A Risk Assessment Tool (OsteoRisk) for Identifying Latin American Women with Osteoporosis

Shuvayu S. Sen, PhD,¹ Vincent P. Rives, PharmD,² Osvaldo D. Messina, MD,³ Jorge Morales-Torres, MD,⁴ Gregorio Riera, MD,⁵ Juan M. Angulo-Solimano, MD,⁶ João F.M. Neto, MD,⁷ Alberto Frisoli, Jr., MD,⁸ Ricardo C. Sáenz, MD,⁹ Olga Geling, PhD,¹⁰ Philip D. Ross, PhD¹¹

¹Merck & Company, Inc., Whitehouse Station, NJ, USA; ²Temple University School of Pharmacy, Philadelphia, PA, USA; ³Department of Rheumatology, C. Argerich Hospital, Buenos Aires, Argentina; ⁴Facultad de Medicina de Leon, Hospital Aranda de la Parra, León, GTO, Mexico; ⁵Department of Medicine, Universidad de Carabobo, Valencia, Venezuela; ⁶Hospital Central de la Fuerza Aérea, Lima, Peru; ⁷Department of Rheumatology, State University (Unicamp), Campinas, SP, Brazil; ⁸Department of Internal Medicine, Universidade Federal de São Paulo, São Paulo, Brazil; ⁹Department of Medicine, Division of Rheumatology, Hospital Dr. R.A. Calderón Guardia, San José, Costa Rica; ¹⁰Rutgers University, Piscataway, NJ, USA; ¹¹Merck Research Laboratories, Rahway, NJ, USA.

OBJECTIVE: To develop a simple and easy-to-use tool for identifying osteoporotic women (femoral neck bone mineral density [BMD] T-scores ≤ -2.5) in Latin America.

DESIGN: Retrospective study involving review of medical records.

SETTING: Osteoporosis clinics in 6 Latin American countries.

PATIENTS: Postmenopausal women ages ≥ 50 in Latin America who had femoral neck BMD measurements.

MEASUREMENTS AND MAIN RESULTS: A risk index was developed from 1,547 patients based on least square regression using age, weight, history of fractures, and other variables as predictors for BMD T-score. The final model was simplified by reducing the number of predictors; sensitivity and specificity were evaluated before and after reducing the number of predictors to assess performance of the index. The final model included age, weight, country, estrogen use, and history of fractures as significant predictors for T-score. The resulting scoring index achieved 91% sensitivity and 47% specificity. Simplifying the index by using only age and weight yielded similar performance (sensitivity, 92%; specificity, 45%). Three risk categories were identified based on OsteoRisk, the index using only age and body weight: high-risk patients (index ≤ -2 ; 65.6% were osteoporotic), moderate-risk patients ($-2 < \text{index} \leq -1$; 26.7% were osteoporotic), and low-risk patients (index > -1 ; 8% were osteoporotic). Similar results were seen in a validation sample of 279 women in Brazil.

CONCLUSION: Age and weight alone performed well for predicting the risk of osteoporosis among postmenopausal women. The OsteoRisk is an easy-to-use tool that effectively targets the vast majority of osteoporotic patients in Latin America for evaluation with BMD.

KEY WORDS: osteoporosis; bone mineral density; risk assessment.

DOI: 10.1111/j.1525-1497.2005.40900.x

J GEN INTERN MED 2005; 20:245-250.

Many publications have reported that osteoporosis is underdiagnosed and that only a small proportion of patients are appropriately treated.¹⁻³ The prevalence of osteoporosis varies among Latin American countries. In Mex-

ico, the prevalence of osteoporosis among women 50 and over is between 16% and 30%,⁴ while in Chile, osteoporosis prevalence was estimated to be 22% and 29.2% in women older than 50 and all postmenopausal women, respectively.^{5,6} In Brazil 10 million people (1 out of 17 persons) have osteoporosis,⁷ while in Venezuela, only 10% of the population older than 70 have normal bone mass.⁸ Earlier studies reported lower hip fracture rates in Latin America than in U.S. or European whites.⁹⁻¹² However, the number of women at risk of osteoporosis and hip fracture is increasing in Latin America. The number of hip fractures for women and men aged 50-64 in Latin America will increase by 400%, while in ages 65 and over the increase will be a staggering 700% in 2050 as compared to the prevalence in 1950.¹³

Although patients with fracture should automatically be considered for treatment for osteoporosis, and assessment of bone mineral density (BMD) using dual energy x-ray absorptiometry (DXA) is the standard for diagnosing osteoporosis prior to fracture, facilities for DXA measurements remain limited in Latin America and certain other parts of the world, and this poses a serious challenge for diagnosing osteoporosis in patients without prior fracture.

Some researchers have examined the relationship between clinical variables and bone mass in the hope of targeting BMD measurements to patients who are more likely to have osteoporosis.¹⁴⁻²⁰ Lydick et al.¹⁷ developed a model that accurately identifies 90% of subjects with low bone mass and 40% of subjects with normal bone mass. Recently, Koh et al.¹⁸ developed an index, the Osteoporosis Self-assessment Tool for Asians (OSTA), for identifying women at increased risk of osteoporosis in a population of Asian patients other than Japanese. The OSTA is based only on age and weight and achieved a sensitivity of 91% for identifying women with osteoporosis; it was further validated in a cohort of Japanese women, with a sensitivity of 98%.¹⁹ The Osteoporosis Self-assessment Tool (OST) was derived from the OSTA by altering the risk category ranges, and performed well in identifying women at risk of osteoporosis in Europe and the United States (sensitivity, 88%; specificity, 52%).²⁰ The OST is simple and easy to use, because only 2 risk factors are involved (age and weight). Moreover, the OST performs consistently in different white populations.^{20,21}

We hypothesized that some adjustment might be necessary to make these instruments applicable to Latin American women. First, risk for osteoporosis varies with racial category.²²⁻²⁴ The racial make-up of Latin American populations is

Accepted for publication July 1, 2004

Dr. Shuvayu S. Sen and Dr. Phillip D. Ross are employees of Merck & Company, Inc.

The results were presented in part at the Fourth Conference on the Clinical and Economic Aspects of Osteoporosis and Osteoarthritis, Nice, France, November 2003.

Address correspondence and requests for reprints to Dr. Sen: Merck & Company, Inc., P.O. Box 100, Whitehouse Station, NJ 08999 (e-mail: shuvayu_sen@merck.com).

very different from the rest of the world. For example, the racial category Mestizo, only present in Latin America, represents a complex and dynamic mixture of white and Native American inhabitants dating from the 16th century. This racial category may vary from having very dominant white characteristics to very dominant Native American characteristics.²⁵ Second, body mass index (BMI) is associated with BMD in different populations,^{26,27} and the distribution of BMI varies from country to country in Latin America. For example, in 1996, women with BMI between 25.0 and 29.9 kg/m² represented 23.8%, 25.0%, and 35.5% in Honduras, Brazil, and Peru, respectively.²⁸ Other risk factors, currently known or unknown, might also influence the performance of existing osteoporosis risk tools in Latin America.

Considering these factors, a risk assessment tool specifically developed for Latin American populations might be most appropriate. To assist clinicians in identifying patients for BMD measurements, the current study aimed to develop an osteoporosis risk assessment tool for Latin American populations using easy and widely available risk factors.

METHOD

This was a retrospective study using data from 6 Latin American countries, Argentina, Brazil, Costa Rica, Mexico, Peru, and Venezuela. One osteoporosis clinic with a BMD facility was identified in each of these 6 countries. Records of the most recent 300 postmenopausal women aged 50 and above who had femoral neck DXA measured at these osteoporosis clinics and met exclusion and inclusion criteria were reviewed. These patients were either consulting spontaneously or referred by their physicians for a BMD measurement. The aim was to have at least 200 patients per country so that the primary ethnic variation in each country was captured. Women were considered postmenopausal if they had been amenorrheic with or without other climacteric symptoms for 6 months or more prior to the BMD measurement. The brand of DXA manufacturer varied among centers, and included Norland, Hologic, and Lunar machines.

Because the objective of the study was to develop an osteoporosis risk assessment tool for average postmenopausal women, certain study exclusion criteria were used in order to minimize the potential effect of confounding factors on the risk of being osteoporotic. Women were excluded from the study if they had a history or evidence of metabolic bone disease (other than postmenopausal bone loss); presence of cancer(s) with known metastasis to bone; history of significant renal impairment (serum creatinine level > 2.5 mg/dl); one or both ovaries removed; history of fracture or replacement of both hips; or history of bisphosphonate, fluoride, or calcitonin use. All data were collected by reviewing patients' medical records that had been documented during their BMD measurement visit to obtain information for the following variables: country of origin, clinical center, BMD values and T-scores at the femoral neck, estrogen use, thyroid use, history of any fracture after 45 years of age, ethnicity, age, height, and body weight. Height and body weight had been measured and documented in the medical records by a clinician at the time of BMD measurement. History of fracture, ethnicity, age, and estrogen and thyroid use had been self-reported by the patients during the same visit.

Data Analysis

Based on World Health Organization (WHO) guidelines, osteoporosis was defined as a BMD value that is 2.5 standard deviations or more below the peak BMD for premenopausal women of the same ethnic origin at that bone site,²⁹ obtained from reference data provided by each DXA manufacturer.

Analysis was performed in two stages: first to identify risk factors with mutually independent associations, and then to develop a simple index from these variables, reducing the number of variables to as few as possible while retaining good performance.

Multivariate Analyses

Multiple least square regression analysis was used to develop a parsimonious model predicting BMD T-scores using standard statistical techniques such as R^2 and forward stepwise model selection.^{30,31} The potential risk factors included in the model development process consisted of the risk factors identified by Koh et al.¹⁸ in the OSTA study: age, weight, history of estrogen use, history of thyroid hormone use, history of fracture since age 45, ethnicity, and country of residence. Additionally, height and BMI were also included in the initial pool of predictors, because several osteoporosis guidelines include BMI as a risk factor for osteoporosis.³² Also, the Latin American population is highly heterogeneous with respect to height and ethnicity, and height or BMI may potentially contribute to the variance in BMD.

Development of the OsteoRisk Index

The following method was used to develop a risk index for osteoporosis from the regression coefficients of the statistical model. Regression coefficients of age and body weight were multiplied by 10 so that the age and weight variables are in units of 10 years and 10 kilograms. Because weight was the strongest predictor of a woman's T-score and had the smallest coefficient of variance, the regression coefficients for other predictors were divided by the coefficient for body weight, and then multiplied by 2 and rounded to the nearest integer to produce the statistical weights used in calculating the index. Each variable was then multiplied by the statistical weight, and the results were summed to calculate the index. This index was further simplified by dropping variables one at a time beginning with the last variable that had been identified using forward stepwise selection, and working backward while calculating specificity and sensitivity each time to retain good performance (defined here as sensitivity $\geq 85\%$ and specificity $\geq 40\%$).

Sensitivity is the proportion of women with osteoporosis (T-score ≤ -2.5) that tested positive (true positives). Specificity is the proportion of women without osteoporosis who tested normal (true negatives). Receiver operating characteristic (ROC) curves and the associated area under the curve (AUC) were used to describe how well various levels of the index can distinguish low bone mass women from those with non-low bone mass.³³ A tool with perfect performance would have an ROC curve near the upper left corner of the plot and an AUC of 1.0, whereas a tool with no value would have an ROC curve directly on the diagonal between the lower left and upper right corners and an AUC of 0.5. Tests are generally considered to have good performance if the AUC is greater than 0.7.

The risk index range corresponding to a sensitivity of $\sim 90\%$ was chosen to define the low-risk group; the index ranges for the medium- and high-risk groups were chosen such that the prevalence of osteoporosis in the high-risk group was $\sim 60\%$; this same process was used in developing previous risk tools.^{18,20} A graphical representation of the risk assessment tool was then developed to simplify clinical use. The sensitivity and specificity of the developed risk assessment tool were further assessed in each of the 6 countries using the development cohort from the respective country in order to check the instrument's consistency of performance across countries.

Validation

The OsteoRisk index was validated using 2 widely accepted methods. First, the risk factors identified as the most useful predictors for BMD in least square regression were compared to those identified as predictors of osteoporosis (T-score ≤ -2.5) using a different statistical method, logistic regression. Second, we assessed the performance in a different sample of 279 postmenopausal women age ≥ 50 in Brazil, with the same inclusion and exclusion criteria as the developmental study. To assess performance of the index, sensitivity and specificity were calculated, an ROC curve was plotted, and the AUC was calculated.

RESULTS

Sample Characteristics

Bone mineral density and records were available for 1,547 women who met the inclusion criteria; Table 1 describes the demographic and clinical characteristics of the sample. There were significant differences among the countries for all variables. Approximately 44% of the women reported they were white, and the remainder Mestizo. The mean age was 65 years, and the mean weight was 63 kg. The mean BMD T-score was -1.8 , with nearly one third of the women (32.5%) being osteoporotic, defined as a BMD T-score ≤ -2.5 , and 6.4% had a history of fracture.

Model Selection

Table 2 presents the final regression model for predicting T-scores after going through the model selection process. The variables considered in the model were age, weight, height,

race, country, history of estrogen use (yes/no), history of thyroid use (yes/no), and history of fractures (yes/no). The results indicate that of these variables, body weight had the greatest explanatory power. In the process of forward selection of the model, body weight entered the model first, alone explaining 20% of variation in BMD T-scores ($R^2 = .20$). The most complete model containing all significant variables had an R^2 of .42.

Development of the Index

The model with all 8 variables yielded a sensitivity of 91% and specificity of 46% for identifying women with osteoporosis. The AUC for the model based on all variables was 0.83. After dropping variables one at a time to meet the prespecified performance criteria (defined as sensitivity $> 85\%$ and specificity $> 40\%$), the simplest model contained only age and body weight; based on this model, the OsteoRisk index is calculated as $0.2 \cdot [(\text{body weight in kg}) - (\text{age in years})]$.

The final OsteoRisk index (≤ 1 vs > 1) had a sensitivity of 92.0% and specificity of 44.7%. The AUC was 0.82, which is generally considered good for a risk assessment tool. Assessment of OsteoRisk's performance separately in each of the 6 countries yielded sensitivity in the range of 84% to 100% and specificity in the range of 35% to 54%, indicating consistent performance of OsteoRisk in identifying osteoporotic women across the countries where it was developed. The prevalence of osteoporosis increased with OsteoRisk category. The low-risk category (OsteoRisk > 1) represented 33% of all women; only 8% of the women in this category had osteoporosis. The prevalence of osteoporosis was 66% among the group at high risk (OsteoRisk ≤ -2), which represent 30% of all women. In the intermediate-risk group ($-2 < \text{OsteoRisk} \leq 1$, 37% of all women), 27% of the patients had osteoporosis (see Fig. 1).

Validation

Use of Different Statistical Technique. Use of logistic regression with backward selection process identified age, body weight, estrogen use, and history of fracture as significant predictors. This is very congruent with the results of the least square regression method. Further, a risk index developed based on odds ratios for these significant predictors yielded a similar level of sensitivity (91%) and specificity (53%) as the risk index developed with regression coefficients of the significant predictors from the ordinary least square regression. When the

Table 1. Characteristics of Women

Sample Characteristics	Grand Total	Argentina	Brazil	Costa Rica	Mexico	Peru	Venezuela
Number of women	1,547	300	261	113	300	273	300
Mean age, y ($\pm$ SD)	64.6 $\pm$ 8.4*	65.5 $\pm$ 6.8	69.2 $\pm$ 8.1	70.3 $\pm$ 8.2	60.6 $\pm$ 8.0	63.3 $\pm$ 9.0	62.9 $\pm$ 7.2
Weight, kg	63.0 $\pm$ 11.4*	68.2 $\pm$ 12.1	59.8 $\pm$ 11.7	54.4 $\pm$ 9.0	64.2 $\pm$ 9.9	64.7 $\pm$ 10.9	61.3 $\pm$ 10.1
Height, cm	153.8 $\pm$ 6.8*	156.1 $\pm$ 5.8	152.7 $\pm$ 6.4	148.8 $\pm$ 7.3	155.8 $\pm$ 6.7	155.0 $\pm$ 6.5	151.2 $\pm$ 6.0
BMI, kg/m ²	26.6 $\pm$ 4.4*	28.0 $\pm$ 4.7	25.6 $\pm$ 4.8	24.6 $\pm$ 4.0	26.5 $\pm$ 4.1	26.9 $\pm$ 4.3	26.7 $\pm$ 3.9
T-score (femoral neck)	$-1.8 \pm 1.1^*$	-1.5 ± 1.0	-2.2 ± 1.4	-3.1 ± 0.7	-1.0 ± 1.1	-2.1 ± 1.0	-1.9 ± 0.9
Osteoporosis (T-score ≤ -2.5)	503 (32.5%)	50 (16.7%)	149 (56.9%)	113 (100%)	25 (8.3%)	89 (32.6%)	77 (25.7%)
History of fracture	99 (6.4%)*	9 (3.0%)	1 (0.4%)	13 (11.5%)	33 (11.0%)	32 (11.7%)	11 (3.7%)
Thyroid use	36 (2.3%)*	0 (0.0%)	2 (0.8%)	8 (7.1%)	0 (0.0%)	17 (6.2%)	9 (3.0%)
Estrogen use	193 (12.5%)*	0 (0.0%)	26 (9.9%)	11 (9.7%)	100 (33.3%)	25 (9.2%)	31 (10.3%)
Ethnicity							
White	681 (44.0%)*	300 (100.0%)	254 (97.3%)	0 (0.0%)	0 (0.0%)	83 (30.4%)	44 (14.7%)
Mestizo	866 (56.0%)*	0 (0.0%)	7 (2.7%)	113 (100.0%)	300 (100.0%)	190 (69.6%)	256 (85.3%)

*Significant difference between the 6 country samples ($P < .05$).
SD, standard deviation; BMI, body mass index.

Table 2. Final Multiple Regression Model Predicting T-Scores

Variable	Regression Coefficient	95% Confidence Interval
Intercept	-2.049	-2.549 to -1.549
Age, y	-0.035	-0.041 to -0.029
Weight, kg	0.037	0.033 to 0.041
Argentina	0.273	0.138 to 0.409
Mexico	0.747	0.608 to 0.886
Peru	-0.272	-0.409 to -0.135
Costa Rica	-0.624	-0.815 to -0.432
Currently using estrogen	0.286	0.136 to 0.435
Previous history of fracture	-0.322	-0.515 to -0.128
$R^2 = .42$		

All variables were significant ($P \leq .001$).

risk index based on logistic regression was further simplified to only age and weight, it produced a similar level of performance (sensitivity, 92%; specificity, 45%) as compared to the index based on all significant variables.

Assessment of OsteoRisk in a Different Sample of Patients. A separate sample of 279 women from Brazil was studied. Mean ($\pm$ SD) age and weight were 69.6 ± 9.2 years and 60.3 ± 11.3 kg, respectively (64.6 ± 8.4 years and 63.0 ± 11.4 kg in the developmental cohort, respectively; both $P < .01$). Mean T-score was -2.22 ± 1.08 , with 44.8% of the sample being osteoporotic (femoral neck T-score ≤ -2.5 ; -1.8 ± 1.1 and 32.5% in the developmental cohort, respectively; both $P < .01$). Using a cutoff point of ≤ 1 versus > 1 yielded a sensitivity of 93.6% and a specificity of 29.2%. The ROC curve yielded an AUC of 0.61 for the OsteoRisk index. The prevalence of osteoporosis in high- (OsteoRisk ≤ -2), intermediate- ($-2 < \text{OsteoRisk} \leq 1$), and low-risk categories (OsteoRisk > 1) were 60.8%, 36.1%, and 15.1%, respectively. These 3 categories represented 51%, 30%, and 19% of the total sample, respectively.

DISCUSSION AND CONCLUSION

To our knowledge no osteoporosis index exists for Latin America in the literature except for a clinical index specifically de-

veloped for Mexican women in Mexico City, which did not provide sufficient detail to allow comparison here.³⁴ Given the cultural and racial variations across Latin America, it would be desirable to have an index that is generalizable to the entire Latin American region. The OsteoRisk, based on weight and age, is a simple and easy-to-use osteoporosis risk assessment tool that addresses this need.

The primary purpose of such a tool is to identify patients at risk of osteoporosis, among whom BMD can then be used to obtain a definitive diagnosis. The use of 3 risk categories provides a useful alternative to a single cutoff approach when there is a spectrum of risk, as with osteoporosis. Three risk categories have been used in other areas of medicine (blood pressure, serum glucose, and serum cholesterol) to classify low, moderate, and high risk.¹⁸ In our study, 62% of high-risk patients in the developmental sample and 61% of high-risk patients in the Brazilian validation sample had osteoporosis. These findings are almost identical to those reported in similar studies of both white^{20,35} and Asian populations.^{18,19} Patients in this category should undergo BMD measurement and, if positive, should be treated with proven therapies for osteoporosis. However, if access to BMD is very limited, clinicians may consider treating these patients directly for osteoporosis.^{18,36} Almost 27% and 36% of patients in the OsteoRisk medium-risk category had osteoporosis in the developmental sample and validation sample, respectively. These patients should also undergo BMD measurement, followed by treatment if found osteoporotic. It would be reasonable to postpone BMD measurements for patients in the low-risk category, unless major risk factors such as fragility fracture or corticosteroid use are present, which would justify measuring BMD.

Both ordinary least square regression and logistic regression identified age and body weight as significant predictors for risk of osteoporosis. The OsteoRisk index, based only on age and weight, performed well in identifying women with osteoporosis. Body weight also showed higher predictive power as compared to BMI.³⁷ These findings are consistent with earlier studies of white and Asian women that reported that age and weight were important predictors of BMD, and that indices based on age and weight performed as well as models that included additional variables.^{18-22,35,38} In fact, the algorithm for calculating OsteoRisk risk for osteoporosis developed in the current study is exactly the same as the algorithm developed independently for the OST and the OSTA, which was originally developed in an Asian cohort and later validated in white cohorts.^{18-20,35} The OsteoRisk cutoffs for defining high, medium, and low risk are slightly different from those reported for the OST, which may in part reflect ethnic or cultural differences of Latin American versus North American and European populations. These findings demonstrate the external validity of the OST and OsteoRisk in identifying postmenopausal women with osteoporosis and underscore the strong relationship of age and body weight with risk for osteoporosis. Further, OsteoRisk is the only validated osteoporosis risk index available for Latin America.

When compared with the performance of other osteoporosis risk indices, OsteoRisk performed well in identifying women at risk of osteoporosis. Table 3 shows a summary of performances of different osteoporosis risk indices in different populations. Combining high- and medium-risk categories, OsteoRisk consistently identified ~90% or more of patients

FIGURE 1. A graphical representation of the risk assessment tool.

Table 3. Specificity, Sensitivity, and Area Under the Curve for Several Indexes

Index	OsteoRisk		OSTA			FOSTA	ORAI	OSIRIS
Population	Latin America	Brazil	Koh et al. ¹⁸ Asia	Koh et al. ¹⁸ Japan	Kung et al. ⁴⁰ China (Hong Kong)	Fujiwara et al. ¹⁹ Japan	Cadarette et al. ⁴¹ Canada	Sedrine et al. ⁴² Belgium
N	1,547	279	797	1,123	722	1,127	1,376	1,303
Sensitivity, %	92	94	91	98	88	87	93	78.5
Specificity, %	45	29	45	29	54	43	46	51.4
Area under the curve	0.82	0.61	0.79					0.71

OSTA, Osteoporosis Self-assessment Tool for Asians; OSIRIS, Osteoporosis Index of Risk; FOSTA, Female Osteoporosis Self-assessment Tool for Asians; ORAI, Osteoporosis Risk Assessment Instrument.

with osteoporosis (sensitivity), and over 60% of patients in the high-risk category have osteoporosis.

The use of simple risk tools such as the OsteoRisk could yield a sizable cost savings compared with measuring BMD in all postmenopausal women. In the Latin American sample, 33% of the women had OsteoRisk scores greater than 1 (low risk). Koh et al.¹⁸ reported 25% of Japanese women with low risk, and 40% of Asian women.

Our study involved a large sample of women from 6 countries located in different parts of Latin America, with varied ethnic distributions that included a large proportion of Mestizo ancestry. The OsteoRisk performed similarly in each country, suggesting that this index could be applicable across Latin America.

As with any retrospective study, this study has some limitations. Only patients who had a BMD measurement were included. The reasons for measuring BMD were not available. Characteristics such as socioeconomic status, health insurance, access to BMD measurement, or other factors might have influenced who would undergo BMD measurement. Further, the prevalence of osteoporosis in this study sample was higher than expected for the general population. All these factors could be sources for potential selection bias. However, this study was conducted in 6 different countries in Latin America and results were consistent across all 6 countries, suggesting that selection bias did not have a large effect on the result.

Although this study included patients from 6 countries in Latin America covering a wide range of ethnicity and race, the study sample primarily included white and Mestizo patients from osteoporosis clinics and relied upon self-report of racial category. The racial category "Mestizo" encompasses a wide spectrum of mixture of races ranging from predominantly white to predominantly indigenous. Because 56% of the study sample were Mestizo from 5 countries, this category captured a very heterogeneous racial population, which is a fair reflection of Latin America. However, the study sample did not include any woman of black racial origin. Prior studies observed that risk of osteoporosis is quite different among blacks as compared to other races.³⁹ Therefore, results from this study may not be applicable to black postmenopausal women. Also, characteristics of Latin Americans who immigrate to other countries might change; additional research would be required to determine how this risk tool would perform in such populations. Additionally, prospective validation testing to evaluate the consistency of performance in different Latin American countries would also be useful.

Because local young adult BMD means for these countries were not available, T-scores were calculated using young adult BMD data provided by densitometer manufacturers. The per-

formance of OsteoRisk outside the development cohort was assessed using a Brazilian sample of postmenopausal women. Validation studies in different ethnic populations, particularly among indigenous and black populations in Latin America, are needed to assess OsteoRisk performance in these populations.

OsteoRisk is a simple, easy-to-use tool based on age and weight for identifying Latin American women with osteoporosis. In this sample of women from osteoporosis clinics it accurately identified the vast majority of postmenopausal women with osteoporosis and performed similarly in a sample of women outside the development sample in Latin America. Further validation in other populations such as unselected postmenopausal women is warranted. In the meantime, however, our findings are very consistent with prior studies in other populations of whites and Asians, providing strong external validation. We recommend that patients identified by OsteoRisk as high or medium risk should undergo BMD measurement, and be considered for treatment if BMD is low.

This study was funded in part by Merck & Company, Inc. The authors would like to acknowledge Dr. Olga Geling for her support with data analysis.

REFERENCES

1. Freedman KB, Kaplan FS, Bilker WB, Strom BL, Lowe RA. Treatment of osteoporosis: are physicians missing an opportunity? *J Bone Joint Surg Am.* 2000;82A:1063-70.
2. Pal B. Questionnaire survey of advice given to patients with fractures. *BMJ.* 1999;318:500-1.
3. Schnitzer TJ, Wehren LE. The patient with a fragility fracture: an evolving role for the orthopaedic surgeon. *Q J Med.* 2004;97:101-4.
4. Murrillo-Urbe A, Deleze-Hinojosa M, Aguirre E, et al. [Osteoporosis in Mexican postmenopausal women. Magnitude of the problem. Multicenter study.] *Ginecol Obstet Mex.* 1999;67:227-33.
5. Lams HG. [Situation of osteoporosis in Chile.] *Rev Med Chil.* 2000;128:809-12.
6. Arrigada M, Arinovich R, Rodriguez JA. The prevalence of osteopoina and osteoporosis in Chile. *Galenus.* 1987;9:33-6.
7. Revista Veja. Edición 1658/Julio 2000, Brazil.
8. Riera G. Realidad de la osteoporosis en Venezuela. *Rev Informe Medico.* 2003;3:354-56.
9. Bacon WE, Maggi S, Looker A, et al. International comparison of hip fracture rates in 1988-89. *Osteoporos Int.* 1996;6:69-75.
10. Castro Da Rocha FA, Ribeiro AR. Low incidence of hip fractures in an equatorial area. *Osteoporos Int.* 2003;14:496-99.
11. Clark P, de la Pena F, Gomez Garcia F, Orozco JA, Tugwell P. Risk factors for osteoporotic hip fractures in Mexicans. *Arch Med Res.* 1998;29:253-7.
12. Barros ER, Kasamatsu TS, Ramalho AC, Hauache OM, Vieira JG, Lazaretti-Castro M. Bone mineral density in young women of the city of Sao Paulo, Brazil: correlation with both collagen type I alpha 1 gene polymorphism and clinical aspects. *Braz J Med Biol Res.* 2002;35:885-93.

13. **Cooper C, Campion G, Melton LJ III.** Hip fractures in the elderly: a world-wide projection. *Osteoporos Int.* 1992;2:285-9.
14. **Slemenda CW, Hui SL, Longcope C, Wellman H, Johnston CC Jr.** Predictors of bone mass in perimenopausal women. *Ann Intern Med.* 1990; 112:96-100.
15. **Ribot C, Pouilles JM, Bonneau M, Tremollieres F.** Assessment of the risk of post-menopausal osteoporosis using clinical factors. *Clin Endocrinol.* 1992;36:225-8.
16. **Bauer DC, Browner WS, Cauley JA, et al.** Factors associated with appendicular bone mass in older women. *Ann Intern Med.* 1993;118: 657-65.
17. **Lydick E, Cook K, Turpin J, et al.** Development and validation of a simple questionnaire to facilitate identification of women likely to have low bone mass. *Am J Manag Care.* 1998;4:37-48.
18. **Koh LK, Sedrine WB, Torralba TP, et al.** Osteoporosis Self-assessment Tool for Asians (OSTA) Research Group. A simple tool to identify Asian women at increased risk of osteoporosis. *Osteoporos Int.* 2001;12:699-705.
19. **Fujiwara S, Masunari N, Suzuki G, Ross PD.** Performance of osteoporosis risk indices in a Japanese population. *Curr Ther Res.* 2001; 62:586-94.
20. **Geusens P, Hochberg MC, van der Voort DJ, et al.** Performance of risk indices for identifying low bone density in postmenopausal women. *Mayo Clin Proc.* 2002;77:629-37.
21. **Cadarette SM, McIsaac WM, Hawker GA, et al.** The validity of decision rules for selecting women with primary osteoporosis for bone mineral density testing. *Osteoporos Int.* 2004;15:361-6.
22. **Ross PD, Wasnich RD, Davis JW.** Fracture prediction models for osteoporosis prevention. *Bone.* 1990;11:327-31.
23. **Mautalen C, Pumarino H.** Epidemiology of osteoporosis in South America. *Osteoporos Int.* 1997;7(suppl 3):S73-S77.
24. **Sapunar J, Bravo P, Schneider H, Jimenez M.** [Is Mapuche ethnicity a risk factor for hip fracture in aged?] *Rev Med Chil.* 2003;131:1135-41.
25. **Garcia-Ramos G, Tellez-Zenteno JF, Zapata-Zuniga M, et al.** HLA class II genotypes in Mexican Mestizo patients with myasthenia gravis. *Eur J Neurol.* 2003;10:707-10.
26. **Ramalho AC, Lazaretti-Castro M, Hauache O, et al.** Osteoporotic fractures of proximal femur: clinical and epidemiological features in a population of the city of Sao Paulo. *Sao Paulo Med J.* 2001;119:48-53.
27. **Carranza-Lira S, Rosas M, Murillo A, Martinez N, Santos J.** Osteoporosis in postmenopausal women (Mexico City): 1. Risk factors. *Int J Fertil Womens Med.* 2002;47:22-5.
28. **Martorell R, Khan LK, Hughes ML, Grummer-Strawn LM.** Obesity in Latin American women and children. *J Nutr.* 1998;128:1464-73.
29. **WHO Study Group.** Assessment of fracture risk and its application to screening for post menopausal osteoporosis. WHO technical report series 843. Geneva, Switzerland: WHO; 1994.
30. **Mallows C.** Some comments on Cp. *Technometrics.* 1973;661-76.
31. **Rawlings JO.** Applied Regression Analysis. Pacific Grove, CA: Wadsworth & Brooks/Cole; 1988.
32. **Reid IR.** Relationships among body mass, its components, and bone. *Bone.* 2002;31:547-55.
33. **Hanley JA, McNeil BJ.** The meaning and use of the area under a receiver operating characteristic (ROC) curve. *Radiology.* 1992;143:29-36.
34. **Carranza-Lira S, Rosas M, Murillo A, Martinez N, Santos J.** Osteoporosis in postmenopausal women (Mexico City): 2. Validation of a predictive clinical index. *Int J Fertil Womens Med.* 2002;47:26-31.
35. **Richy F, Gourlay M, Ross PD, et al.** Validation and comparative evaluation of the osteoporosis self-assessment tool (OST) in a Caucasian population from Belgium. *QJM.* 2004;97:39-46.
36. **Hawker GA, Jamal SA, Ridout R, Chase C.** A clinical prediction rule to identify premenopausal women with low bone mass. *Osteoporos Int.* 2002;13:400-6.
37. **Sen SS, Geling O, Messina OD, et al.** Comparison of body weight and body mass index as predictors for osteoporosis among postmenopausal Latin American women. *Osteoporos Int.* 2002;(suppl 3):S27.
38. **Goemaere S, Zegels B, Toye K, et al.** Limited clinical utility of a self-evaluating risk assessment scale for postmenopausal osteoporosis: lack of predictive value of lifestyle-related factors. *Calcif Tissue Int.* 1999; 65:354-8.
39. **Bohannon AD, Hanlon JT, Landerman R, Gold DT.** Association of race and other potential risk factors with nonvertebral fractures in community-dwelling elderly women. *Am J Epidemiol.* 1999;149:1002-9.
40. **Kung AW, Ho AY, Sedrine WB, Reginster JY, Ross PD.** Comparison of a simple clinical risk index and quantitative bone ultrasound for identifying women at increased risk of osteoporosis. *Osteoporos Int.* 2003; 14:716-21.
41. **Cadarette SM, Jaglal SB, Kreiger N, McIsaac WJ, Darlington GA, Tu JV.** Development and validation of the Osteoporosis Risk Assessment Instrument to facilitate selection of women for bone densitometry. *CMAJ.* 2000;162:1289-94.
42. **Sedrine WB, Chevallier T, Zegels B, et al.** Development and assessment of the Osteoporosis Index of Risk (OSIRIS) to facilitate selection of women for bone densitometry. *Gynecol Endocrinol.* 2002;16:245-50.