growth (RSSPMTO data)

Correlation	**r**	**r_{max}**	**p_{value}**	**P_{exact}**
Total 2020-2024 period, including COVID-19 peak (n=5)	0,29	0,22	0,6	0,350
2020-2024 period excluding COVID-19 peak in 2022 (n=4)	0,77	0,74	0,8	0,333

Correlation analysis revealed a weak positive association between population size and detected osteoporosis cases during the full study period (r = 0.29). After excluding the outlier year 2022 (COVID-19 peak), the correlation coefficient increased to 0.77, suggesting a potential positive relationship. However, due to the small sample size (n = 4–5) and the lack of statistical significance ($p > 0.05$), these findings should be interpreted with caution. The annual number of detected pathological cases was defined as the sum of osteoporosis and osteopenia cases identified by densitometric examination at the RSSPMTO.

To further characterize the demographic profile of the studied population, the age distribution of osteoporosis cases in Uzbekistan in 2024 is presented in Figure 3A. The analysis showed that 24.5% of cases occurred in individuals under 40 years of age, while the majority (75.5%) were concentrated among individuals aged 40 years and older.

The gender distribution of osteoporosis cases is shown in Figure 3B. According to national statistics, women accounted for 53% of all diagnosed cases, while men accounted for 47%. In contrast, densitometric data revealed a more pronounced gender disparity: 74.3% of individuals with decreased bone mineral density were women, compared with 25.7% men. The distribution of osteoporosis cases by level of urbanization is presented in Figure 3C. In 2024, 53.5% of cases were recorded among urban residents, while 46.5% were recorded among rural residents. In addition to demographic characteristics, economic factors influencing AOMs consumption were also analyzed. To evaluate the potential effect of reference pricing on AOMs consumption and pricing, sales and price indicators were analyzed before and after its implementation (Table 5).

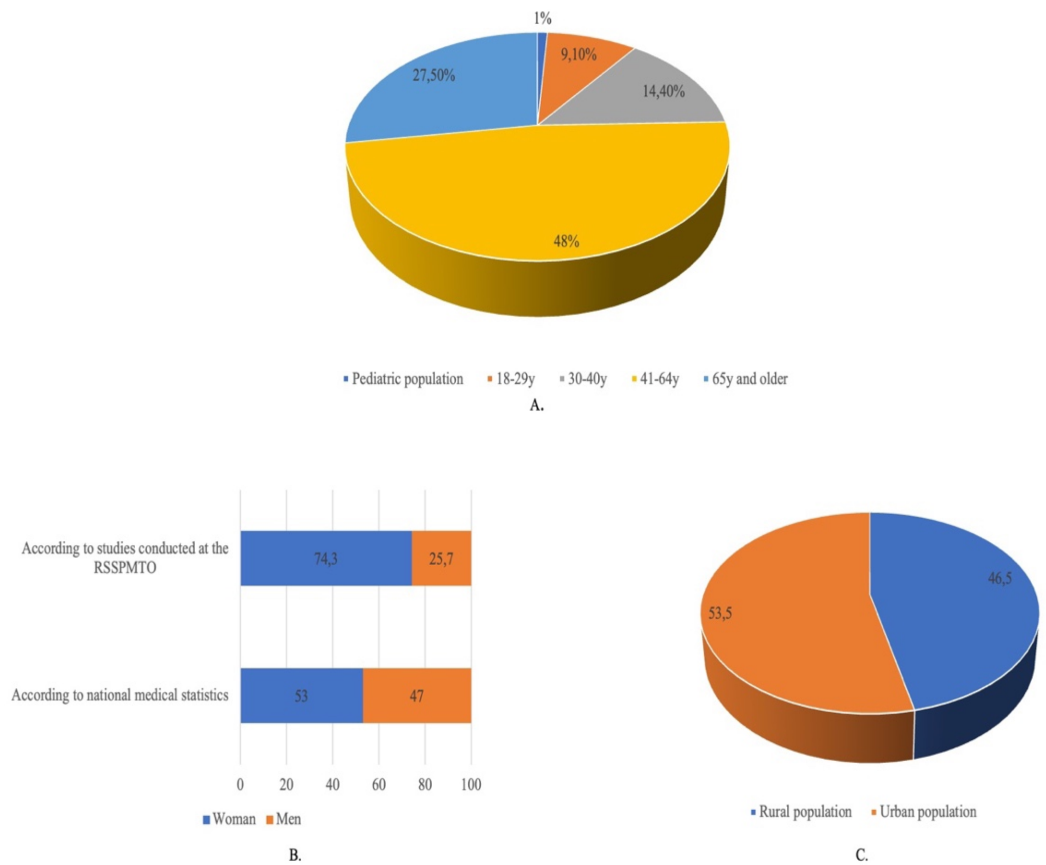

Figure 3: Demographic characteristics of osteoporosis cases in Uzbekistan (2024): (A) Age groups; (B) Gender distribution; (C) Level of urbanization.

Table 5: Changes in AOM sales volume and pricing indicators between 2020 and 2024. Values represent absolute and percentage changes in sales volume (packages), total market value (USD), and average price per package.

Indicator	2020	2024	Absolute change	Percentage change
Sales volume (packages)	115,831	146,078	30,247	26.1%
Total sales value (USD)	732,072.11	1,879,630.47	1,147,558.36	156.8%
Average price (USD/package)	6.32	12.87	6.55	103.6%

The analysis showed that sales volume increased from 115,831 to 146,078 packages (+26.1%), while total sales value rose from 732,072.11 USD to 1,879,630.47 USD (+156.8%). At the same time, the average price per package increased from 6.32 USD to 12.87 USD (+103.6%). Thus, despite the introduction of reference pricing, substantial increases in prices and market value were observed during the study period. To better understand these trends, pharmaceutical consumption patterns were analyzed using 2024 Drug Audit data, highlighting the role of pharmaceutical factors in shaping AOM demand.

The analysis revealed that 146,078 packages were sold in Uzbekistan, with a market value of 1,879,630.47 USD.
Alendronic acid dominated the market, accounting for 65.83% of total sales (96,169 packages), followed by zoledronic acid (18.14%, 26,498 packages) and ibandronic acid (16.03%, 23,411 packages).

DISCUSSION

The observed increase in the incidence of osteoporosis in Uzbekistan reflects a combination of demographic and healthcare-related factors. Population aging and increased awareness of osteoporosis may contribute to the overall upward trend. The decline observed in 2022–2023 and the subsequent increase in 2024 likely reflect fluctuations in diagnostic activity rather than true epidemiological changes. Variations in healthcare utilization and access to diagnostic services may have influenced case detection during this period.

The marked increases observed in certain regions, particularly Andijan and Jizzakh in 2024, are unlikely to represent abrupt epidemiological shifts. Instead, these changes may be explained by intensified case detection and improved registration practices. This pattern is consistent with the phenomenon of “catch-up detection”, where previously undiagnosed cases are identified following improvements in diagnostic capacity. Regional disparities in trends further suggest unequal access to diagnostic infrastructure, including densitometry services, as well as differences in healthcare delivery across regions.

In this context, the role of diagnostic capacity becomes particularly important. Osteoporosis is a clinically silent disease that often remains undiagnosed until the occurrence of fragility fractures. Therefore, its timely detection largely depends on the availability and accessibility of diagnostic technologies, particularly densitometry. A decrease in the incidence of osteoporosis was observed in the Kashkadarya (CAGR = –17%) and Surkhandarya (CAGR = –6%) regions. Given the overall national growth trend, this decline may reflect regional differences in diagnostic activity and case registration rather than a true reduction in disease burden. Therefore, these regional trends should be interpreted with caution. Despite the official registration of 33 densitometers, there is no publicly available systematic information regarding their installation and operational status. This suggests that the effective diagnostic capacity may be lower than nominal estimates, with some devices potentially not yet commissioned or not fully utilized due to organizational or logistical constraints. Consequently, both the availability of densitometric equipment and its actual utilization represent key technological determinants of osteoporosis detection. These factors directly influence the timely identification of patients and, therefore, the demand for anti-osteoporotic medicines.

In addition to the numerical availability of densitometers, their effective utilization may be limited by several qualitative factors. These include insufficient maintenance and calibration services, shortages of trained technical personnel, delays in equipment repairs, high costs for procuring and delivering spare parts, and prolonged wait times for replacement components. Such organizational and technical barriers may reduce the operational status of densitometers and consequently limit access to timely osteoporosis diagnosis, particularly in regions with limited healthcare infrastructure. This may subsequently contribute to underdiagnosis and reduced demand for anti-osteoporotic medicines.

Beyond technological factors, clinical characteristics of the disease also play an important role in shaping pharmacotherapy patterns. According to the World Health Organization classification, osteoporosis is defined by bone mineral density (BMD) and includes osteopenia, osteoporosis, and severe osteoporosis, with the latter associated with fragility fractures [8]. Against this background, the observed peak in the prevalence of osteopenia and osteoporosis in 2022 may be associated with a substantial increase in the number of osteoporosis screenings conducted at the RSSPMTO (by 104.13%), as well as with external factors such as post-pandemic effects. The subsequent increase in the proportion of individuals with normal bone mineral density may indicate the effectiveness of the preventive and therapeutic measures implemented. However, despite this positive trend, the persistently high combined prevalence of osteopenia and osteoporosis highlights the ongoing burden of reduced bone mineral density in the population. These findings emphasize the importance of incorporating bone health status into the selection and optimization of pharmacological therapy. Furthermore, the choice of appropriate pharmacotherapy depends on the type of osteoporosis. Primary osteoporosis typically develops independently, most often in postmenopausal women, elderly individuals (senile osteoporosis), or in cases of idiopathic etiology. In contrast, secondary osteoporosis develops as a consequence of underlying conditions such as endocrine, rheumatologic, or gastrointestinal diseases, as well as prolonged use of medications including glucocorticoids [9,10].

In this context, the increase in detection in 2022 is also likely associated with a substantial rise in diagnostic activity, as well as external factors related to the COVID-19 pandemic. Previous studies have shown that SARS-CoV-2 infection and its management—through systemic inflammation, reduced physical activity, glucocorticoid therapy, and vitamin D deficiency—can negatively affect bone metabolism and accelerate bone loss [11]. In addition to these biological mechanisms, pandemic-related disruptions in healthcare delivery may have significantly influenced diagnostic patterns. Evidence indicates that access to densitometry was limited during the COVID-19 period: 29% of clinicians scheduled DXA immediately, 11% relied solely on clinical risk assessment, 29% combined clinical assessment with delayed DXA, 33% postponed examinations, and 5% reported temporarily suspending DXA services [12]. As a result, the increase in detected cases in 2022 may reflect not only a true rise in disease burden but also a rebound effect due to delayed diagnoses. The subsequent increase in the proportion of individuals with normal bone mineral density may suggest improvements in preventive and therapeutic interventions, as well as stabilization of healthcare services after the pandemic period. However, despite this positive trend, the persistently high combined prevalence of osteopenia and osteoporosis (50–70%) indicates a substantial and ongoing burden of reduced bone mineral density in the population.

The correlation analysis indicates that the observed relationship between population size and detected incidence of osteoporosis is strongly influenced by the COVID-19–related peak. Including pandemic-period data attenuates the association, whereas excluding the 2022 peak reveals a more pronounced relationship under relatively stable diagnostic activity. These findings indicate that external shocks, such as the COVID-19 pandemic, can substantially distort epidemiological correlations and that demographic factors should be interpreted with caution, only within a stable diagnostic and healthcare context. When the 2022 peak is excluded, a positive correlation ($r = 0.77$) is observed between population size and osteoporosis incidence, although it remains statistically non-significant, likely due to the small number of observations. This suggests a potential contribution of demographic factors to the underlying disease burden. This underscores the importance of accounting for population growth when planning the provision of AOMs in Uzbekistan, particularly under conditions of stable diagnostic activity.

These findings highlight the importance of interpreting epidemiological data within the broader healthcare context, particularly during periods of systemic disruption. They also emphasize the need to consider demographic dynamics, including population growth and aging, when planning the provision and optimization of AOMs, thereby supporting more evidence-based decision-making in osteoporosis management. In this regard, age represents one of the most important demographic determinants influencing AOMs consumption. A decline in bone mineral density (BMD) is predominantly observed among the elderly population and in women during the postmenopausal period. Hormonal imbalance, particularly estrogen deficiency in postmenopausal women, plays a central role in the development of osteoporosis.

Between 2000 and 2019, global life expectancy increased by more than six years, reaching 73.4 years. Demographic projections indicate that by 2050, the proportion of the population aged 65 years and older will be 16% worldwide (approximately 1.6 billion people), while the population aged 80 years and older will triple to approximately 426 million. These trends highlight the growing relevance of osteoporosis as a major public health concern [13,14]. The relatively higher proportion of osteoporosis cases observed in younger individuals (24.5% under 40 years of age) is more likely attributable to secondary osteoporosis associated with underlying comorbid conditions rather than primary age-related bone loss. Endocrine, gastrointestinal, and inflammatory disorders, as well as long-term use of medications affecting bone metabolism, may play a predominant role in this age group (Figure 3A). Globally, osteoporosis is more prevalent among women, primarily due to hormonal changes during the postmenopausal period, leading to accelerated bone loss [15]. This is consistent with the findings of the present study, which demonstrate a substantially higher proportion of women among individuals with decreased bone mineral density (Figure 3B).

The discrepancy between national statistical data (53.0% women) and densitometric findings (74.3% women) may reflect differences in diagnostic coverage and healthcare-seeking

behavior, suggesting that women are more likely to undergo densitometric examinations and be diagnosed at earlier stages.
Modern lifestyle factors, including low physical activity, urbanization, and insufficient dietary calcium intake, contribute to the increasing prevalence of osteoporosis [16]. In this context, the predominance of osteoporosis cases among the urban population (Figure 3C) may be associated with lifestyle-related risk factors characteristic of urban environments. At the same time, the increasing proportion of rural residents undergoing densitometric examinations since 2022 suggests improved access to diagnostic services in rural areas. Therefore, while the recorded incidence remains higher in urban populations, expanded screening coverage in rural regions contributes to increased detection rates.

This suggests the importance of considering age and gender characteristics when developing preventive strategies and optimizing pharmacotherapy for osteoporosis. In addition to demographic and clinical determinants, social factors also play a significant role in shaping AOMs consumption. Thus, within the framework of the present study, the level of urbanization is considered not only as a demographic indicator but also as a significant social factor influencing lifestyle, the accessibility of medical care and diagnostic services, and the formation of AOMs consumption, along with other social determinants. The predominance of osteoporosis cases among rural populations highlights the necessity of developing mechanisms to ensure access to specialized medical care and adequate pharmaceutical provision for these groups. In addition, the consumption of AOMs is significantly influenced by the following social factors:

- the level of public awareness and knowledge about osteoporosis, its consequences, and the need for long-term pharmacotherapy;
- participation in preventive examinations, including screening programs;
- timely seeking of medical care by the population;
- patients' attitudes toward osteoporosis diagnosis;
- the degree of trust in medical recommendations;
- conscious adherence to treatment and commitment to therapy;
- compliance with medical prescriptions and regular, long-term use of AOMs.

Recent studies demonstrate that even after the occurrence of fractures, patients often do not attach sufficient importance to the diagnosis or treatment of osteoporosis [17]. Consistent with previous findings, non-adherence to bisphosphonates increases fracture risk by approximately 30%, while discontinuation of treatment is associated with a 30–40% higher risk [18].

Furthermore, patient trust in healthcare professionals and confidence in treatment recommendations have been identified as important determinants of medication adherence. These patterns of patient behavior may be explained by broader social determinants influencing treatment adherence. However, the social factors listed above, including trust in medical recommendations and public awareness, were not quantified in the present study through primary sociological surveys. These variables are included as conceptual determinants based on evidence from the published literature. Kelly et al. reported that trust in physicians was among the highest-ranked factors influencing adherence behavior among patients with osteoporosis and other rheumatic diseases [19]. These determinants are intended to frame potential behavioral influences on AOM consumption rather than to represent empirically measured indicators.

In addition to social determinants, economic and regulatory factors also play a significant role in shaping AOMs consumption. Key factors include price levels, population income, inflation, exchange rate fluctuations, and the effectiveness of healthcare and pharmaceutical policies. Drug prices are a key determinant of the accessibility and continuity of osteoporosis therapy. The structure of imports and domestic production, as well as macroeconomic conditions, significantly influence price formation. In this regard, increasing the share of domestically produced AOMs is essential for improving treatment affordability.

The implementation of a reference pricing system in Uzbekistan since July 1, 2020, aimed to regulate pharmaceutical prices by establishing maximum allowable price levels. However, the results of the present study indicate that, despite this policy, prices continued to rise. This may be explained by the influence of additional market and structural factors. This pattern is consistent with findings from neighboring Central Asian countries. For example, in Kazakhstan, the pharmaceutical market is highly dependent on imported medicines (86.9%), making it vulnerable to exchange rate fluctuations and external pricing pressures [20].

Furthermore, discrepancies between regulated prices and actual market prices may contribute to the observed increase in market value, as the analyzed data reflect real sales transactions rather than administratively set prices. This observation suggests that price regulation alone may be insufficient to control pharmaceutical expenditures. Comprehensive strategies, including support for domestic production, optimization of procurement systems, and mitigation of currency-related risks, are required to ensure sustainable affordability of anti-osteoporotic medicines.

From a policy perspective, an important area of state support is regulating access to essential medicines, especially for chronic diseases requiring long-term therapy. The inclusion of osteoporosis in the list of diseases financed from the state budget for preferential categories of citizens [21] strengthens access to pharmacotherapy and supports treatment adherence. It should be noted that 24.14% of the bisphosphonate products registered in Uzbekistan are domestically manufactured [5]. However, their market presence remains limited compared with imported alternatives. In particular, the anti-osteoporotic medicines market in 2024 was entirely represented by imported products. This finding highlights a gap between the registration of locally manufactured bisphosphonates and their actual availability in the market, and may indicate challenges related to the competitiveness of domestic manufacturers and the supply of locally produced medicines. As a result, the high dependence on imported products may increase the vulnerability of the pharmaceutical supply system and potentially limit patients' access to treatment.

Furthermore, anti-osteoporotic pharmacotherapy in Uzbekistan in 2024 was limited exclusively to bisphosphonates. Other therapeutic classes—including SERMs, RANKL inhibitors, and parathyroid hormone analogs [22]—were not registered, restricting treatment options for patients with contraindications or intolerance. This underscores the need to expand the range of registered AOMs in line with international standards. Based on the findings, the main pharmaceutical factors influencing AOM demand include:

- assortment and its renewal;
- development of domestic production;
- clinical efficacy and safety;
- convenience of use;
- level of information support.

Figure 4: Conceptual model illustrating the pathways of influence on anti-osteoporotic medicines (AOMs) consumption in Uzbekistan. Solid arrows indicate direct influences, dashed arrows indicate indirect (hypothesized) influences, and green arrows represent policy impact pathways.

While the present study is primarily descriptive due to data limitations, the findings provide a foundation for developing a predictive model for AOM demand in future research. Based on the identified factors, a conceptual framework may be proposed that integrates medical, demographic, technological, economic, and pharmaceutical determinants. Future studies may apply advanced statistical approaches, such as multivariate regression or time-series analysis, to quantify the relationships between these factors and AOMs demand. The development and validation of such models may require more detailed and structured data, particularly at the regional level.

CONCLUSION

Thus, the present study analyses medical, socio-demographic, technological, pharmaceutical, and economic–legal factors influencing the consumption of AOMs. The conceptual model of factor analysis is presented in Figure 4. Government support may affect AOMs consumption primarily through preferential financing mechanisms, which may reduce out-of-pocket costs and improve treatment adherence, ultimately increasing medicine use. Technological factors, particularly the availability of densitometry, may influence consumption by enhancing case detection and subsequent demand for pharmacological therapy. In contrast, limited diagnostic infrastructure may lead to under-detection and lower recorded consumption. Economic factors, including reference pricing and currency-related effects, operate through price mechanisms that affect affordability.

The study of the most significant medical factor revealed a steady increase in osteoporosis incidence in the Republic of Uzbekistan, accompanied by pronounced regional variability and a significant correlation with the population's demographic characteristics. Key socio-demographic determinants influencing consumption include the age structure of the population, the level of urbanization, and gender-specific patterns of morbidity, which collectively shape the structure of demand and the volume of consumption. The analysis of technological factors indicates that diagnostic detection of osteoporosis remains insufficient. In this regard, the findings suggest that strengthening diagnostic capacity—by expanding access to densitometric examinations, improving equipment in regional healthcare facilities, and implementing early screening programs for high-risk population groups—may enhance disease detection. These measures could also contribute to more appropriate use of anti-osteoporotic therapy. Given the limited availability of DXA devices, osteoporosis screening may prioritise high-risk groups: (1) adults aged ≥65 years (both men and women), as age-related bone loss places them at the highest fracture risk; (2) postmenopausal women under 65 years with additional clinical risk factors (fragility fracture, glucocorticoid use, parental hip fracture, low BMI); (3) adults aged 50–64 years with clinical risk factors; and (4) adults under 50 years with secondary osteoporosis risk. A stepwise implementation strategy may be considered, beginning with pilot programs in regions with existing densitometry capacity, followed by targeted expansion to high-risk populations and gradual nationwide scale-up. The results suggest the importance of a comprehensive approach that strengthens economic mechanisms and regulatory frameworks to enhance the accessibility of anti-osteoporotic medicines and optimize pharmaceutical provision for patients. In this context, strengthening the role of state pharmaceutical policy may be considered, including expanding reference pricing mechanisms, promoting local drug manufacturing, and implementing price regulation measures that may help reduce financial barriers for patients and improve the affordability of anti-osteoporotic therapy. In addition, the observed association between osteoporosis incidence and population growth suggests the importance of incorporating demographic trends into planning and forecasting the provision of anti-osteoporotic medicines across Uzbekistan.

Several potential sources of bias and confounding factors should be acknowledged. First, regional differences in access to diagnostic services, availability of densitometry equipment, and variations in diagnostic activity may have influenced the detection and reporting of osteoporosis cases. Second, some analyses were based on densitometric data obtained from the RSSPMTO, a specialized national referral center. Therefore, the patient population examined at this institution may not be fully representative of the broader population of patients with osteoporosis in Uzbekistan. These factors should be considered when interpreting the findings. The findings of this study are limited to Uzbekistan and are based on aggregated data.

Therefore, the results should not be directly generalized to other settings or populations. The analysis is based on descriptive and correlational methods and should be interpreted with caution. Further studies using multivariate approaches are needed to better quantify the relative contributions of individual factors.

ETHICS STATEMENT

This study was based on aggregated secondary data obtained from official statistical sources and medical records at the RSSPMTO. The data were collected in anonymized form and did not include individual patient identifiers. Therefore, ethical approval was not required according to national regulations.

FINANCIAL ASSISTANCE
NIL

CONFLICT OF INTEREST
The authors declare no conflict of interest.

AUTHOR CONTRIBUTION
Ziyodakhon K. Yusupova conceptualized and designed the study, collected and analyzed the data, interpreted the results, and drafted the manuscript. Dilfuza T. Saipova provided academic supervision, critically reviewed the manuscript, and contributed to improving its scientific content. All authors read and approved the final manuscript and agree to be accountable for all aspects of the work.

DECLARATION OF USE OF AI TOOLS
The authors used Grammarly to assist with language editing and improving the readability of the manuscript. All content, analysis, and conclusions were reviewed and verified by the authors. The authors take full responsibility for the originality, accuracy, and integrity of the work.

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