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The impact of Choosing Wisely™ recommendations and insurance coverage restrictions on the provision of low-value care: an interrupted time series analysis of vitamin D tests

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Abstract

Background Interventions to reduce low-value care vary considerably in effectiveness. International consensus considers vitamin D blood testing in a general population as a low-value care intervention, which lead to its inclusion in the Swiss Choosing Wisely™ recommendation in April 2021. In mid-2022, the Swiss Public Health authorities further restricted basic health insurance coverage for the test.

Methods We conducted a retrospective analysis of health insurance claims data covering about 880'000 Swiss residents in the compulsory health insurance market. To assess the effects of a) the Choosing Wisely recommendation and b) the federal coverage restriction, we applied interrupted time series models at the physician level, controlling for seasonal effects, physician fixed effects, and patient characteristics.

Results The Choosing Wisely recommendation reduced the average monthly number of tests prescribed per physician per 100 consultations by approximately 5.98% in the 12 months following the intervention. The national coverage restriction led to a significant 57.82% drop in vitamin D testing per physician per 100 consultations in the 6 months following the intervention.

Conclusions Medical recommendations marginally reduced low-value services, and their impact on clinical practice was limited. In contrast, federal coverage restrictions drastically reduced unnecessary testing. Multicomponent strategies combining evidence-based guidance for healthcare professionals, patient involvement, and national regulation related to reimbursement could be a best practice model for guiding public health stakeholders and politicians in order to reduce low-value care.

Keywords Choosing wisely, Overuse, Low-value care, Claims data, Health policy, Vitamin D blood testing

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Background

Testing for vitamin D deficiency has increased significantly due to its association with several diseases [1]. In Switzerland, the standardized rate of vitamin D tests per 1,000 inhabitants more than doubled between 2013 and 2020, rising from 96.3 in 2013 to 199.4 in 2020 [2]. However, there is international consensus that testing for vitamin D deficiency among low-risk patients is inappropriate [3, 4]. Previous studies have documented inappropriate testing in Switzerland [5, 6]. As such, vitamin D blood tests are a well-documented example of low-value care [7, 8].

The "Choosing Wisely" initiative, which originated in the United States in 2012, aims to foster conversations between patients and healthcare providers about the necessity and appropriateness of various medical tests and treatments [9]. In Switzerland, the initiative was adapted and branded as "Smarter Medicine" by the Swiss Society of General Internal Medicine in 2014. It is a broad alliance of medical professional associations that issues recommendations in the form of "Top 5" lists, with the goal of reducing overuse and misuse in the healthcare system. In April 2021, "Smarter Medicine" started recommending against routine vitamin D testing for patients without risk factors [9].

In July 2022, the Swiss Federal Office of Public Health (FOPH) restricted coverage of vitamin D tests under compulsory health insurance, limiting reimbursement to specific conditions. As a result of this restriction, the costs of vitamin D tests were borne by patients themselves, except for patients with specific medical conditions listed by the FOPH [10].

The introduction of two population-level policies in Switzerland created a unique opportunity to compare the impact of two different types of public health interventions: recommendations with voluntary character and coverage restrictions on the provision of low-value care. This setting in turn enables the development of a best-practice model to guide public health stakeholders, with the aim to reduce low-value care. This study analyzes claims data from a large Swiss insurance company, SWICA, to estimate and compare the effects of these interventions. The analysis is based on time series data of vitamin D testing utilization rates per physician from 2018 to 2023, applying interrupted time series methods to assess the impact of the interventions. The model controls for patient characteristics, seasonal and regional patterns, and physician fixed effects. Additionally, the study examines vitamin D supplementation utilization rates to rule out undertreatment and provides back-of-the-envelope estimates of cost savings resulting from the interventions.

Methods

Swiss healthcare system

In Switzerland, health insurance is compulsory for all residents and is provided by private insurance companies. Basic health insurance covers all medical services provided or prescribed by physicians, including vitamin D testing. Health plans vary by deductible levels and may include managed care features, such as gatekeeping through a general practitioner, telemedicine center, or health maintenance organization (HMOs). Switzerland's healthcare system is largely decentralized, operating across 26 Cantons and different language regions (German, French, and Italian).

Data

Anonymized claims data from a major Swiss health insurance provider, SWICA (Winterthur, Switzerland), were used for this study, covering the period from 2018 to 2023. The data included patients over 18 years old who had at least one consultation with a general practitioner (GP) or group medical practice between 2018 and June 2023. SWICA health insurance covers approximately 10% of the total Swiss health insurance market during the study period. SWICA is a major health insurance provider and is predominantly present in the German-speaking part of Switzerland. Since the benefit basket in Switzerland is administered federally, including all appropriate and cost-effective inpatient and outpatient services, the coverage in compulsory health insurance is most likely independent of the insurer. Furthermore, physicians are not expected to adjust their behavior based on the specific health insurance provider of their patients. The analysis focused on 3,630 distinct GPs and group medical practices that consistently treated at least five different patients per month throughout the intervention period.

Outcome measures

The primary outcome measures included the number of vitamin D tests covered by compulsory health insurance, prescribed per physician per month, and the number of vitamin D tests, prescribed per physician per month per 100 consultations. The so-called "Analyseliste" catalogues all laboratory tests that are reimbursed by compulsory health insurance in Switzerland. Vitamin D tests can be identified based on the codes 1000 for 1,25-Dihydroxy-Vitamin D and code 1006 for 25-OH-Vitamin D.

To assess whether the interventions led to insufficient medical care (i.e., unintended consequences), the study examined whether monthly vitamin D supplementation was impacted. This included active substances with ATC codes A11CB, A11CC, and A12AX that were reimbursed by the insurer.

To determine whether the reduction in vitamin D tests resulted from changes in physicians' behavior or from health insurance claim rejections, the analysis considered the proportion of vitamin D test claims that were accepted and those that were not accepted by the insurer.

To offer estimates of costs and savings resulting from the interventions, the analysis investigated the change in total costs of vitamin D tests in the sample. Costs of vitamin D tests in Swiss Francs were used as the dependent variables in the main regression model (instead of the number of tests), using total costs 12 months before the "Smarter Medicine" intervention and 6 months before the coverage restriction as the baseline. Costs are the costs billed to the healthcare insurer exclusively for the vitamin D test (i.e., excluding consultation fees). The estimates were then extrapolated to the entire Swiss population based on SWICAs market share (9.59% of the Swiss population in 2022, see Statistics on compulsory health insurance, FOPH).

Patient & physician characteristics

The claims data set included information on patient demographics (age, gender), choice of insurance model and deductible, the number of monthly consultations per physician or group practice, the physician's or group practice's location (German-speaking cantons, Italian- and French-speaking cantons, and bilingual cantons), and an indicator for participation in a managed-care network or a telemedicine model.

Proxies for increased risk of vitamin D insufficiency

Three indicator variables for patients at increased risk for vitamin D insufficiency were created and included in the main regression. These variables were: having a chronic disease (as classified by pharmaceutical cost groups, PCGs, a classification system that assigns individuals based on their pharmaceutical claims to chronic conditions such as hypertension, Type 2 diabetes and cancer), being a woman over 65 years of age, and having medical conditions associated with vitamin D insufficiency as specified by Swiss guidelines [5, 10]. The third variable was based on coverage criteria defined by the FOPH for vitamin D testing and constructed from claims data. We added a detailed list of these conditions in the additional files. The conditions were assessed within 12 months prior to the month under consideration.

Statistical methods

First, descriptive statistics were used to present the main characteristics of the data. Second, interrupted time series models were employed to analyze the evolution of vitamin D testing utilization rates over time and to estimate the impact of the interventions, while controlling for physician fixed effects and patient characteristics [11–17]. The final analysis data set was aggregated at the physician-month-level. Control variables were included in the regression models to account for any changes in patient characteristics over time.

To evaluate the impact of the two interventions on vitamin D testing (the smarter medicine recommendation of April 2021 and the coverage restriction of July 2022), we estimated interrupted time series models of the following form:

$$y_{it} = \beta_0 + \beta_1 t_{it} + \beta_2 x_t + \beta_3 (t_{it} \times x_t) + \beta_4 Z_{it} + \alpha_i + \gamma_t + \in_{it}$$

- y_{it}: The number of tests or the number of tests per 100 consultations for physician i in month t.
- t_t: A continuous time trend variable indexed at 0 for the time of the intervention (either the "Smarter Medicine" intervention or the coverage restriction by the FOPH).
- x_t: An indicator variable for the post-intervention period, i.e. if $t_t > 0$. In the analysis of the first intervention, this variable is 1 after April 2021. In the analysis of the second intervention, this variable is 1 after July 2022.
- $(t_{it} \times x_t)$: An interaction term between the time trend and the intervention indicator, capturing changes in trend following the intervention.
- Z_{it}: A vector of variables controlling for patient characteristics at the physician-month level. These include the number of patients per gender group, the number of patients per age group, the number of patients per deductible choice, the number of patients per insurance model, the number of patients with at least one chronic disease, the number of women over 65, the number of patients with medical conditions associated with vitamin D insufficiency according to Swiss guidelines.
- α_i: Physician fixed effects.
- γ_t: Monthly indicators controlling for monthly seasonalities affecting all physicians.
- $\in_{it}$: The error term.

This model was estimated using OLS with fixed effects. It was adapted to accommodate the second intervention by adding an indicator variable for the post-second-intervention period and its corresponding interaction term. For the cost analyses, the independent variable was replaced by the total monthly costs (in Swiss Francs) billed to the healthcare insurer exclusively for the vitamin D test (i.e., excluding consultation fees).

The model was designed to estimate how many vitamin D tests would have occurred if the intervention had not been implemented (the "counterfactual" scenario). To estimate the counterfactual scenario, the effect of the

intervention variable is switched off ($x_t = 0$) to see the expected testing levels without intervention. The model predicts the outcome as if the intervention did take place when the intervention variable is switched on ($x_t = 1$).

The model measures the impact of the interventions by comparing two scenarios: the counterfactual (no intervention) against the predicted testing rates after intervention. This comparison is made at two points in time: once immediately after the intervention, by calculating the difference between the predicted and counterfactual outcomes one month after the intervention, and once over the long term, by comparing predicted testing levels over a 12-months period after the first intervention and over a 6-months period after the second intervention. The final point estimates and 95% confidence intervals were calculated using bootstrapping with clustering at the physician level and 500 draws, following [17]. P]oint estimates and 95% confidence intervals were reported in the result tables. For all results, we reported absolute differences and relative differences in percent between the predicted testing rates and the counterfactual rates.

To test whether the difference in effect between subgroups was statistically significant, an interacted version of the main model was estimated. A set of binary variables indicating the group of interest was interacted with the time trend, the indicator variable for the post-intervention, and the interaction between time trend and post-intervention indicator. To test the statistical significance of the cross-differences in the effects between subgroups, bootstrapping was used on the differences. Only differences in percentage of the baseline for both groups were tested, as baselines at the time of intervention are different for both groups.

Robustness checks, plausibility checks, and subsample analyses

Patient and physician characteristics

To ensure that the risk composition of patients did not change at the intervention cutoffs, a graphical analysis was conducted to examine the evolution of patient numbers per physician, consultations per physician, and consultations per patient per physician. These outcomes were regressed on a time trend and monthly indicators, with the observed time series plotted alongside the predicted series. A similar analysis was done for the share of patients with chronic illness, the share of female patients aged 65 and older, and the share of patients at risk of vitamin D deficiency.

Unintended consequences

Restricting vitamin D tests could result in unintended medical consequences for patients, such as reducing care for those who need the test. The analysis examined whether vitamin D supplementation was impacted by the interventions by plotting the share of patients receiving supplementation per physician over time. Similarly to the main regression model, the share of patients with supplementation was predicted with a linear regression on seasonal effects, a time trend, patients characteristics and physician fixed effects, and plotted against the observed share and its counterfactual. Note, however, that only vitamin D supplementation that was prescribed by a physician and billed to the insurance is captured, which excludes any over-the-counter purchases.

Subsample analyses

To provide more clarity on the impact on appropriate testing, the analysis first examined whether the magnitude of the effects was consistent for individuals with a proxy indicating increased risk of vitamin D insufficiency. This analysis investigates the hypothesis that the interventions should have a smaller effect on at-risk individuals than on not-at-risk individuals. An additional dataset, consisting only of patients at risk of vitamin D insufficiency, was created to perform the main analysis on this subset. Second, the effect of the interventions was investigated separately for the three language regions - German-speaking cantons, Italian- and French-speaking cantons, and bilingual cantons - to explore whether the impact of guidelines was related to the language.

Results

Patient and physician characteristics

Table 1 presents the characteristics of patients seen by physicians in the sample. On average, each physician treated roughly 32 unique patients per month. Likewise, the same physicians had about 45 consultations per month. Physicians saw an average of 13.4 male patients (42% of total), 5.8 female patients over 65 (18%), and 5.2 patients at risk of vitamin D insufficiency (16%) each month. Additionally, they treated 10.3 patients with at least one chronic illness (PCGs) per month. As mentioned in the methods section, these numbers correspond to patients observed in the insurance collective (roughly 10% of the Swiss population).

On average, physicians prescribed 1.83 vitamin D tests per month, for an average cost of 96.83 CHF per month. Moreover, 2.6 patients per physician took vitamin D supplementation monthly, while about 0.5 patients received both a vitamin D test and supplementation.

The age distribution of patients as well as the choice of insurance models and deductibles are further reported in Table 1.

Intervention effects: Choosing Wisely™ recommendation

Figure 1 presents the main results. The grey line represents the observed average number of vitamin D tests per physician per month per 100 consultations in the data.

Table 1 Summary statistics

	Mean	SD	Min	Max
Consultations and patients per physician per month				
Number distinct patients	32.05	65.43	6	1654
Average number of consultations	45.01	93.04	6	2471
Patients characteristics per physician per month				
Average number of male patients	13.43	29.32	0	761
Age 0–18	0.00	0.00	0	0
Age 19–25	1.84	5.28	0	171
Age 26–30	1.75	6.18	0	193
Age 31–35	2.20	7.70	0	234
Age 36–40	2.30	7.16	0	186
Age 41–45	2.26	5.87	0	165
Age 46–50	2.45	5.77	0	176
Age 51–55	3.01	6.61	0	187
Age 56–60	3.10	6.45	0	189
Age 61–65	2.76	5.33	0	146
Age 65–70	2.48	4.52	0	135
Age 71–75	2.43	4.20	0	125
Age 76–80	2.18	3.66	0	116
Age 81–85	1.66	2.82	0	66
Age 86–90	1.07	2.00	0	40
Age 91+	0.57	1.29	0	41
Women over 65	5.81	8.92	0	237
Total patients with indication for Vit. D test	5.18	8.79	0	237
Total patients with 1 or more PCGs	10.28	17.57	0	486
Total patients who used Vit. D supplementation	2.64	4.81	0	146
Total patients who received a Vit. D test and who used Vit. D supplementation	0.45	1.18	0	56
Number of patients in STANDARD model	8.99	9.73	0	154
Number of patients in Telemedicine model	8.80	13.08	0	328
Number of patients in HMO model	14.15	52.66	0	1484
Number of patients with lowest deductible	19.54	35.45	0	890
Number of patients with middle deductible	7.94	17.93	0	645
Number of patients with highest deductible	4.58	14.28	0	416
Outcome				
Total costs Vit. D test in Swiss Francs	96.82	200.74	0	6583
Total quantity of Vit. D tests	1.83	3.79	0	123

Legend: The table gives summary characteristics at the physician per month level. *N* = 209493 physicians-months. PCG (Pharmaceutical Cost Group) is a classification system that categorizes individuals into chronic conditions based on their pharmaceutical claims. Please refer to Additional File 1 for further information

The red line represents the predicted number of tests from the interrupted time series model, while the blue dotted line estimates the counterfactual number of tests had the two interventions not occurred. The red dotted vertical line marks the timing of the Smarter Medicine – Choosing Wisely™ Recommendation, and the purple dotted line indicates the timing of the coverage restriction. The figure shows an upward trend in vitamin D testing from 2018 until April 2021. The gap between the predicted line and the counterfactual line reflects the estimated effects of the interventions.

Table 2 presents the effects of the Smarter Medicine - Choosing Wisely™ Recommendation on the number of vitamin D tests per physician per month. The recommendation led to a modest but significant reduction in the number of prescribed tests per physician and per consultation. The immediate absolute change was −0.08 tests (−0.09, −0.07) per physician per month, reflecting a relative reduction of −3.5% (−4.0%, −2.9%) tests.

The average monthly number of tests prescribed per physician per 100 consultations decreased by approximately −4.7% (−5.2%, −4.2%) following the recommendation, and by −4.9% (−5.4%, −4.4%) after adjusting for patient-level characteristics. This represents a cumulative reduction of −5.8% (−6.2%, −5.4%) to −6% (−6.4%, −5.6%) in the number of tests 12 months after the intervention.

Intervention Effects: Coverage Restriction

In contrast, the coverage restriction led to significant reductions, with an absolute decrease of −1.47 (−1.49, −1.44) tests per physician per month and a relative change of −67.3% (−67.9%, −66.8%) one month after the intervention (Table 3). The immediate effect on the number of vitamin D tests per physician per month per 100 consultations showed a drop of −3.25 (−3.29, −3.21) tests, representing a −60% (−60.8%, −59.8%) reduction.

Six months after the intervention, the reduction persisted, with an estimated −57% (−57.6%, −56.8%) decrease in the number of tests and a −58% (−58.3%, −57.5%) reduction in tests per physician per 100 consultations. These effects remained stable even after adjusting for patient characteristics.

Back-of-the-envelope cost estimates

The Smarter Medicine recommendation led to a cost reduction of −7.1% (−7.5%, −6.5%) within 12 months. Based on the sample's total costs of 4'868'220 CHF in the 12 months prior to the intervention, this corresponds to a cost reduction of −344'346 CHF (−365'049 CHF −315'507 CHF).

The coverage restriction resulted in a more substantial cost reduction of −60% (−60.4%, −59.5%) within 6 months. Compared to the sample's total costs of 2'632'849 CHF before the intervention and 917'419 CHF after, this represents an estimated reduction of −1'578'606 CHF (−1'590'904 CHF, −1'566'468 CHF).

Considering that SWICA covered 9.59% of the Swiss population in 2022 (Statistics on compulsory health insurance, FOPH), the potential cost savings across Switzerland were estimated at 16'460'955 CHF over 6 months. With a population of 8.776 million in 2022, this translates

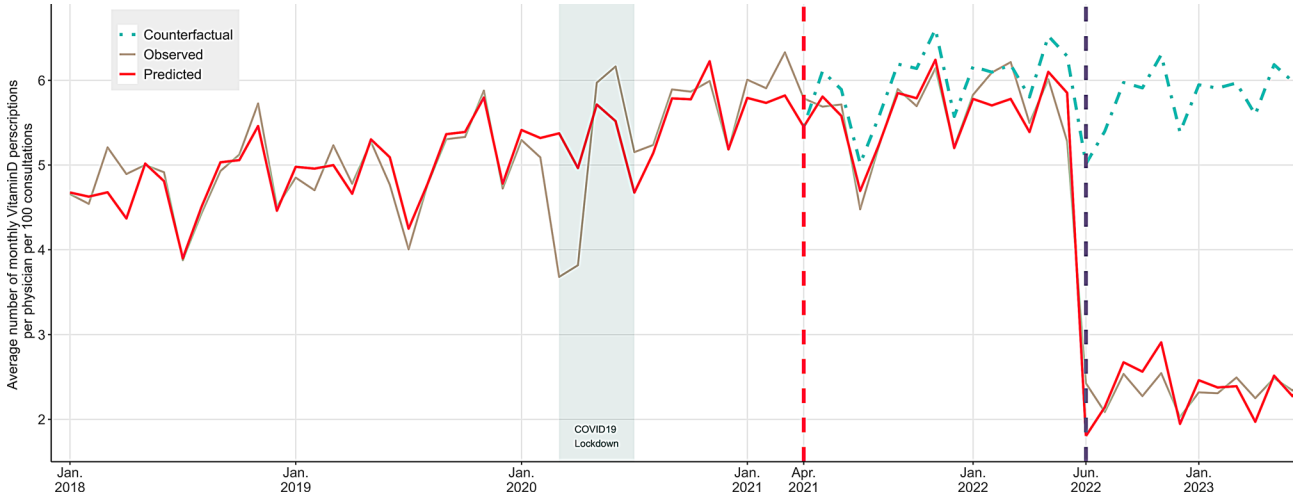

Fig. 1 Effect of the smarter medicine recommendation on the number of vitamin D tests per Physician per consultation. Legend: this figure depicts the number of vitamin D tests per Physician per consultation over time before and after the smarter medicine recommendation in April 2021. The grey line represents the observed number of tests, the red bar shows the predicted number of tests using the interrupted time series framework. The green dotted line represents the predicted number of tests, had the intervention not happened (counterfactual). In this specification, physician fixed-effects and patient characteristics are included in the interrupted time series

Table 2 Results for the first intervention: smarter medicine recommendation (April 2021)

Estimate	Regression with physician effects	Regression with patient controls and physicians
Number of tests per physician per month		
Absolute change	−0.08 (−0.09, −0.07)	−0.14 (−0.15, −0.12)
Absolute change after 12 months	−1.12 (−1.26, −0.96)	−2.1 (−2.24, −1.91)
Relative change (in %)	−3.48 (−4, −2.92)	−5.79 (−6.34, −5.21)
Relative change after 12 months (in %)	−4.01 (−4.49, −3.46)	−7.26 (−7.7, −6.65)
Number of tests per physician per month per 100 consultations		
Absolute change	−0.29 (−0.32, −0.26)	−0.3 (−0.33, −0.27)
Absolute change after 12 months	−4.11 (−4.41, −3.8)	−4.24 (−4.54, −3.93)
Relative change (in %)	−4.74 (−5.19, −4.25)	−4.91 (−5.39, −4.41)
Relative change after 12 months (in %)	−5.81 (−6.21, −5.39)	−5.98 (−6.39, −5.56)

Legend: The table gives the estimated absolute changes in the number of tests per physicians and the relative changes (in %) in the number of tests per physician per 100 consultations. The baseline is the counterfactual situation. Bootstrapped 95% confidence intervals with 500 repetitions are given in parentheses

Table 3 Results for the second intervention: coverage restriction by the Federal office of Public health (July 2022)

Estimate	Estimate Simple Regression	Estimate with all controls and physicians
Number of tests per physician per month		
Absolute change	−1.47 (−1.49, −1.44)	−1.52 (−1.54, −1.49)
Absolute change after 6 months	−9.31 (−9.46, −9.16)	−8.12 (−8.25, −7.99)
Relative change (in %)	−67.31 (−67.92, −66.76)	−69.19 (−69.79, −68.47)
Relative change after 6 months (in %)	−62.06 (−62.55, −61.63)	−57.21 (−57.64, −56.76)
Number of tests per physician per month per 100 consultations		
Absolute change	−3.25 (−3.29, −3.21)	−3.25 (−3.29, −3.21)
Absolute change after 6 months	−20.71 (−20.99, −20.44)	−20.84 (−21.1, −20.56)
Relative change (in %)	−60.29 (−60.75, −59.78)	−60.3 (−60.8, −59.85)
Relative change after 6 months (in %)	−57.72 (−58.1, −57.29)	−57.87 (−58.26, −57.52)

Legend: The table gives the estimated absolute changes in the number of tests per physicians and the relative changes (in %) in the number of tests per physician per 100 consultations. The baseline is the counterfactual situation. Bootstrapped 95% confidence intervals with 500 repetitions are given in parentheses

to an approximate cost reduction of –1.9 CHF per inhabitant over the same period.

Robustness and plausibility checks relating to patient and physician characteristics

The analysis confirmed no significant changes in the risk composition of patients at the intervention cutoffs. Graphical analyses, shown in Figures A1 and A2 of the Additional Files, indicated that the number of consultations per physician and the size of patient pools remained stable, suggesting that the observed effects resulted from changes in physician behavior rather than patient selection. Additionally, no notable shifts were observed at the intervention cutoffs in the share of female patients aged 65 and older, or patients at risk of vitamin D deficiency.

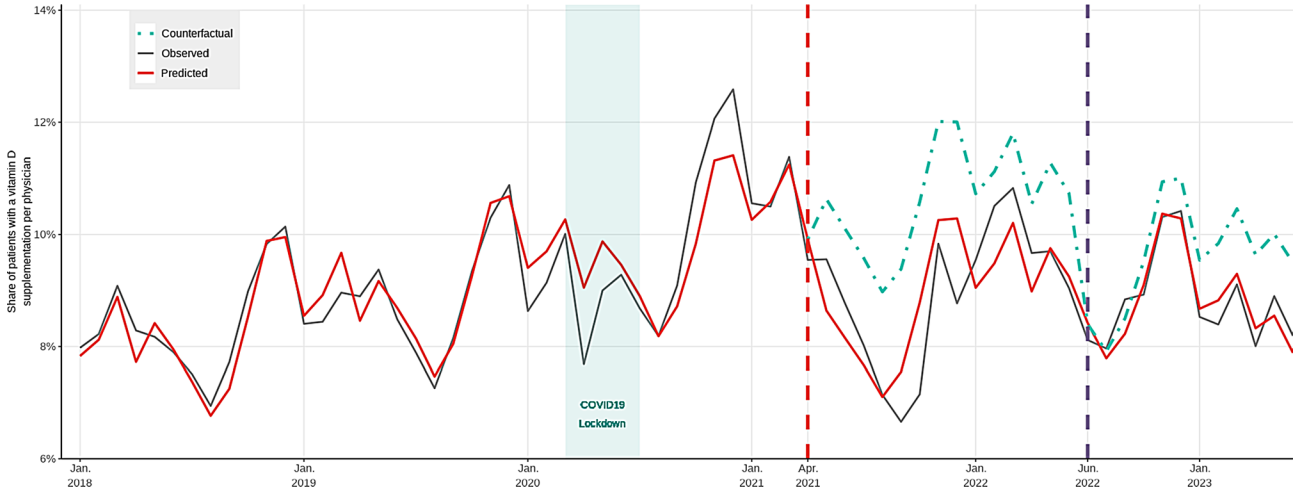

Fig. 2 Share of patients with a vitamin D supplementation over time. Legend: this figure depicts the share of patients who took vitamin D supplementation per physician per month over time. The black line represents the observed share of patients with a vitamin D supplementation, and the green dotted line represents the predicted share of patients taking a vitamin D supplementation, had the intervention not happened (counterfactual). The red bar shows the predicted share of patients with a vitamin D supplementation using a regression on seasonal indicators, time trends, patients' characteristics and physician fixed effects. The effect estimates correspond to the difference between the counterfactual and the predicted values

Some discrepancies between the predicted and the observed the number of patients with chronic illnesses (at least one PCG) in 2020 and in 2022 were observed. This is most likely explained by the COVID outbreak.

Robustness and plausibility checks relating to unintended consequences

A major concern was that patients might not receive the vitamin D supplementation they need in response to the two interventions as physicians might not only reduce testing but also (necessary) vitamin D supplementation. Monitoring the pickup rates showed in fact a significant decline in supplementation after the first intervention, but only a small reduction after the second intervention. Specifically, as shown in Fig. 2 and in Table A5 of the Appendix, the actual share of patients with supplementation dropped by roughly −17% (−17.3%, −16.8%) in the 12 months following the first intervention in comparison to what would have expected, had the first intervention not happened. In contrast, the share of patients with supplementation only dropped by about −5.2% in the six months after the coverage restriction (−5.7%, −4.7%) which triggered a reduction in vitamin D testing by about 57%. Whether the observed patterns can be reconciled with better patient targeting – i.e., physicians more carefully prescribing supplements to patients who actually need them – or undertreatment with potential health consequences cannot be inferred from this analysis and thus requires further research.

Subsample analyses

The reaction to the recommendation was much smaller for the population of individuals at risk of vitamin D deficiency. The number of tests per 100 consultations for the at-risk population decreased by −3% (−4.0%, −1.8%) over the 12 months following the first intervention. For the population of individuals not at risk of vitamin D deficiency, the number of tests per 100 consultations decreased by −6.6% (−7.0%, −6.2%) over the 12 months following the first intervention. The effects of the coverage restriction were roughly similar for the at-risk and for the not-at-risk groups, with a −54.7% (−55.5%, −54%) drop in tests per 100 consultations for the at-risk population, and a −60.3% (−60.8%, − 59.9%) drop for the not-at-risk population in the 6 months following the coverage restriction. Results for the sample of at-risk and not-at-risk individuals and significance tests for the difference across the two groups are detailed in Tables A1 and A2 of the Additional Files.

The Choosing Wisely^{TM} recommendation had a larger impact on physicians in bilingual and German-speaking cantons. As shown in Figure A3, Table A3 and Table A4 of the additional files, the 12-month effect was estimated at −9% in bilingual regions, −6.8% in German-speaking cantons, and −1.54% in French- and Italian-speaking cantons. The 6-month effect of the coverage restriction resulted in a −42.7% decrease in bilingual cantons, −61% in German-speaking cantons, and −58% in French- and Italian-speaking cantons.

Discussion

This study demonstrated that restricting insurance coverage was significantly more effective in reducing the utilization of vitamin D testing than relying on evidence-based recommendations by medical societies, with voluntary character. The effect remained stable across

various sensitivity analyses, and a notable finding was the similar reduction in utilization among individuals at increased risk of vitamin D insufficiency after the second intervention.

The prevalence rate of vitamin D testing observed in this study aligns closely with official Swiss data. The Swiss Health Observatory (OBSAN) reported an increase in standardized test prescriptions from 96.3 per 1,000 inhabitants in 2013 to 199.4 in 2020 [2]. These findings are also consistent with previous studies analyzing health insurance claims data [5, 6].

The Choosing Wisely™ recommendation led to only a modest reduction in vitamin D testing, highlighting the limited impact of soft policy interventions on changing physician behavior. This aligns with previous research indicating that clinical recommendations alone often fail to significantly reduce low-value care [18–20]. In contrast, the regulatory intervention resulted in a substantial and immediate decrease in vitamin D testing, suggesting that payment policies, such as restricting insurance coverage, are more effective in reducing low-value care. The same conclusions were reached in other settings [21]. However, such measures must be carefully designed to avoid unintended consequences, such as underuse among populations with genuine health care needs.

Several factors may explain these findings. First, the Smarter Medicine recommendations may not have been effectively integrated into routine care. This might be explained by external barriers like environmental factors (such as lack of time and resources), low exposure to the guidelines and low awareness, or financial incentives of test prescription [22, 23]. Patient factors are likely to contribute to the results: influenced by public opinion, patients might request vitamin D testing, often overriding their GPs' recommendations. However, when patients are required to pay for the tests out-of-pocket, their demand typically decreases [23]. In Switzerland, the development and dissemination of evidence-based recommendations and guidelines are carried out by different individual organizations, including physician networks, medical associations, or academic institutions. This fragmented approach may limit the power of impact for large-scale implementation efforts. Also, differences in popularization and exposure to the guidelines might explain the differences in effect magnitudes across language regions.[1]

Secondly, adherence to Smarter Medicine recommendations is generally voluntary. However, there is a large and well-established number of general practitioners organized in physician networks actively promoting intrinsic quality measures such as quality circles, development and implementation of evidence-based medical practice guidelines, or disease management programs. Physician networks and health insurances are free to make agreements aiming to finance and incentivize quality efforts in these networks [24, 25]. To the best of our knowledge, as for the investigated time interval, implementation of Smarter Medicine recommendations had not been explicitly included in the currently established agreements.

Given the fact that there are no financial incentives for Swiss physicians in general to adhere to the smarter medicine recommendations, it might be a powerful implementation strategy to integrate professional recommendations into contractual relationship between physician networks and health insurers. This could help reduce overuse and misuse in medical care by aligning professional guidelines with financial incentives.

Strengths and limitations

A first strength of the paper was the use of interrupted time series to estimate the effects of the two interventions. Adding physician effects, a rich set of control variables for the patient composition, and time effects to account for seasonal effects enables the isolation of changes in prescriptions of vitamin D test attributable to the two interventions. A second strength of this paper was the use of claims data. The large sample size and the level of details at the physician and patient level gave insights into the effects of the interventions.

The paper is limited in the following regards. First, even though the data represented 10% of the market share in Switzerland, data were sourced from a single health insurance provider, limiting the generalizability of findings for the whole population. However, as mentioned in the methods, this is not expected to distort the main results in a considerable manner.

Second, the information on diseases and treatments linked to vitamin D testing was imprecise, as not all morbidities could be inferred from claims data. For instance, personal factors associated with vitamin D deficiency, such as skin color or overweight, were not included in the analysis. Additionally, it was unknown whether patients had an actual vitamin D deficiency. The variable indicating whether a patient was eligible for vitamin D testing under the coverage restriction was constructed retrospectively from claims data, potentially missing patients who were not insured by SWICA in previous years.

Third, the analysis did not fully capture out-of-pocket payments for vitamin D tests, vitamin D supplementation, or unsubmitted bills due to deductible. However, analyses of the rate of cancelled invoices for vitamin D tests did not reveal relevant differences over the course of the investigated time interval.

[1] See as examples the guidelines of the Swiss Medical Association (Online-Plattform «Guidelines Schweiz» (fmh.ch)), guideline of the "Institut für Hausarztmedizin" of the University of Zürich (Guidelines | Institut für Hausarztmedizin | UZH) or the guidelines published on mediX Guidelines.

Finally, identifying the causal effect of the two interventions using an interrupted time series approach relies on the assumption that the model accurately predicts pre-intervention levels and trends in vitamin D testing, allowing for reliable extrapolation into the future to estimate the counterfactual development. While no other significant effects in the population were observed at the two intervention cutoffs, the possibility of residual confounding cannot be entirely ruled out.

Implications for practice

Coverage restrictions are an effective tool to reduce the use of unnecessary medical services. Given the modest decline in the overall share of patients receiving vitamin D supplementation, especially compared to the sharp drop in testing in the 6 months following the coverage restriction, we consider it unlikely that the restriction resulted in undertreatment among subpopulations who might have benefited from supplementation. Nonetheless, further research is needed to better understand patterns of supplementation and the potential for undertreatment.

The findings suggested that Choosing Wisely™ campaigns and similar recommendations were valuable but required to be supplemented by more intense implementation measures. Previous research has shown that it is possible to reduce the use of low-value medical tests in primary care, especially by using multiple components including reminders, audit/feedback, and patient-targeted interventions [26]. Specifically, de-implementation interventions that engage patients within the patient-clinician interaction through patient-targeted educational materials or shared decision-making tools have been shown to be effective in decreasing the use of low-value care [27]. Reducing coverage served as one regulatory approach; however, this option could be associated with increased administrative burden and patient dissatisfaction, and, potentially, lead to underuse. Agreements (in contrast to coverage restrictions) between health insurers and healthcare providers could address this issue: rather than focusing solely on incentivizing a raw decrease of the service, these agreements might also include monitoring of both potential over- and underuse and thus incentivize appropriate utilization.

Implications for research

Further research should investigate heterogeneities in the response to both interventions and explore the channels and reasons that make recommendations and guidelines less effective. In addition, further research should validate that populations at risk are underserved.

Conclusion

The Choosing Wisely™ recommendations alone had a modest effect on reducing vitamin D testing in Switzerland, highlighting the limited impact of voluntary professional guidelines. In contrast, the government-led coverage restriction led to a substantial reduction in low-value testing, demonstrating the greater effectiveness of financial incentives. These findings suggest that future strategies to reduce low-value care should integrate both professional recommendations and regulatory measures to maximize their impact. Combining evidence-based guidance for healthcare professionals, patient involvement, and national regulation related to reimbursement could be a best practice model for guiding public health stakeholders and politicians in order to reduce low-value care.

Abbreviations

AL	Analysis list
ATC	Anatomical therapeutic chemical groups
CHF	Swiss francs
DRG	Diagnosis related groups
EUR	Euro
FOPH	Federal Office of Public Health
GP	General practitioner model
HIV	Human immunodeficiency virus
HMO	Health maintenance organization
PCG	Pharmaceutical cost groups
TARMED	Tariff system for outpatient medical services

Supplementary information

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Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

Supplementary Material 4

Supplementary Material 5

Supplementary Material 6

Supplementary Material 7

Supplementary Material 8

Supplementary Material 9

Supplementary Material 10

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Author contributions

AS was responsible for data preparation, study design, analyzing the data and drafting the article. EB supervised the analysis, interpreted the data and results, and drafted the article. DA and TM reviewed the code and contributed to writing the article. CB, SNJ, and OS contributed to writing the article. All authors reviewed and approved the final manuscript.

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Data availability
The datasets generated and analyzed during the current study are not publicly available due to data protection considerations but are available from AS on reasonable request and signature of a data protection contract. SWICA claims data may under no circumstances be combined with other data sources that may allow identification of individuals in the sample.

Declarations

Ethics approval and consent to participate
All data sources were retrospective, routinely collected, and anonymized. The data contains no identifiable information on individuals, and there is no possibility of re-identification. No intervention at the individual level was conducted. Approval for this study was not required according to article 2 of the Swiss Federal Law on Research Involving Human Subjects. Since data were completely anonymized, no patient consent was necessary (The Human Research Act and the Ethics Committees for Research, Factsheet by the Coordination Office for Human Research (kofam), page 9: "Research projects with (…) anonymous health-related personal data are exempt from the requirement for approval").

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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