ORIGINAL RESEARCH | Annals of Internal Medicine

A Before-and-After Study of Fracture Risk Reporting and Osteoporosis Treatment Initiation

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Background: Several national organizations recommend that fracture risk assessment and osteoporotic treatment be based on estimated absolute 10-year fracture risk rather than bone mineral density (BMD) alone.

Objective: To assess the changes in physician prescribing behavior after introduction of absolute 10-year fracture risk reporting.

Design: Before-and-after study.

Setting: Manitoba, Canada, which has an integrated BMD program in which tests are linkable to a population-based administrative health database repository.

Patients: Women 50 years or older who were not receiving osteoporosis medication (2042 before and 3889 after intervention).

Intervention: Introduction of a system reporting absolute 10-year fracture risk along with dual-energy x-ray absorptiometry results.

Measurements: The proportion of untreated women who were prescribed osteoporosis medications in the year after baseline BMD measurement.

Results: Absolute fracture risk reporting reclassified more women (32.7%) into lower-risk categories than into higher-risk categories (10%). This effect was more prominent in women younger than 65 years. Fewer women per physician were prescribed osteoporosis drugs after introduction of absolute fracture risk reporting. The absolute fracture risk reporting system was associated with an overall reduction in osteoporosis medications dispensed (adjusted absolute reduction, 9.0 percentage points [95% CI, 3.9 to 14.2 percentage points]; relative reduction, 21.3% [CI, 9.2% to 33.5%]; $P < 0.001$). The reduction was attributed to fewer drugs dispensed to women at low and moderate risk for fracture. No differences in fracture rates were observed.

Limitations: This was a nonrandomized study. The risk assessment system studied differs slightly from other 10-year fracture risk assessment models.

Conclusion: Change from a T-score–based fracture risk reporting system to a system based on absolute 10-year fracture risk was associated with appropriate, guideline-based changes in prescription of osteoporosis medications.

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Worldwide, approximately 9 million new osteoporotic fractures occur each year, and osteoporosis leads to an estimated loss of 5.8 million disability-adjusted life-years (1). The case-fatality rate for hip fractures exceeds 20% (2, 3), and osteoporosis-related fractures lead to clinically significant long-term disability and decreased quality of life (4, 5). In 2003, osteoporosis was estimated to cost $17 billion annually in the United States alone (6). The global burden of osteoporosis will increase over the coming decades as the elderly population increases (7).

Until recently, most clinical practice guidelines recommended treatment based on dual energy x-ray absorptiometry (DXA)–measured T-score (number of SDs above or below the reference mean of bone mineral density [BMD] for young adults) (8, 9). We now know that fracture risk depends on risk factors in addition to low BMD. Several national organizations now recommend that treatment decisions be based on estimates of 10-year fracture risk from validated prediction models that incorporate information about risk factors (such as smoking and corticosteroid use) in addition to BMD (10–14). A recent Canadian survey indicated that general practitioners prefer absolute fracture risk reporting with DXA results over risk reporting based on T-scores alone (15).

Throughout Manitoba, Canada, BMD testing is performed and reported similarly. Before 2006, BMD results were reported with a statement about fracture risk based on T-score only. Beginning on 1 January 2006, BMD results have been reported with a statement about 10-year absolute fracture risk. We designed this study to assess whether the change in reporting translated into different physician prescribing behaviors and whether those prescribing behaviors aligned with guideline recommendations at the population level. We hypothesized that the change in reporting would lead to a decline in treatment of patients at lower risk for fracture.

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METHODS

Population

We defined 2 study periods: the 9 months before (1 April to 31 December 2005) and the 12 months after

(1 January to 31 December 2006) introduction of absolute fracture risk reporting. No new osteoporosis drugs were added to the provincial drug formulary, and no change in access occurred during these periods. The 2 observation periods differ slightly in duration because data elements required for absolute fracture risk calculation and before–after comparisons of changes were collected (but not used for reporting) in the 9 months before absolute risk reporting.

We identified all women having initial BMD testing during both study periods who were 50 years or older at the testing date ($n = 7849$). We excluded women who were prescribed osteoporosis medication (including systemic hormone replacement therapy) in the year before BMD testing ($n = 1867$) and those with missing fracture risk estimates ($n = 51$). The study protocol was approved by the Health Research Ethics Board of the University of Manitoba, Winnipeg, Manitoba, Canada.

Administrative Data Sources

Manitoba has a population of approximately 1.2 million people, and health services are provided to almost all residents through a single public health care system. All residents have a unique personal health identification number through which all health system encounters are tracked. The number allows linkage of the health records for hospital discharges, physician claims, prescription drug dispensations, and demographic characteristics contained in a population registry (16). To protect patient confidentiality, the linkages were performed via scrambled identification numbers using anonymous versions of the health record databases.

A computerized record of all outpatient drugs dispensed from pharmacies has been available since 1 April 1995. With approximately 20 million transactions annually, this system captures information about pharmaceutical use in real time for all Manitoba residents. The pharmacy database is accurate both for capture of drugs dispensed and for prescription details (17). Each prescription record contains the date of dispensation; exact identification of the dispensed drug, including substance, strength, route of administration, and dosage form; number of doses provided; anticipated duration (days) of the prescription; and code for prescribing physician and dispensing pharmacy. All drugs are classified according to the Anatomical Therapeutic Chemical classification system of the World Health Organization (18).

BMD Testing

Bone density testing with DXA has been an insured health service since 1990 and has been managed as an integrated program since 1997 (19). Criteria for testing are consistent with published guidelines and emphasize the importance of female sex, age 65 years or older, premature ovarian failure, previous fragility fracture, radiographic evidence of osteopenia, prolonged corticosteroid use, and other clinical risk factors (8). The Manitoba Bone Density Program maintains a regionally based clinical database of all DXA results, which can be linked with other population-based computerized health care databases through a unique anonymous personal identifier (20). The BMD database has been described, with completeness and accuracy greater than 99% (20).

Dual-energy x-ray absorptiometry was performed and scans were analyzed in accordance with manufacturer recommendations (Lunar Prodigy, GE Healthcare, Madison, Wisconsin). Hip T-scores were calculated by using revised reference data for white women based on the Third National Health and Nutrition Examination Survey (21). Lumbar spine T-scores were calculated by using the manufacturer's U.S. white female reference values. We excluded vertebral levels affected by artifact by using conventional criteria (22). Densitometers showed stable long-term performance (coefficient of variation $<0.5\%$) and satisfactory in vivo precision (coefficient of variation, 1.7% for L1 to L4 and 1.1% for the total hip) (23).

Fracture Risk Reporting

From 1 April to 31 December 2005, fracture risk was reported on the basis of the lowest T-score (no increased risk, -1.0 or higher; mild risk, -1.1 to -1.9; moderate risk, -2.0 to -2.9; marked risk, -3.0 to -3.9; or extreme risk, -4.0 or lower) without adjustment for other risk factors. A general statement, however, was provided that fracture risk is also affected by age, sex, and other risk factors.

The fracture risk reporting system used from 1 January to 31 December 2006 has been described (24, 25). We calculated 10-year risk for major osteoporotic fracture (hip, humerus, clinical spine, or distal forearm) from the total hip T-score, age, sex, and the following clinical risk factors

Context

Beginning in 2006, absolute fracture risk, not just T-score, has been reported with bone mineral density testing results in Manitoba, Canada.

Contribution

In this before-and-after study, investigators found reductions in prescriptions for osteoporosis drugs after introduction of the new reporting system. The reductions were primarily in people at low and intermediate risk for fracture.

Caution

Factors other than the change in reporting could have contributed to the findings.

Implication

Standardized reporting of absolute fracture risk seemed to lead to appropriate reductions in use of osteoporosis drugs in people at lower risk for fractures.

—The Editors

Table 1. **Sample Report Illustrating T-Score–Based and Absolute 10-Year Fracture Risk Approaches to Fracture Risk Reporting**

Variable	Fracture Risk Approach	
	T-Score–Based	Absolute 10-Year
Interpretation	Fracture risk: moderate BMD category: osteoporotic	Fracture risk: medium Patient's risk: 17.5% Average risk (patient aged 52 y): 6.7% NNT*: 114 BMD category: osteoporotic
Results		
Spine		
Level	L1–4	L1–4
BMD	1.054 g/cm^2	1.054 g/cm^2
T-score	−1.2	−1.2
Total hip		
Site	Right total hip	Right total hip
BMD	0.681 g/cm^2	0.681 g/cm^2
T-score	−2.7	−2.7

BMD = bone mineral density; NNT = number needed to treat.
* Similar patients would have to be treated for 1 y to prevent 1 osteoporotic fracture.

(assessed by a combination of self-report, technologist interview, and direct observation, with supplementary information from the test requisition): previous fragility fracture, parental hip fracture, current smoking, recent prolonged corticosteroid use (≥7.5 mg of prednisone or an equivalent for ≥90 days in the previous year), low body mass index (<22 kg/m^2), and inability to rise from a chair without using arms ("failed chair test"). Height was measured by a wall-mounted stadiometer, and weight was measured with a bathroom scale. When contradictory information on fracture history was obtained from the patient and the test requisition, the referring physician's office was contacted for clarification and radiographic documentation. Before 1 January 2006, assessment of the chair test was by self-report. After that date, it was based on direct observation by the DXA technologist.

The absolute fracture risk assessment system was initially calibrated with published 10-year fracture risk data from Sweden, which were subsequently shown to be applicable to our population (26). The clinical risk factors and their relative risks were derived from previous publications from the Study of Osteoporotic Fractures (27, 28). The Web-based BMD reporting system automatically calculated 10-year fracture risk using the entered data and automatically categorized it as low (<10%), moderate (10% to 20%) or high (>20%). These categories are based on BMD reporting recommendations for Canada (10) and are consistent with the designation of "high risk" used by the National Osteoporosis Foundation (29). The fracture risk calculator is available as a standalone, Web-based applet (http://apps.sbgh.mb.ca/bmd-web-calculator/calculator.action). Examples of the 2 BMD reporting formats are provided in **Table 1**.

Treatment Rates

We used the provincial pharmacy database to identify osteoporosis medications dispensed in the 365 days after BMD testing. We defined osteoporosis medications as oral bisphosphonates (alendronate, risedronate, and etidronate), raloxifene, parenteral salmon calcitonin, and systemic estrogen preparations (still used as a second-line treatment). Systemic estrogen accounted for 22% of the osteoporosis medications used; its exclusion did not substantially alter the study findings.

Fracture Outcomes

We assessed osteoporotic fracture outcomes until 31 March 2008 by using physician visit and hospitalization databases. We calculated person-time of follow-up as the difference between the date of BMD testing and 31 March 2008; the date of canceled coverage was used if death or migration occurred before 31 March 2008. We identified fractures through hospital discharge abstracts and physician billing claims (inpatient, outpatient, and office-based) by using established definitions (30). Hip, clinical vertebral, forearm, and humerus fractures not associated with trauma codes were collectively designated as "osteoporotic" fractures because they are the basis for the 10-year absolute fracture risk estimates by Kanis and colleagues (31, 32). Hip fracture and forearm fracture codes had to be accompanied by a site-specific fracture reduction, fixation, or casting code to enhance diagnostic and temporal specificity. Fracture rates during each period were calculated as the number of fractures divided by the total person-time of follow-up and expressed per 1000 person-years of observation, and CIs were constructed by using the normal approximation method for a binomial distribution.

Statistical Analysis

The primary outcome of interest was the proportion of untreated patients before BMD testing who were dispensed an osteoporosis medication at least once during the subsequent year. We compared the periods before and after 1 January 2006 for the overall population and for subgroups defined by 10-year fracture risk category (low, <10%; moderate, 10% to 20%; or high, >20%) (10) and bone density T-score category (normal, low bone mass [osteopenia], or osteoporosis). We did analyses by using a population-averaged nonlinear model. Specifically, we adopted a generalized linear model for a binomial distribution with generalized estimating equations to account for the clustering of individuals within a physician's practice (33, 34). An exchangeable working correlation matrix was selected. The models contained the main effects of reporting period (before vs. after), subgroup (defined from 10-year fracture risk category, bone density T-score category, or age), and their 2-way interaction. We tested relative differences between reporting periods by using a score statistic, which follows a chi-square distribution. In addition, we studied variables associated with dispensing an osteoporosis drug, reported as odds ratios with 95% CIs, by using

multivariable mixed-effects logistic regression models with a random intercept for physicians; the models were stratified by reporting period.

A secondary outcome was the change in the median proportion of women per physician who were given an osteoporosis drug in the year after BMD testing, where the denominator was all women in that physician's practice who had BMD testing done in the reporting period.

We also assessed reclassification with T-score–based risk categories (normal, low bone mass [osteopenia], or osteoporosis) and 10-year fracture risk categories (low, moderate, or risk) in the study population overall and stratified by age (<65 years vs. ≥65 years).

All statistical analyses were performed using SAS software (version 9.2, SAS Institute, Cary, North Carolina). We considered a result statistically significant if the *P* value was less than the nominal α level of 0.05.

Role of the Funding Source

No funding was received for this study.

RESULTS

A total of 2042 women met inclusion criteria in the T-score–based reporting period; 3889 met criteria in the absolute risk reporting period. The 2 groups had similar osteoporosis and fracture risk factors, although women in the earlier period were slightly younger and had a higher prevalence of failed chair testing (self-report) than women in the later period (direct assessment) (**Table 2**). Absolute risk reporting reclassified more women (32.7%) into lower-risk than higher-risk categories (10%), an effect that was more prominent in women younger than 65 years (**Appendix Figure**, available at www.annals.org).

During T-score–based reporting, BMD tests were requested by 722 physicians (median, 1 BMD test; interquartile range [IQR], 1 to 3 BMD tests per physician), and the median proportion of women per physician who were prescribed an osteoporosis drug in the year after BMD testing was 14.3% (IQR, 0% to 50.0%). With absolute fracture risk reporting, BMD tests were requested by 1105 physicians (median, 2 BMD tests; IQR, 1 to 4 BMD tests per physician), and the median proportion of women per physician who were prescribed an osteoporosis drug in the year after BMD testing was 0% (IQR, 0% to 42.9%).

Overall, 627 (30.7%) women were prescribed an osteoporosis medication in the year after BMD testing in the initial observation period, compared with 943 (24.3%) women in the subsequent period. This was a statistically significant reduction in dispensation of osteoporosis medication (absolute reduction, 9.0 percentage points [95% CI, 3.9 to 14.2 percentage points]; relative reduction, 21.3% [CI, 9.2% to 33.5%]; $P < 0.001$), after adjustment for within-physician clustering and other covariates. Results were qualitatively unchanged in analyses restricted to the last 3 months of 2005 and the first 3 months of 2006 (data not shown).

The findings were largely attributable to reductions in treatment of women at low and moderate risk for fracture, women with T-score–defined low bone mass and osteoporosis, and women younger than 80 years (**Table 3**).

Analyses of the association between clinical characteristics and treatment rates in the 2 study periods suggest a larger effect of clinical risk factors on treatment decisions in the period after introduction of absolute risk reporting (**Appendix Table**, available at www.annals.org).

Compared with those who received osteoporosis medications, osteoporotic women (T-scores of −2.5 SD or lower) who did not receive osteoporosis medications during the absolute fracture risk reporting period ($n = 1108$) were slightly younger (mean age, 70.0 years [SD, 10.2] vs. 71.4 years [SD, 9.8]; $P = 0.021$), had lower 10-year fracture risk estimates (19.0% [SD, 10.7%] vs. 21.2% [SD, 10.9%]; $P < 0.001$), higher hip T-scores (−1.93 [SD, 0.87] vs. −2.12 [SD, 0.83]; $P < 0.001$), and a lower prevalence of nontraumatic fracture after age 50 years (28.8% vs. 35.9%; $P = 0.021$) and parental hip fracture history (9.5% vs. 13.5%; $P = 0.058$).

During a median of 2.0 years (IQR, 1.6 to 2.5 years) of observation after BMD testing, 75 patients had incident osteoporotic fractures: 38 during T-score–based risk reporting (7.1 per 1000 person-years [CI, 3.5 to 10.8]) and 37 during absolute fracture risk reporting (5.5 per 1000 person-years [CI, 3.1 to 7.8]; absolute risk difference, 1.7 per 1000 person-years [CI, −2.7 to 6.0]; $P = 0.45$).

DISCUSSION

In this comparison of prescribing behaviors before and after modification of BMD reporting in Manitoba, Can-

Table 2. **Characteristics of the Study Populations Before and After Introduction of 10-Year Absolute Fracture Risk Reporting**

Variable	Before ($n = 2042$)	After ($n = 3889$)	*P* Value
Mean age (SD), *y*	66.5 (9.9)	67.1 (10.0)	0.027
Mean body mass index (SD), kg/m^2	27.9 (5.5)	27.7 (5.6)	0.149
Nontraumatic fracture after age 50 y, *n (%)*	499 (24.4)	510 (25.5)	0.38
Parental hip fracture, *n (%)*	252 (12.3)	267 (13.4)	0.27
Current smoker, *n (%)*	251 (12.3)	262 (13.1)	0.38
Failed chair test, *n (%)*	212 (10.4)	121 (6.0)	<0.001
Corticosteroid use, *n (%)*	55 (2.7)	40 (2.0)	0.077
Total hip T-score	−0.9 (1.2)	−1.0 (1.2)	0.82
Minimum T-score	−1.5 (1.3)	−1.5 (1.3)	0.94
Normal, %	609 (29.8)	1198 (30.8)	
Low bone mass, %	882 (43.2)	1583 (40.7)	
Osteoporotic, %	551 (27.0)	1108 (28.5)	
10-year estimated fracture risk, *n (%)*	13.5 (9.8)	13.1 (9.0)	0.109
Low	951 (46.6)	1758 (45.2)	
Medium	704 (34.5)	1471 (37.8)	
High	387 (19.0)	660 (17.0)	

Table 3. **Rates of Osteoporosis Medication Dispensation Before and After Introduction of Absolute Fracture Risk Reporting***

Variable	Rates of Osteoporosis Medication Dispensation (95% CI), %		*P* Value for Change†	Absolute Reduction (95% CI), *percentage points*	Relative Reduction (95% CI), %
	Before (*n* = 2042)	After (*n* = 3889)			
Fracture risk category					
Low	13.5 (11.3 to 15.9)	6.7 (5.6 to 7.9)	<0.001	6.8 (4.4 to 9.1)	50.3 (32.8 to 67.9)
Moderate	38.1 (34.7 to 41.6)	28.4 (26.1 to 30.9)	<0.001	9.7 (5.5 to 13.8)	25.3 (14.5 to 36.2)
High	60.2 (55.0 to 65.3)	62.3 (58.5 to 65.9)	0.51	−2.0 (−8.5 to 4.4)	−3.4 (−14.1 to 7.4)
T-score category					
Normal	3.9 (2.6 to 5.7)	3.2 (2.4 to 4.4)	0.47	0.7 (−0.9 to 2.2)	17.0 (−22.2 to 56.1)
Low bone mass	20.2 (17.4 to 23.3)	9.2 (7.8 to 10.8)	<0.001	11.0 (7.9 to 14.1)	54.5 (39.2 to 69.9)
Osteoporosis	77.8 (74.0 to 81.2)	68.9 (65.8 to 71.8)	<0.001	8.9 (4.0 to 13.8)	11.4 (5.1 to 17.8)
Age category					
50–59 y	24.8 (21.5 to 28.5)	15.7 (13.6 to 18.1)	<0.001	9.1 (5.1 to 13.1)	36.6 (20.7 to 52.6)
60–69 y	26.3 (23.0 to 29.7)	20.6 (18.4 to 22.9)	0.005	5.7 (1.8 to 9.6)	21.7 (6.9 to 36.5)
70–79 y	38.2 (34.1 to 42.3)	32.1 (29.4 to 34.9)	0.015	6.1 (1.2 to 10.9)	15.9 (3.3 to 28.6)
≥80 y	45.0 (38.0 to 52.1)	38.4 (33.8 to 43.2)	0.122	6.6 (−1.7 to 14.9)	14.7 (−3.8 to 33.2)

* Results are stratified by 10-year fracture risk category (low, <10%; moderate, 10%–20%; or high, >20%), bone mineral density T-score category (normal, −1 or greater; low bone mass [osteopenia], −1 to −2.5; or osteoporosis, −2.5 or lower) and age (by decade).
† *P* values are based on a chi-square test where relative change was from a generalized linear model with main effects for reporting period (before vs. after), subgroup (defined from 10-y fracture risk category, bone mineral density T-score category, or age), and their interaction.

ada, we found that reporting absolute fracture risk was associated with a statistically significant reduction in osteoporosis treatment owing to reduced treatment of women at low and medium risk for fracture. The subgroup with the largest relative reduction in medication dispensations (54.5%) was women with BMD in the low bone mass (osteopenic) range. Because of few events and limited observation time, we could not detect a statistically significant difference in fracture rates with approximately 2 years of follow-up.

A shift in osteoporosis management from using BMD categories to a more comprehensive assessment of fracture risk has been evolving for many years. Although this has been the focus of recent clinical guidelines and traditional education efforts, high-quality evidence is not being used consistently in practice (35). This knowledge-to-practice gap has been identified in many areas of medicine (36). The results of our study support the fact that when test results are presented to clinicians in a way that integrates knowledge with applicability, treatment patterns are better aligned with practice guidelines.

Access to BMD testing is not sufficient to ensure optimal patient care. A major barrier to osteoporosis care might be the lack of BMD reports that are comprehensible to primary care physicians (37). Stock and colleagues (37) randomly assigned 57 physicians from community teaching hospitals to receive short technical reports or long clinical reports written by endocrinologists with access to clinical information. Receiving long reports led to a significant increase in BMD testing, more modifications in the pharmacologic treatment of osteoporosis by gynecologists, and less confusion about reports among physicians. A survey of 206 clinical practitioners receiving BMD reports based on 10-year absolute fracture risk suggested that this explicit method of reporting fracture risk was helpful to the clinician in selecting patients who are more likely to benefit from osteoporosis drugs (38). Furthermore, physicians gave a higher ranking to the absolute fracture risk report when asked whether it was understandable and contained the information required for osteoporosis management. Together, these data suggest that the structure of BMD reporting is as important in clinical decision making as the numerical accuracy of the BMD measurement.

Concern has been expressed that the use of absolute fracture risk reporting could dramatically increase osteoporosis treatment (39). Older age is a strong risk factor for osteoporotic fractures, independent of BMD and other clinical risk factors. Consequently, absolute fracture risk assessment systems that incorporate age will increase the number of older individuals designated as high risk and decrease the number of younger individuals designated as high risk, the transition point being approximately at age 65 years in women (40). Therefore, projections based on studies in older women (such as the Study of Osteoporotic Fractures cohort, who were all older than 65 years at entry [39]) would be expected to show a significant increase in high-risk designation. However, although fracture risk is highest in elderly persons, BMD is tested less frequently in this group (41). Therefore, studies that base projections on age standardization to the general population would also tend to overestimate the prevalence of a high-risk designation under routine referral patterns.

The clinical implications of our study are self-evident, including potential cost savings related to a reduction in treatment of women at low risk for fractures. Cost-effectiveness analyses have suggested that a 10-year fracture

risk greater than 20% is a reasonably cost-effective intervention threshold, although this may be country-specific (29). Analyses suggest that drug treatment of osteopenia is usually not cost-effective (42).

The study has several limitations. Its observational before–after design cannot establish causality, but there are reasons to believe that the change in physician behavior was linked with the change in BMD reporting. The 2 periods evaluated (1 April to 31 December 2005 and 1 January to 31 December 2006) spanned less than 2 years, and no other changes in access to BMD testing or therapeutic agents occurred during this time. The change in osteoporosis treatment rates consistently favored avoidance of treatment in lower-risk patients, which was the hypothesized effect. The assessment of fracture outcomes was also limited and is not of sufficient duration to conclude equivalence in fracture outcomes. The 10-year fracture risk assessment used in our study is similar but not identical to other risk assessment systems. In particular, it includes most of the elements of the World Health Organization fracture risk assessment tool (FRAX) (43, 44) but differs in some of the clinical risk factors (inclusion of a failed chair test and exclusion of rheumatoid arthritis or alcohol use). Implementation details also differ because the relative risks for FRAX are not published; these were taken from the Study of Osteoporotic Fractures (27, 28). We compared 10-year fracture risk calculations from the system used in our study with those obtained from FRAX; they showed close agreement ($r = 0.85$). Furthermore, physician behavior is not strongly influenced by the details and technical implementation of the absolute fracture risk assessment system, and the generalizability of our findings are probably not limited to the specifics of an individual risk assessment model. Finally, the failed chair test was ascertained differently during the 2 study periods, but this is unlikely to have significantly affected the estimated fracture risks, which were similar in the 2 cohorts (**Table 2**).

In summary, we have shown that a systemic change in BMD test reporting to reflect absolute fracture risk was associated with a statistically and clinically significant change in physician-prescribed osteoporosis medications that was better aligned with clinical guideline recommendations. Dispensation of osteoporosis drugs statistically and clinically significantly decreased in patients found to be in lower risk categories, without any statistically significant change in those designated at high risk. Our study demonstrates the need for knowledge-dissemination strategies that will also lead to appropriate interventions in women at highest risk for osteoporotic fractures. The findings suggest that tools that close gaps between knowledge and practice, such as a novel BMD reporting system, can have a significant effect on clinical processes and outcomes.

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Appendix Table. **Odds Ratios for Prediction of Osteoporosis Medication Use Before and After Introduction of Absolute Fracture Risk Reporting**

Variable	Odds Ratio (95% CI)	
	Before*	After†
Age (per decade)	0.91 (0.80–1.05)	1.08 (0.98–1.19)
Body mass index <22 kg/m^2	1.00 (0.70–1.45)	0.91 (0.71–1.17)
Nontraumatic fracture after age 50 y	1.29 (0.98–1.72)	1.45 (1.19–1.76)
Parental hip fracture	1.30 (0.89–1.88)	1.23 (0.94–1.60)
Current smoker	0.97 (0.66–1.42)	0.93 (0.70–1.22)
Failed chair test	0.87 (0.57–1.33)	2.40 (1.67–3.44)
Corticosteroid use	2.01 (1.00–4.05)	3.55 (2.03–6.19)
Minimum T-score (per SD unit decrease)	5.67 (4.73–6.81)	4.85 (4.26–5.52)

* Variance of random intercept for physician in period before introduction of absolute fracture risk reporting: $\sigma^2 = 0.26$ ($P = 0.090$).
† Variance of random intercept for physician in period after introduction of absolute fracture risk reporting: $\sigma^2 = 0.00$ ($P = 1.00$).

Appendix Figure. **Change in screening category with T-score–based compared with absolute fracture risk reporting.**

T-Score Category	Total, n (%)	Fracture Risk Category, n (%)			Reclassified Into New Risk Category (%)		
		Low	Moderate	High	Lower	Higher	Total
All ages							
Normal	1807 (30.5)	1514 (83.8)	274 (15.2)	19 (1.1)	–	16.2	16.2
Low bone mass	2465 (41.6)	1005 (40.8)	1158 (47.0)	302 (12.3)	40.8	12.3	53.0
Osteoporotic	1659 (28.0)	190 (11.5)	743 (44.8)	726 (43.8)	56.2	–	56.2
Total	5931 (100.0)	2709 (45.7)	2175 (36.7)	1047 (17.7)	32.7	10.0	42.7
Age <65 y							
Normal	1038 (39.7)	973 (93.7)	61 (5.9)	4 (0.4)	–	6.3	6.3
Low bone mass	1086 (41.6)	727 (66.9)	328 (30.2)	31 (2.9)	66.9	2.9	69.8
Osteoporotic	488 (18.7)	153 (31.4)	278 (57.0)	57 (11.7)	88.3	–	88.3
Total	2612 (100.0)	1853 (70.9)	667 (25.5)	92 (3.5)	44.3	3.7	48.0
Age ≥65 y							
Normal	769 (23.2)	541 (70.4)	213 (27.7)	15 (2.0)	–	29.6	29.6
Low bone mass	1379 (41.5)	278 (20.2)	830 (60.2)	271 (19.7)	20.2	19.7	39.8
Osteoporotic	1171 (35.3)	37 (3.2)	465 (39.7)	669 (57.1)	42.9	–	42.9
Total	3319 (100.0)	856 (25.8)	1508 (45.4)	955 (28.8)	23.5	15.0	38.5

Red shading indicates an increase in risk category, and blue shading indicates a decrease in risk category.