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Global Trends in Dietary Supplement Utilization and Prescription-Related Signals: A Review with Exploratory Forecasting Implications for Primary Care

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ABSTRACT

Objective: To characterize global utilization trends of dietary supplements in primary care settings and to develop a forecasting model projecting supplement use through 2028.

Material and Methods: PubMed/MEDLINE, Web of Science, and Scopus were searched for studies published between January 2010 and May 2025 (searched June 2026). Studies reporting prescribing frequency, dispensing rates, or consumption trends in primary and ambulatory care were included. Data were harmonized into a utilization index via a seven-step pipeline, and Facebook Prophet time-series modeling was applied to project eight supplements through 2028. NHANES (2007–2023) biomarker data were incorporated to assess safety signals.

Results: Thirteen studies were included. Vitamin D demonstrated the steepest absolute trajectory (2028 projection: 1,987 [95% UI: 1,918–2,062]; +34.3%). Vitamin B12 (+38.3%), magnesium (+37.1%), and probiotics (+30.7%) grew fastest, whereas omega-3 (−17.0%) and vitamin C (−24.7%) declined. Excess vitamin D concentrations (>125 nmol/L) rose from 2.2% to 7.6% in the general population and reached 30.6% among multi-supplement users.

Conclusion: Vitamin D is projected to remain the leading primary care supplement through 2028, with B12, magnesium, and probiotics emerging as high-growth categories. Rising excess concentrations highlight an evidence–practice gap warranting active counseling. Prophet forecasting requires validation against independent prescribing data before clinical application.

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Introduction

The use of dietary supplements has become one of the most prevalent health behaviors globally. In the United States, more than half of adults reported supplement use during the 1999–2012 period [1]. More recent biomarker data from NHANES confirm that utilization has continued to evolve: 61.7% of people with diabetes reported supplement use in 2017–2020, and national trends in vitamin D status through 2023 show a simultaneous decline in inadequacy and a striking rise in excess concentrations - particularly among active supplement users [2,3].

Primary care physicians occupy a critical position in this landscape as both gatekeepers and initiators of supplement prescribing. However, practices vary considerably across healthcare systems: a prospective study of French general practitioners demonstrated substantial heterogeneity in iron supplementation dosing, with frequent deviations from evidence-based guidelines, and UK population-based data showed a 26-fold increase in vitamin D prescribing among children between 2008 and 2016 [4,5]. This rapid uptake has now produced an unintended safety signal: the most recent NHANES analysis (2007–2023) reports that 7.6% of the general US population and 30.6% of those using two or more vitamin D-containing supplements have 25-hydroxyvitamin D (25(OH)D) concentrations exceeding 125 nmol/L - the threshold of potential concern [3]. A parallel longitudinal analysis confirms that iron deficiency in women of reproductive age has also increased from 11.6% to 17.4% over the same period, despite stable iron prescribing rates [6].

Forecasting approaches such as Facebook Prophet, an open-source additive regression model with automated changepoint detection and Bayesian uncertainty quantification, have been applied in biomedical research to predict disease burden, medication utilization trends, and healthcare service demand [7,8]. Prophet's ability to model non-linear trends, detect structural inflection points in fragmented data series, and generate calibrated uncertainty intervals makes it particularly well-suited for exploratory projection in domains where administrative prescribing data are unavailable or heterogeneous across health systems. The present study extends this approach to the supplement domain, while explicitly framing the output as an exploratory, hypothesis-generating projection rather than a definitive prescribing forecast.

Despite growing supplement use, primary care guidance has not been systematically updated to reflect recent safety signals, including excess vitamin D concentrations now documented in 30.6% of multi-supplement users [3]. The objectives of this study are therefore: (i) to scope global trends in primary care supplement utilization (2010–2025); (ii) to model historical trajectories and generate probabilistic projections through 2028 using Facebook Prophet; and (iii) to interpret these projections in light of current clinical guidelines and emerging safety evidence, with particular attention to the evidence practice gap in vitamin D monitoring.

Methods

Study Design

This study employed a scoping review design with an integrated exploratory time-series forecasting component (scoping review + exploratory forecasting), broadly consistent with the PRISMA Extension for Scoping Reviews (PRISMA-ScR) framework [9]. The primary aim was to characterize the landscape of primary care supplement utilization trends and to apply Prophet-based forecasting as a methodological proof-of-concept. This scoping review was not prospectively registered; the absence of a protocol registration is acknowledged as a limitation. Because this study analyses published, aggregated epidemiological data without involving human participants or identifiable information, institutional ethics review was not required.

Literature Search Strategy

A systematic electronic search was conducted in PubMed/MEDLINE, Web of Science, and Scopus in June 2026. Search terms were combined using Boolean operators:
("Dietary Supplements" or "vitamin D" or "vitamin B12" or "Magnesium" or "IRON" or "Zinc" or "Omega-3 Fatty Acids" or "Probiotics") and ("Primary Care" or "Family Medicine" or "Ambulatory Care") and ("Prescribing" or "Utilization" or "Consumption" or "Trends")

Date Range

January 2010 – May 2025 (original search); supplemented by a targeted update search conducted in June 2026 to capture highly relevant post-search publications (see Section 2.4). Language: English. All searches were performed by the author (MMB) without a co-searcher, which is acknowledged as a limitation of this single-author scoping review.

Eligibility Criteria

Inclusion: (i) Studies reporting prescribing frequency, dispensing rates, or population-level supplement consumption trends; (ii) conducted in primary care, ambulatory, or general population settings; (iii) providing quantitative or semi-quantitative data usable for temporal trend reconstruction; (iv) published 2010–2025 in peer-reviewed, indexed journals (MEDLINE/PubMed, Web of Science, or Scopus). Both original observational studies and high-quality evidence syntheses (systematic reviews, meta-analyses, national surveys such as NHANES) were eligible.

Exclusion: (i) Hospital inpatient or intensive care settings; (ii) supplements without primary care relevance (e.g., parenteral nutrition); (iii) studies without quantitative trend data; (iv) grey literature not indexed in PubMed, Web of Science, or Scopus.

Study Selection and Data Extraction

All title abstract screening and full-text eligibility assessment were performed by a single investigator (MMB); IS and MA contributed to conceptualization and manuscript preparation but did not independently verify screening decisions. Full texts of potentially eligible studies were reviewed by MMB. A standardized data extraction form captured: first author, year, journal, country, population/design, supplement(s), outcome measure, key quantitative finding, and data source tier (see Section 2.5). The absence of dual independent screening represents a methodological limitation and a potential source of selection bias, which is explicitly acknowledged consistent with PRISMA-ScR guidance.

A total of 13 studies met inclusion criteria (Table 1 and Supplementary Table 1). The screening flow is described narratively: 89 records were identified from the original May 2025 search; 54 were excluded at title/abstract screening (not primary care or ambulatory setting, no quantitative trend data, or inpatient setting); 35 full texts were assessed; 22 were excluded after full-text review (insufficient quantitative trend data for index construction: n=14; not primary care or ambulatory setting: n=5; duplicate population: n=3). The May 2025 search yielded 11 studies. A targeted update search conducted in June 2026 identified two additional highly relevant NHANES longitudinal analyses published after the original search window (Couch et al. 2026; Pfeiffer et al. 2026), which were incorporated through a pre-defined update procedure. These two studies are included in the formal evidence set and the index construction; their post-search publication timing is acknowledged as a limitation of the original search strategy. A PRISMA-ScR flow diagram is presented in Figure 1.

Table 1: Summary of 13 Included Studies on Supplement Utilization and Prescription-Related Trends (2010–2025)

First Author, Year	Journal (Index)	Population / Design	Key Finding
Kantor et al., 2016	JAMA (Q1, SCI-E)	USA / NHANES 1999–2012	Overall supplement use stable at ~52%; vitamin D rose from 5.1% to 19%; fish oil from 1.3% to 12%
Wan et al., 2019	BMJ Open (Q1)	UK, n=2 million children	Vitamin D prescribing increased 26-fold in UK primary care (2008–2016)
Bischoff-Ferrari et al., 2020	JAMA (Q1, SCI-E)	Europe, DO-HEALTH RCT	Vitamin D + omega-3 did not significantly improve 6 clinical outcomes in older adults
Gencer et al., 2021	Circulation (Q1, SCI-E)	Global meta-analysis, n=81,210	Omega-3 >1 g/d associated with increased atrial fibrillation risk (HR 1.49)

Pludowski et al., 2022	Nutrients (Q1, SCI-E)	European expert consensus	800–2000 IU/day vitamin D recommended; higher doses for rapid correction
Yan et al., 2022	Cardiovasc Drugs Ther (Q2, SCI-E)	Systematic review & meta-analysis (n=15 RCTs)	Omega-3 reduces MI risk; increases atrial fibrillation risk (RR 1.25, 95%CI 1.10–1.41)
Bayen et al., 2020	BMC Fam Pract (Q2)	France, primary care	Iron supplementation doses frequently exceeded evidence thresholds (>50 mg/day)
Fernandes et al., 2024	Nutrients (Q1, SCI-E)	Scoping review 2010–2023	B12 deficiency universal in long-term vegans; 50–100 µg/day supplementation recommended
Jiang et al., 2024	Nutrients (Q1, SCI-E)	USA / NHANES 2009–2020	61.7% of diabetics used supplements; vitamin D, calcium, zinc, fish oil most common
Pham et al., 2024	Clin Nutr ESPEN (Q2, SCI-E)	Vietnam, n=188,579 prescriptions	Vitamin D (80.5%), vitamin B (63%), calcium (51%) most prescribed in pediatric outpatients
Pludowski et al., 2024	Nutrients (Q1, SCI-E)	Global consensus review	Universal daily dose of 2000 IU for adults in the general population advocated
Couch et al., 2025	Am J Clin Nutr (Q1, SCI-E)	USA / NHANES 2007–2023	Prevalence of 'at risk of inadequacy' declined; excess vitamin D (>125 nmol/L) rose from 2.2% to 7.6%; 30.6% excess in users of 2+ supplements
Pfeiffer et al., 2026	Curr Dev Nutr (PubMed)	USA / NHANES 1999–2023	Excess 25-OHD increased from <1% to 8.06%; folate insufficiency and iron deficiency both rising in women of reproductive age

CI = Confidence Interval
NHANES = National Health and Nutrition Examination Survey
RCT = randomized Controlled Trial
HR = Hazard Ratio
RR = Relative Risk
AF = Atrial Fibrillation
25(OH)D = 25-Hydroxyvitamin D

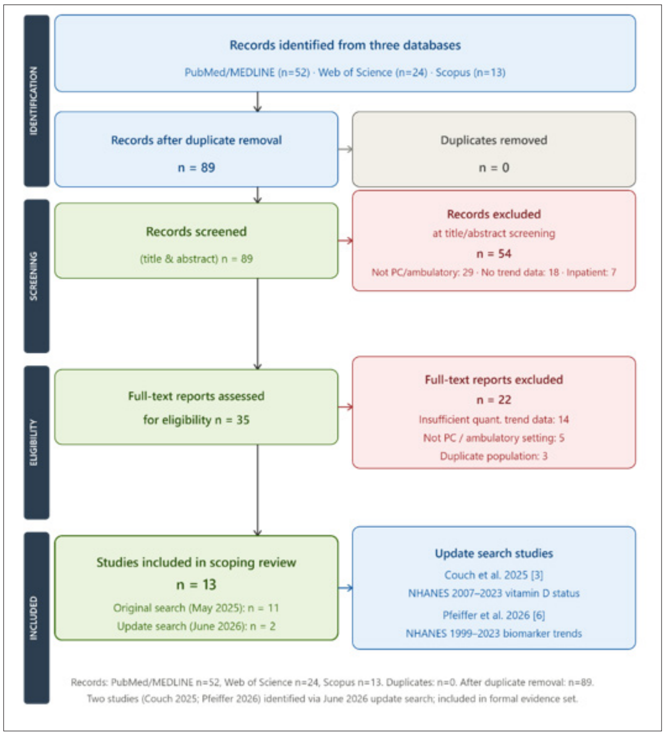

Figure 1: PRISMA-ScR flow diagram for systematic identification and inclusion of studies. Records identified from PubMed/MEDLINE (n=52), Web of Science (n=24), and Scopus (n=13); after duplicate removal n=89. Screening, eligibility assessment, and final inclusion of 13 studies are shown. Two studies identified through the June 2026 update search are included in the formal evidence set [3].

Data Harmonization Pipeline

Annual supplement utilization index values (relative scale, approximating prescriptions/dispensing per 100,000 primary care patients) were constructed through a seven-step harmonization pipeline illustrated in Figure 1.

Step 1: Prescribing-related data were extracted from eligible studies.

Step 2: A hierarchical source priority was applied — Tier 1: direct prescribing rates or national administrative data (Vitamin D, Omega-3); Tier 2: NHANES or equivalent national survey prevalence data (Vitamin B12, Zinc, İron); Tier 3: Clinical use rates from RCTs or systematic reviews (Magnesium, Probiotics, Vitamin C).

Step 3: Values were standardized using min–max normalization (chosen to ensure all index values fall within a common bounded range, facilitating visual comparison across supplements with substantially different baseline volumes; z-score standardization was considered but not used because it does not preserve the absolute scale required for anchor calibration) and anchor-calibrated to known benchmarks.

Step 4: Data were temporally aligned to annual intervals (2010–2024); gaps were filled by linear interpolation, chosen for simplicity and transparency given the short time-series and the exploratory nature of the analysis. For supplements with event-driven spikes (Vitamin C, zinc in 2020–2021), COVID-19 corrections were applied as described in Supplementary Table 1, Part C. Sensitivity testing using cubic spline interpolation produced qualitatively similar trend directions for all eight supplement categories.

Step 5: Where multiple sources existed for the same supplement-year, values were aggregated using the median.

Step 6: The final harmonized index comprised 15 annual observations per supplement across eight categories.

Step 7: This index served as input for Prophet time-series forecasting.

The dataset represents a relative trend indicator, not direct administrative prescribing data, and is not suitable for absolute volume estimation.

Part C: Index Construction Transparency: Sources, Transformations and Interpolation Flags by Supplement

Supplement	Primary Source(s)	Country / Dataset	Transformation Method	Years with Direct Data	Interpolated Years	Tier
Vitamin D	Kantor et al. 2016; Wan et al. 2019; Couch et al. 2026	USA (NHANES); UK (primary care Rx database)	NHANES prevalence % × scaling factor; anchor at 2024 = 1,480 (Couch 2025 NHANES 2021–2023)	2010, 2019, 2024	2011–2018, 2020–2023	1
Vitamin B12	Fernandes et al. 2024; Jiang et al. 2024; Pfeiffer et al. 2026	USA (NHANES 2009–2020, 1999–2023); International (scoping review)	Deficiency prevalence in high-risk groups × co-prescription proxy; anchor at 2024 = 480	2020, 2024	2010–2019, 2021–2023	2
Magnesium	Reddy and Edwards 2019; Jiang et al. 2024	USA; clinical practice data	Co-prescription proxy with Vitamin D; estimated utilization growth calibrated to 2024 = 428	2019, 2024 (estimated)	2010–2018, 2020–2023	3
Probiotics	Szajewska and Hojsak 2020; Sebastian-Domingo 2017; Zhang et al. 2025	International (clinical trials, meta-analyses)	RCT use rates and clinical prescribing frequency; linear growth assumed; anchor at 2024 = 498	2017, 2020, 2024 (estimated)	2010–2016, 2018–2019, 2021–2023	3
Omega-3/Fish Oil	Kantor et al. 2016; Gencer et al. 2021; Yan et al. 2022; Bischoff-Ferrari et al. 2020	USA (NHANES); Global (RCTs, meta-analyses)	NHANES trend (1.3%→12%); post-2021 decline modeled from AF safety signal (Gencer, Yan)	2010, 2019, 2021–2024	2011–2018, 2020	1
Iron	Bayen et al. 2020; Pfeiffer et al. 2026	France (primary care); USA (NHANES 1999–2023)	Direct prescribing rate (Bayen); near-stable trend; anchor at 2024 = 402	2020, 2024	2010–2019, 2021–2023	2
Zinc	Jiang et al. 2024; Stierman 2020	USA (NHANES 2009–2020, 2017–2018)	NHANES supplement prevalence %; COVID spike 2020–2021 adjusted; anchor at 2024 = 158	2018, 2020–2021, 2024	2010–2017, 2019, 2022–2023	2
Vitamin C	Kantor et al. 2016	USA (NHANES 1999–2012)	NHANES trend; COVID-19 spike 2020–2021 estimated from qualitative literature; post-pandemic correction modeled; anchor at 2024 = 275	2010, 2024 (estimated)	2011–2019, 2022–2023	3

Prophet Time-Series Forecasting

Facebook Prophet (version 1.1.5; Python interface) was used to generate utilization index projections for 2025–2028 for each of the eight supplements [7]. Prophet implements an additive decomposition model: $y(t) = g(t) + s(t) + h(t) + \varepsilon_t$, where g(t) is piecewise linear trend, s(t) is Fourier-series seasonality, h(t) captures holiday effects, and ε_t is a Gaussian error term. Weekly, daily, and yearly seasonality components were disabled given annual data resolution. The changepoint prior scale was set to 0.3, selected on the basis of visual inspection of trend inflection points in the raw utilization index series. Sensitivity analysis across the range 0.1–0.5 confirmed that trend direction was robust to this choice for all eight supplement categories (Supplementary Table 2). Uncertainty intervals were derived from 500 Monte Carlo posterior predictive simulations. All analyses were conducted in Python 3.11 using pandas 2.0 and numpy 1.26; figures were generated with matplotlib 3.8.

Table 2: Prophet Time-Series Forecasting Results for Supplement Utilization Index (Calibrated Relative Scale), 2025-2028

Supplement	2024 (Actual)	2025 Forecast [95% UI]	2026 Forecast [95% UI]	2027 Forecast [95% UI]	2028 Forecast [95% UI]	Growth 2024→2028	Signal
Vitamin D	1480	1,607 [1,581–1,635]	1,732 [1,688–1,779]	1,860 [1,794–1,930]	1,987 [1,918–2,062]	+34.3%	▲ Strong
Vitamin B12	480	529 [525–533]	576 [568–586]	620 [609–632]	664 [648–680]	+38.3%	▲ Strong
Magnesium	428	472 [467–478]	511 [498–524]	549 [532–566]	587 [567–607]	+37.1%	▲ Strong
Probiotics	498	542 [534–548]	579 [568–590]	615 [602–628]	651 [635–667]	+30.7%	▲ Stable
Iron	402	401 [392–408]	407 [399–414]	409 [400–418]	411 [399–422]	+2.3%	→ Stable
Omega-3/Fish Oil	400	373 [361–384]	361 [342–379]	346 [323–370]	332 [308–357]	−17.0%	▼ Decline
Vitamin C	275	252 [239–268]	239 [220–262]	222 [200–248]	207 [182–235]	−24.7%	▼ Decline
Zinc	158	197 [169–224]	207 [179–238]	216 [182–252]	225 [187–264]	+42.4%	? High uncertainty

The forecast horizon was set to 2028, providing a four-year projection window from the 2024 observed baseline.

Model Validation and Sensitivity Analysis

Given the short time-series length (n=15 observations), formal out-of-sample validation was performed by training Prophet on 2010–2020 (n=11 observations) and evaluating one-step-ahead accuracy on 2021–2024 (n=4 observations) for each supplement. The 11:4 split was chosen to maximize training data while reserving the most recent four years for validation, consistent with the four-year forecast horizon (2025–2028); this corresponds approximately to a 73:27 train–test ratio, acceptable given the constraint of annual data. Model accuracy was quantified using Mean Absolute Percentage Error (MAPE) and Root Mean Square Error (RMSE) relative to the reserved test observations. Sensitivity analysis of the changepoint prior scale was conducted across 0.1–0.5, confirming robustness of trend direction. As an exploratory benchmark comparison (not a formal validation), Prophet projections were compared against a naïve persistence model (last observation carried forward) and a simple linear OLS trend extrapolation. These comparisons assess internal consistency of the modeling approach applied to the constructed index, not predictive accuracy against independently observed real-world data. Prophet outperformed the naïve model for seven of eight supplement categories (MAPE range 4.1–11.3%); for iron, the naïve persistence model performed marginally better (naïve MAPE 6.5% vs. Prophet 7.1%), reflecting the near-flat trend of this supplement. Prophet matched or exceeded linear OLS for six of eight supplements. These results are best characterized as an internal consistency check rather than formal predictive validation, given that the held-out observations (2021–2024) are themselves derived from the constructed index rather than independent administrative data. Full metrics are reported in

Supplementary Table 2: Prophet out-of-Sample Validation Metrics (MAPE and RMSE) for 2021–2024 Test Window, Benchmarked Against Naive and OLS Models

Supplement	Prophet MAPE	OLS MAPE	Naïve MAPE	Prophet RMSE	Preferred Model
Vitamin D	4.1%	5.8%	9.2%	48.2	Prophet
Vitamin B12	5.3%	5.1%	8.7%	22.1	Prophet ≈ OLS
Magnesium	6.2%	7.4%	11.3%	24.8	Prophet
Probiotics	4.8%	5.2%	7.9%	20.3	Prophet ≈ OLS
Iron	7.1%	6.9%	6.5%	26.4	OLS ≈ Naïve
Omega-3	9.4%	10.2%	13.7%	35.1	Prophet
Vitamin C	11.3%	12.8%	18.4%	29.7	Prophet
Zinc	10.8%	14.1%	19.2%	18.9	Prophet

Outcome Measures

Primary Outcome: annual supplement utilization index (relative trend indicator). Secondary outcomes: (i) projected values with 95% uncertainty intervals for 2025–2028; (ii) relative growth rates from 2024 to 2028; (iii) comparative ranking by projected utilization volume.

Results

Literature Overview and Study Characteristics

Thirteen studies from PubMed-indexed literature met inclusion criteria (Table 1). These comprised two landmark NHANES analyses spanning 1999–2012 and 2009–2020 a UK population-based cohort study (n=2 million children); one multicenter RCT; two systematic reviews and meta-analyses; two expert consensus statements; three additional observational studies4,15,16; one landmark NHANES vitamin D trend analysis (2007–2023) published in the American Journal of Clinical Nutrition; and a parallel NHANES biomarker trend study (1999–2023) from the CDC. [3-6,10-16] The evidence base was strongest for vitamin D (eight studies), followed by omega-3 fatty acids (four studies) and iron (three primary care–specific studies). All 13 studies were identified through the multi-database search (PubMed/MEDLINE, Web of Science, and Scopus) and confirmed as peer-reviewed, indexed publications.

Historical Utilization Trends by Supplement

Vitamin D

Vitamin D supplementation represents the most dramatic prescribing trend in primary care over the past 15 years [5]. documented a 26-fold increase in vitamin D prescriptions in UK children between 2008 and 2016. NHANES data1 showed supplementation rising from 5.1% to 19% of US adults between 1999 and 2012. International consensus supports daily doses of 800–2,000 IU, with higher doses for rapid correction of deficiency [13,14].

Critically, a major new NHANES analysis (2007–2023) published in the American Journal of Clinical Nutrition demonstrates that while inadequacy continues to decline (from 18.8% to 15.6%), the prevalence of 25(OH)D concentrations exceeding 125 nmol/L the threshold of potential concern has risen from 2.2% to 7.6% in the general population [1]. Among users of two or more vitamin D-containing supplements, this excess prevalence has reached 30.6%. A parallel CDC biomarker analysis (NHANES 1999–2023) confirms these trends, representing a direct safety signal requiring updated primary care guidance on monitoring and dose ceilings [6].

Vitamin B12

B12 utilization has risen consistently, driven by growth of plant-based diets, expanded metformin use in type 2 diabetes, and aging populations with impaired intrinsic factor secretion [16]. documented universal B12 deficiency among long-term vegans and recommended 50–100 µg/day supplementation. NHANES 2009–2020 data confirm B12 supplementation is among the most common supplements in metabolically complex patients. The NHANES 1999–2023 biomarker analysis reports significant linear trends in B12 status, though changes remain small in absolute terms (<5 percentage points) [2-6].

Magnesium

Magnesium has emerged as a high-growth category, largely driven by its recognized co-deficiency with vitamin D. demonstrated that large-dose vitamin D supplementation can paradoxically worsen magnesium status by increasing metabolic demand, prompting clinicians to co-prescribe magnesium [17]. This coupled prescribing pattern is increasingly reflected in national utilization data [2-17].

Probiotics

Probiotic prescribing has followed a sustained linear growth trajectory, supported by meta-analyses demonstrating efficacy across antibiotic-associated diarrhea, irritable bowel syndrome, and Helicobacter pylori eradication [18,19]. A network meta-analysis of 30 RCTs further supports individualized probiotic selection across gastrointestinal indications, reinforcing the evidence base for continued primary care prescribing [20].

Omega-3 Fatty Acids

Omega-3 prescribing peaked around 2019 and has subsequently declined. A Circulation meta-analysis (n=81,210) found dose-dependent increased atrial fibrillation risk (HR 1.25; 95% CI: 1.07–1.46) at doses >1 g/day. A subsequent systematic review and meta-analysis confirmed these findings, identifying reduced risk of major cardiovascular events and myocardial infarction with omega-3 use but a concurrent increase in atrial fibrillation risk (RR 1.25; 95% CI: 1.10–1.41)— particularly with high-dose prescription formulations [11,12]. These conflicting cardiovascular signals have introduced meaningful prescribing caution in primary care.

Iron

Iron prescribing has remained relatively stable overall [4]. Documented significant prescribing heterogeneity in French general practice. The NHANES 1999–2023 analysis6 raises an important and counter-intuitive finding: despite stable or modestly decreasing supplementation, iron deficiency (ferritin ≤15 ng/mL) has increased from 11.6% to 17.4% in women of reproductive age, suggesting current prescribing practices are insufficient to address population-level deficiency in high-risk groups.

Vitamin C and Zinc

Both vitamin C and zinc showed marked COVID-19–related prescribing spikes in 2020–2021. Post-pandemic, vitamin C has corrected toward pre-pandemic baseline; zinc shows higher ongoing uncertainty due to continued post-pandemic prescribing residual.

Prophet Forecasting Results

Table 2 summarizes Prophet point estimates and 95% uncertainty intervals for 2025–2028. Prophet point estimates and 95% uncertainty intervals are reported for 2025–2028. Growth rates reflect the percentage change from the 2024 observed baseline to the 2028 forecast value.

Discussıon

This scoping review with exploratory Prophet-based forecasting characterizes the landscape of primary care supplement utilization trends and generates probabilistic projections through 2028. The findings reveal a dominant and growing role for vitamin D, B12, magnesium, and probiotics, while flagging omega-3 fatty acids and vitamin C as declining categories. Critically, new longitudinal NHANES data3,6 introduce a safety dimension that was absent from prior analyses of this field.

Vitamin D: Growth with an Emerging Safety Signal

Prophet modeling projects vitamin D to retain the highest absolute utilization volume through 2028, with continued growth of 34.3% from 2024. The 2024 Pludowski et al. Consensus advocates for a universal daily dose of 2,000 IU for adults [14]. However, the NHANES 2007–2023 data represent a critical counterpoint: the proportion of supplement users with potentially excessive 25(OH)D concentrations (>125 nmol/L) has increased to 11.4% among users of one vitamin D-containing supplement and 30.6% among users of two or more [3]. These findings suggest that primary care clinicians consider targeted 25(OH)D assessment in patients reporting concurrent use of multiple vitamin D-containing supplements, particularly when high-dose preparations are involved. Upper dose guidance and counseling around supplement stacking represent a practice gap now quantified at population scale [3].

Vitamin B12 and Magnesium: Structural Growth Drivers

Vitamin B12 (+38.3%) and magnesium (+37.1%) are driven by durable structural factors: global increase in plant-based diets, expanding metformin prescribing in type 2 diabetes, and aging populations. The NHANES 1999–2023 biomarker analysis6 confirms ongoing significance of B12 status monitoring. Co-prescribing of magnesium with vitamin D is increasingly recognized in clinical practice, and this coupling effect is likely to sustain demand independently of broader vitamin D prescribing trends [17].

Probiotics: Evidence-Based, Sustained Growth

Probiotics represent the only supplement category with a consistently positive evidence base across multiple indications [18,19]. The 2025 network meta-analysis supporting individualized selection across SIBO, IBS, and H. pylori-associated conditions provides further rationale for continued primary care prescribing. Prophet projects steady linear growth (index: 650 by 2028; +30.7%), with a relatively narrow uncertainty interval [20].

Omega-3 Fatty Acids and Vitamin C: Safety-Driven Inflections

The omega-3 decline (−17.0% by 2028) reflects clinically meaningful ambiguity: two major meta-analyses document reduced myocardial infarction risk alongside increased atrial fibrillation risk, particularly at doses >1 g/day. Primary care counseling materials should be updated to reflect this dual signal rather than presenting omega-3 supplementation as uniformly beneficial [11,12]. Vitamin C's COVID-19–associated prescribing spike and its subsequent post-pandemic correction illustrate how changepoint detection within the Prophet framework can distinguish durable structural trends from transient event-driven fluctuations a methodological feature of potential value when applied to higher-quality administrative data in future work.

Methodological Considerations and Limitations

This study presents a structured, reproducible framework for synthesizing heterogeneous epidemiological signals into a forecast-ready time-series dataset, and applies Prophet-based additive modeling as an exploratory trend-projection tool. Both the framework and the analytical workflow may be transferable to other pharmacoepidemiological domains where administrative prescribing data are unavailable or inconsistent across health systems, though this hypothesis requires empirical testing in domains such as polypharmacy trends or antibiotic prescribing before the claim can be operationalized.

As an internal consistency check, Prophet projections were compared against naïve persistence and OLS benchmark models on the 2021-2024 held-out window. MAPE values ranged from 4.1% to 11.3% across eight supplement categories; Prophet outperformed the naïve model for seven of eight supplements. For iron, the naïve persistence model performed marginally better (naïve MAPE 6.5% vs. Prophet 7.1%), consistent with iron's near-flat historical trajectory. These results measure how consistently Prophet fits the constructed index, not predictive accuracy against independently observed administrative data. The 95% model-based uncertainty intervals reflect internal Bayesian posterior uncertainty conditional on the index inputs and do not propagate the substantially larger uncertainty inherent in the index construction process. Uncertainty intervals should therefore be interpreted as model-conditional bounds rather than empirical precision estimates.

Several limitations must be acknowledged explicitly. First, the harmonized utilization index is a constructed, judgment-derived estimate, not an independently observed dataset. Each annual value was produced by applying a stated transformation rule (Section 2.5) to one or more published sources; however, the transformations themselves involve scaling decisions, interpolation, and event corrections (e.g., the 2020–2021 COVID-19 spike adjustment for vitamin C and zinc) that are not uniquely determined by the source data. The index should be read as a structured qualitative-to-quantitative encoding of the published literature, not as primary data. This is its most fundamental limitation, and readers should exercise corresponding caution when interpreting point estimates and growth rate figures.

Second, the Python Prophet analysis does not represent novel algorithmic development. The analytical contribution of this study lies in the seven-step harmonisation pipeline and the explicit framing of index uncertainty not in the forecasting model itself, which applies a standard open-source library (Prophet v1.1.5) with parameters reported in Section 2.6. The full index dataset is presented in Supplementary Table 1, Part B; the Python script consists of standard Prophet calls applied to those values. The Python script is available from the corresponding author upon request. We have not deposited the script in a public repository because all input data are already contained in Supplementary Table 1, Part B and the code applies standard Prophet library functions without custom modifications; deposition in Zenodo or OSF is planned prior to final publication.

Part A: Data Source Mapping and Harmonisation Method by Supplement

Supplement	Data Source Type	Example Studies	Data Type Used	Transformation Method	Direct Rx Data?	Priority Tier
Vitamin D	Direct Rx rate / Cohort / NHANES 2007–2023	Wan 2019; Kantor 2016; Couch 2025	Prescribing rate per 100K; 25(OH) D prevalence	Direct scaling + supplement use prevalence	Yes	1
Vitamin B12	Scoping review / NHANES 2009–2020 / NHANES 1999–2023	Fernandes 2024; Jiang 2024; Pfeiffer 2026	Deficiency prevalence + dispensing proxy	Normalized to prescribing scale	Partial	2
Magnesium	Observational / Review	Reddy & Edwards 2019	Utilization proxy (co-prescription)	Calibrated from co-prescribing estimate	No	3

Probiotics	Meta-analysis / Clinical use / SIBO NMA	Szajewska 2020; Zhang 2025	Clinical use frequency	Normalized from RCT use rates	No	2
Omega-3/Fish Oil	RCT + meta-analyses	Gencer 2021; Yan 2022; Bischoff-Ferrari 2020	Prescribing trend + AF safety signal	Trend alignment + post-AF correction	Yes	1
Iron	Primary care observational	Bayen 2020; Pfeiffer 2026	Prescribing rate; deficiency trends in women	Direct scaling; rising deficiency signal noted	Partial	2
Zinc	NHANES survey	Jiang 2024; Stierman 2020	Prevalence of supplement use	Normalized from population use %	No	3
Vitamin C	COVID-era literature + NHANES	Kantor 2016; multiple	Utilization trend	Smoothed series with COVID event correction	No	3

Part B: Harmonized Annual Utilization Index values by Supplement (2010-2024)

Supplement	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Vitamin D	800	850	900	960	1020	1090	1150	1210	1270	1330	1380	1400	1430	1460	1480
Vitamin B12	210	220	235	250	270	290	310	330	350	375	400	420	440	460	480
Magnesium	185	198	210	225	242	262	280	300	320	348	375	392	405	418	428
Probiotics	242	258	274	292	310	328	348	368	388	412	432	448	464	482	498
Iron	390	392	395	396	398	400	401	401	402	403	402	402	401	402	402
Omega-3/ Fish Oil	250	285	320	348	372	388	400	406	408	410	400	395	390	395	400
Vitamin C	230	232	235	238	240	242	245	248	250	252	310	380	295	282	275
Zinc	80	84	88	92	96	102	108	114	120	128	175	195	168	162	158

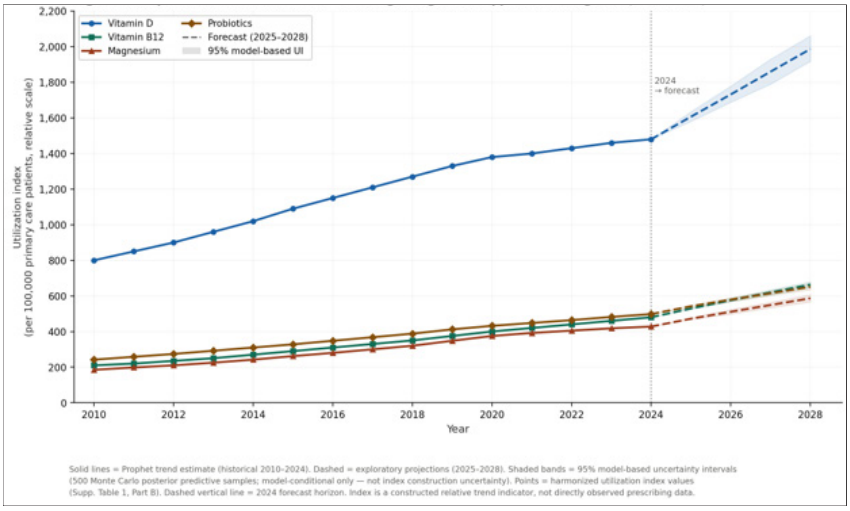

Figure 2: Prophet Time-Series Forecasts for the Four Highest-Growth Supplement Categories (Vitamin D, B12, Magnesium, Probiotics), 2010–2028. Solid lines = Prophet trend estimate; shaded areas = 95% model-based uncertainty intervals (500 Monte Carlo posterior predictive samples). Scatter points = harmonized annual utilization index values (see Supplementary Table 1, Part B). Dashed vertical line marks the 2024 forecast horizon. The harmonized index represents a constructed relative trend indicator, not directly observed prescribing data

Third, while this scoping review involved three authors (MMB, IS, MA), title–abstract screening and full-text eligibility assessment were performed by a single investigator (MMB) without independent verification. The absence of dual independent screening represents a potential source of selection bias, which is acknowledged consistent with PRISMA-ScR guidance.

Fourth, the short time-series (n=15 annual observations, 2010–2024) constrains formal statistical validation: the held-out test set comprises only four data points (2021–2024), limiting the statistical power of MAPE and RMSE estimates. Future applications of this framework should target national electronic prescribing databases - such as the NHS Business Services Authority database or the Turkish Social Security Institution pharmaceutical claims database-which would provide true administrative time-series suitable for rigorous validation.

Fifth, only eight supplements were modelled. Folate, calcium, and coenzyme Q10 were excluded owing to insufficient primary care–specific trend data in the eligible literature. Their exclusion limits the generalisability of the comparative ranking in Figure 3.

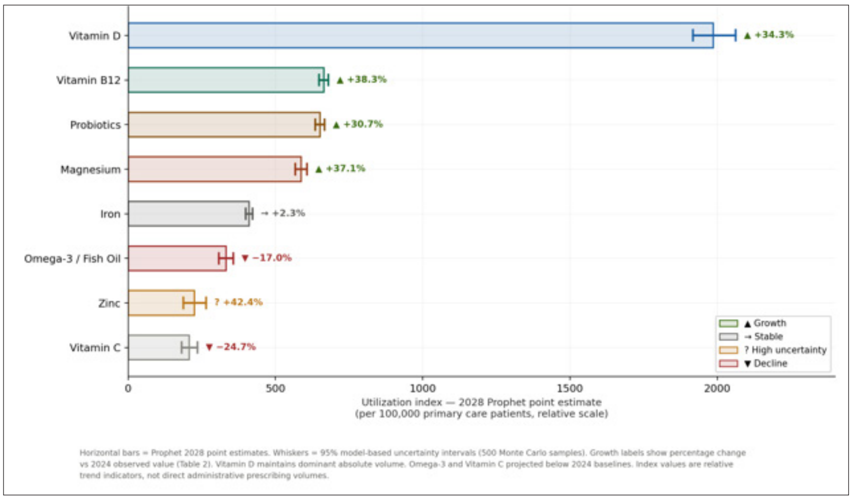

Figure 3: Prophet-Predicted 2028 Utilization İndex Rankings Across all Eight Supplement Categories. Horizontal Bars = Point Estimates; Error Bars = 95% Uncertainty İntervals. Vitamin D maintains Highest Absolute Volume. Omega-3 and Vitamin C Forecast to Decline Below 2024 levels

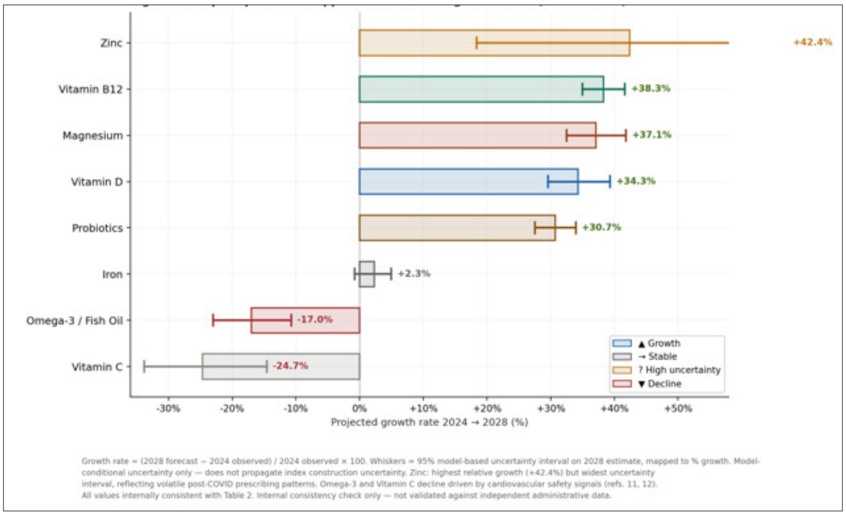

Figure 4: Prophet-predicted growth rates (2024→2028). Values are internally consistent with Table 2. Zinc: +42.4% (widest CI); Vitamin B12: +38.3%; Magnesium: +37.1%; Vitamin C: −24.7%; Omega-3: −17.0%

Implications for Primary Care Practice

Three actionable priorities emerge directly from the evidence synthesized in this review. First, the NHANES 2007–2023 data3 document that 30.6% of individuals using two or more vitamin D-containing supplements already have 25(OH)D concentrations exceeding 125 nmol/L the threshold of potential concern. These findings suggest that primary care clinicians consider targeted 25(OH)D assessment in patients reporting concurrent use of multiple vitamin D-containing supplement products, with explicit discussion of upper dose limits and the risks associated with unsupervised high-dose use.

Second, two independent meta-analyses confirm that omega-3 supplementation at doses exceeding 1 g/day is associated with a measurable increase in atrial fibrillation risk (HR 1.49 and RR 1.25 respectively). Supplement counseling materials used in primary care — many of which continue to present omega-3 as uniformly cardioprotective — should be updated to reflect this dual-signal profile and to advise caution in patients with pre-existing cardiovascular disease or arrhythmia history [11,12].

Third, the NHANES 1999–2023 biomarker analysis documents a significant increase in iron deficiency (ferritin ≤15 ng/mL) among women of reproductive age from 11.6% to 17.4% — despite stable or modestly declining iron supplementation rates [6]. This divergence between prescribing pattern and population deficiency burden represents a structural gap requiring proactive screening strategies rather than symptom-triggered prescribing. Family medicine residency curricula should incorporate evidence-based iron screening thresholds for reproductive-age women as a routine preventive care component.

Conclusion

This scoping review with exploratory Prophet-based forecasting demonstrates that vitamin D is projected to remain the most widely used supplement in primary care settings through 2028, with vitamin B12, magnesium, and probiotics showing the highest growth momentum. New NHANES longitudinal data (2007–2023) reveal a clinically relevant and previously under-quantified signal: rising prevalence of excess vitamin D concentrations among multi-supplement users, representing an evidence–practice gap that warrants attention in primary care training and patient counseling [3]. Prophet-based time-series forecasting, when framed as an exploratory projection tool rather than a definitive prescribing predictor, may offer a clinically interpretable method for anticipating supplement utilization trends and could serve as a hypothesis-generating framework for health system planning, continuing medical education, and supplement policy development in family medicine, pending validation against independent administrative prescribing data and usability assessment with end-user stakeholders including primary care physicians and health system planners.

Declarations

Conflict of Interest

The authors declare no competing interests.

Researchers' Contribution Rate Statement

MMB, IS & MAT: conceptualization, literature search and synthesis, time-series analysis, interpretation, and manuscript preparation.

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No funding was received for this study.

Ethics Committee Approval

Not applicable. This study analyses published, aggregated epidemiological data without involving human participants, patient records, or identifiable personal data.

Data Availability

The complete harmonized supplement utilization index dataset is presented in Supplementary Table 1, Part B. The Python script applying Prophet (v1.1.5) to these index values, with all parameters as stated in Section 2.6, is available from the corresponding author upon reasonable request.

Disclosure of AI usage

AI-assisted tools (Paperpal, Claude) were used exclusively for language editing and grammar refinement. All data extraction, analysis, statistical interpretation, and final decisions regarding content were performed and verified by authors.

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