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Osteoporosis Knowledge, Self-Efficacy, and Health Beliefs among Chinese Individuals with HIV

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Abstract

Purpose—Individuals with HIV are at increased risk for osteoporosis and fracture. Few studies have systematically explored concerns related to osteoporosis prevention among this group. Applying the Health Beliefs Model (HBM), we examined associations between osteoporosis-related preventive health behaviors (i.e., physical exercise and dietary intake) and knowledge, self-efficacy and health beliefs in a large cohort of Chinese individuals with HIV.

Methods—We conducted a cross-sectional study with participants from an ongoing multi-center trial. Volunteers completed a questionnaire consisting of the International Physical Activity Questionnaire (IPAQ), a calcium and vitamin D intake assessment, the Osteoporosis Knowledge Test, Osteoporosis Self-Efficacy Scale, Osteoporosis Health Beliefs Scale, and relevant sociodemographic and clinical risk factors.

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Preliminary data from this study was previously presented as an abstract at the 2014 European Workshop for Rheumatology Research in Lisbon, Portugal [49].

CONFLICT OF INTEREST: Evelyn Hsieh, Liana Fraenkel, Elizabeth H. Bradley, Weibo Xia, Karl L. Insogna, Qu Cui, Kunli Li, and Taisheng Li state that they have no conflicts of interest.

ETHICAL STANDARDS: This study was reviewed and approved by the institutional review board of PUMCH and the human investigations committee of Yale School of Medicine prior to initiation, and was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Results—A total of 263 of 297 eligible participants enrolled in this study. Mean age of participants was 38.4 ± 9.8 years, average BMI was 21.6 ± 2.6 kg/m², and 76% were men. About 30% of the sample reported low physical activity. Consumption of foods from each calcium and vitamin D-rich category averaged between multiple times per month to weekly. Knowledge regarding osteoporosis was universally low and self-efficacy correlated directly with engagement in preventive behaviors. Women and individuals with lower education perceived greater barriers to adopting preventive behaviors. Multivariate logistic regression adjusted for age, sex and BMI showed that calcium and vitamin D intake was directly correlated with knowledge and self-efficacy, whereas physical activity correlated with manual labor occupation, perceived barriers to exercise and health motivation.

Conclusions—Behavioral frameworks such as the HBM may provide important insight into promoting adoption and maintenance of osteoporosis-related preventive behaviors among individuals with HIV.

Keywords

Prevention; Health Beliefs Model; HIV; China

BACKGROUND

Osteoporosis causes almost 9 million fractures worldwide each year, accounting for considerable costs to health care systems, and contributing to substantial disability and mortality for individuals [1–3]. Patients with human immunodeficiency virus (HIV) are increasingly recognized as a population at high risk for bone loss both due to viral factors as well as the direct deleterious impact of antiretroviral therapy (ART) on bone [4]. Several population-based studies have now demonstrated an increased risk of osteoporosis and fracture in this population ranging from 1.2 to 6.2 times that of people living without HIV [5–7], regardless of sex or age group [8].

Despite an increasing number of studies illuminating the biology underlying bone loss in patients living with HIV, few studies have systematically explored concerns related to osteoporosis prevention in this population. Previous studies, conducted in diverse populations without HIV, have applied the Health Belief Model (HBM) to classify factors associated with health behaviors that mitigate risks of osteoporosis, particularly physical exercise and dietary intake [9]. The key domains of the HBM include *perceived susceptibility to* and *severity of* a particular disease, *perceived benefits* and *barriers* of specific preventive behaviors, and environmental or internal *cues to action* [10]. The concept of *self-efficacy*, defined as “the conviction that one can successfully execute the behavior required to produce the outcomes,” [11] has been incorporated into the model as a critical component of an individual’s ability to maintain long-term change [12]. Several validated scales exist for measuring HBM domains in the context of osteoporosis including the Osteoporosis Knowledge Test (OKT), Osteoporosis Self-Efficacy Scale (OSSES), and Osteoporosis Health Belief Scale (OHBS) [13]. These scales have been utilized in descriptive and intervention studies involving a wide range of populations spanning college-aged students to older women and men in various countries [14–21]. Only a few of these studies have focused on patients with chronic conditions or treatment regimens that place

them at risk for secondary osteoporosis [22–4]. No studies to date have applied the HBM framework to study the role of knowledge, self-efficacy, and health beliefs in osteoporosis-related preventive behaviors among patients with HIV taking ART.

To address this gap, we sought to examine the associations between osteoporosis-related preventive health behavior (i.e., physical exercise and dietary intake) and knowledge, self-efficacy and health beliefs among a large cohort of patients with HIV. We conducted this study in China, an ideal setting for this examination because access to ART has risen exponentially over the past decade [25], coinciding with a rapid growth in fragility fracture rates among the general population attributed to the country's demographic and economic transition [26]. As well, prior studies in the general population in China have consistently found low levels of knowledge regarding osteoporosis and insufficient levels of dietary calcium intake [24,27–9]. Findings from this study may be useful in identifying opportunities for improved primary prevention efforts as part of a strategy to decrease risk of bone loss in this vulnerable population.

METHODOLOGY

Study Design and Sampling

We conducted a cross-sectional study with participants from an ongoing multi-center randomized controlled trial (RCT) carried out in 12 HIV-care centers from eight cities across China: Beijing, Shanghai, Zhengzhou, Fuzhou, Guangzhou, Shenzhen, Xi'an, and Yunnan ([ClinicalTrials.gov](https://clinicaltrials.gov/ct2/show/study/NCT00872417) identifier: NCT00872417). Details of the original RCT have been described previously [30]. In brief, between January and November 2009, a group of 517 treatment-naïve men and women with confirmed HIV infection and CD4⁺ cell count less than 350 cells/mm³ were enrolled and randomized to receive one of three ART regimens to compare the long-term safety and efficacy of these regimens. Demographic and clinical data were collected for all participants at baseline, and follow up clinical and laboratory evaluations were performed at weeks 4, 12, and every 12 weeks thereafter.

All individuals still actively participating in the original RCT as of January 1, 2013 were deemed eligible for inclusion in the present study. Three sites were not able to accommodate the study procedures during the recruitment period and were therefore excluded (Xi'an, Shanghai, and Zhengzhou). A total of 297 participants from the remaining nine sites were eligible and approached for participation. In each site, all patients were invited by the local study coordinator to participate in the study during their routine follow-up visits for the RCT. All willing participants provided written informed consent. This sub-study was reviewed and approved by the ethics committees of Peking Union Medical College Hospital (PUMCH) as well as Yale School of Medicine.

Data collection and measures

We collected data from 1/10/2013 to 7/17/2013 using a self-administered questionnaire, except in cases of patients who were illiterate, to whom the questionnaire was read by a trained, local study coordinator. Whenever possible, previously validated Mandarin-language sources were used as detailed below. To pre-test the instrument, we distributed the

preliminary version of the questionnaire to ten patients living with HIV presenting for routine care at the PUMCH HIV/AIDS Center for Treatment and Diagnosis in August 2012 and used cognitive interviewing methods [31] to assess the instrument for ease of use, clarity of questions, and consistency of answers. In addition, three staff members (nurses and physicians) from the PUMCH HIV clinic reviewed the questionnaire for comprehensibility and scope, after which the questionnaire was refined and finalized.

Outcomes

Physical Activity: We used the short-format version (seven items) of the International Physical Activity Questionnaire (IPAQ), a tool originally developed for obtaining internationally comparable estimates of physical activity [32]. It has been validated in multiple languages, including Mandarin [33], and asks participants to recall the amount of time spent in the past seven days on vigorous-intensity activity, moderate-intensity activity, walking, and sitting. Answers for each activity category are weighted to calculate a total weekly metabolic equivalent of tasks (MET) score in minutes to determine the total energy cost of the participants' activities in the past week. Based on the IPAQ recommended cut-off values, [34] each participant's scores are further categorized into low, moderate, and high levels of physical activity.

Dietary Intake: Participants were presented with six food categories, adapted from a food frequency questionnaire developed by the Chinese Center for Disease Control Nutrition Department: dairy products, soy products, leafy green vegetables, nuts, seafood, and vitamin D rich products. Example food items were provided for each category. Using a Likert-type scale, patients were asked to indicate the frequency with which they consume foods from each category (1=never in past year, 2=once a year, 3=few times a year, 4=once a month, 5=few times a month, 6=once a week, 7=few times a week, 9=few times a day, 9=once a day). A Total Intake Score was calculated for each participant by summing the responses for all six categories (range: 6–54).

Independent Variables

Knowledge: To measure knowledge, we utilized the validated Mandarin-language Osteoporosis Knowledge Test (OKT) [27] which was translated and culturally adapted from the original OKT [13]. The first 11 questions presented participants with a list of characteristics and asked whether the items are more or less likely to affect a person's chance of getting osteoporosis. The next seven questions explore knowledge regarding the relationship between exercise and osteoporosis. The last eight questions test knowledge regarding the relationship between calcium intake and osteoporosis. The number of correct responses to the first 11 questions summed with the number of correct responses to the seven exercise-related questions yields the Exercise Score (range: 0–18). The number of correct responses to the first 11 questions added to the number of correct responses to the 8 calcium-related questions yields the Calcium Score (range: 0–19). The sum of correct responses to all three sections of the test produces the Total Score (range: 0–26). Cronbach's alpha coefficients for the three scales ranged from 0.83 to 0.87 [27]. In our study, participants were considered to have *low knowledge* if Exercise Score < 9, Calcium Score

<9.5, and Total Score <13, and considered to have *high knowledge* if Exercise Score ≥ 9, Calcium Score ≥ 9.5, and Total Score ≥ 13.

Self-Efficacy: We used the 12-item scale Osteoporosis Self-Efficacy Scale (OSES) to measure confidence for adopting behavior change regarding calcium intake (6 items) and exercise (6 items). The English-language version [35] was translated into Mandarin and validated by Chen and Liu [36]. Participants are asked, “If it were recommended that you do any of the following THIS WEEK, how confident or certain would you be that you could:” and then presented with a list of examples such as: “Do exercises even if they are difficult” and “Obtain foods that give an adequate amount of calcium even when they are not readily available.” Participants then respond on a 10-point Likert-type scale of 0 to 10 (0=not confident at all, 10=very confident). For each participant, an Exercise Score is calculated by averaging the responses to the 6 exercise-related items and multiplying by 10, and a Calcium Score is derived by averaging the responses to the 6 calcium-related items and multiplying by 10 (range: 0–100). Cronbach’s alpha coefficients ranged from 0.90 to 0.94 [36]. In our study, we grouped self-efficacy scores into the following categories: *low* (Score of 0–25), *moderately low* (Score of 26–50), *moderately high* (Score of 51–75) and *high* (Score of 76–100).

Health Beliefs: We used the Osteoporosis Health Beliefs Scale (OHBS), which was originally developed by Kim, *et al* [37], and has been translated into Mandarin, adapted, and validated by Chen, *et al.* in a Chinese population [38]. The scale includes 42 items divided into seven domains: perceived susceptibility to osteoporosis, perceived seriousness of osteoporosis, perceived benefits of exercise and calcium intake, perceived barriers to exercise and calcium intake, and health motivation. Each question is graded on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The responses to questions within each domain are summed to yield a score for that domain ranging from 6 to 30. Cronbach’s alpha coefficients ranged from 0.68 to 0.85 [38]. For each health beliefs domain, we categorized participants’ scores into the following categories: *low* (score of 6–11), *moderately low* (score of 12–16), *neutral* (score of 17–19), *moderately high* (score of 20–24) and *high* (score of 25–30).

Sociodemographic and Clinical Characteristics: Background information was collected regarding: personal characteristics including age, sex, ethnicity (Han vs. Chinese ethnic minority), education level (less than high school vs. high school and beyond), occupation (manual labor: farmer or laborer vs. non-manual labor: civil servant, self-employed, service profession, unemployed, student, other); HIV-related factors such as baseline viral load, CD4⁺ cell count, route of infection (sexual, blood-borne vs. other), time since diagnosis; and fracture-associated risk factors, including BMI, smoking history (ever vs. never), current alcohol use (yes or no), history of a fall within the last year (yes or no), parental history of fracture (yes, no, or don’t know), personal history of prior fracture (yes or no), prior bone density test (yes or no) and current calcium or vitamin D supplement use (yes or no).

Data Analysis

We described the sample characteristics and outcomes using standard frequency analyses and examined differences between men and women in these factors using t-tests, Wilcoxon Rank Sum, and χ^2 tests, as appropriate. We also described the prevalence of our measures of knowledge, self-efficacy, and health beliefs for the entire sample, and evaluated differences sex, age group (20–39 vs. 40 years), BMI (underweight, normal, or overweight/obese), education level (less than high school vs. high school or beyond), and baseline CD4⁺ cell count (<200 vs. 200 cells/mm³) using t-tests and one-way analysis of variance.

We estimated both unadjusted and adjusted logistic regression models to examine the associations between each of our independent variables (measures of knowledge, self-efficacy, health beliefs, and sociodemographic and clinical characteristics) and each of the two outcomes (Physical Activity and Dietary Intake). Because we were interested in factors associated with the lowest engagement in preventive behaviors, we dichotomized Physical Activity into *low activity* (participants in low IPAQ Category) versus *high activity* (participants in moderate and high IPAQ Categories), and Dietary Intake into *low intake* (lowest tertile of Total Intake Score) and *high intake* (upper two tertiles of Total Intake Score).

Before estimating the multivariable model, we assessed for possible multicollinearity of the independent variables. Variables with a very high correlation coefficient ($r > 0.40$) were deemed collinear. Based on these tests, we excluded perceived benefits of exercise from the candidate independent variables for Physical Activity in order to retain knowledge regarding exercise and health motivation. We similarly excluded perceived benefits of dietary calcium intake and health motivation from the candidate independent variables for dietary intake in order to retain knowledge and self-efficacy regarding dietary calcium intake, respectively. With the remaining variables, we fit the multivariable model using backward regression [39] beginning with all variables that were hypothesized to be related to preventive behaviors and/or that were significant (p -value < 0.10) in the unadjusted analyses. To attain a parsimonious model, we removed non-significant variables one at a time beginning with the least significant; in each step, remaining parameter estimates remained largely unchanged ($< 20\%$). We retained age, sex, and BMI in all models regardless of their significance. Results were reported as unadjusted and adjusted odds ratios with 95% confidence intervals. For the knowledge, self-efficacy, and health beliefs scales, the odds ratios were calculated based a one unit change within the respective scale. All statistical analyses were performed using Stata Intercooled 13 (StataCorp, College Station, TX).

RESULTS

Characteristics of Sample

A total of 263 out of 297 (88.6%) potentially eligible participants enrolled in this study. Our sample did not differ significantly from the original RCT cohort in terms of baseline variables such as age, education level, and gender distribution. The participants had a mean age of 38.4 ± 9.8 years, average BMI of 21.6 ± 2.6 kg/m², and 76% were men (Table 1). Men were more highly educated ($p < 0.001$), had lower median CD4⁺ cell counts at the time of

HIV diagnosis ($p=0.016$) and were more likely to report ever smoking ($p<0.001$) and current alcohol use ($p=0.022$). Only 14 patients (5.4%) from 3 sites reported ever having a bone density test. About 30% of the sample reported low physical activity, and this did not vary significantly by sex. The mean scores for dietary intake indicate consumption from each of the food categories ranged between multiple times per month to weekly, depending on the category. Only consumption of leafy green vegetables differed significantly by sex, with women consuming more of this food than men.

Knowledge, Self-Efficacy and Health Beliefs

Average total knowledge score was low (9.4 ± 4.7 out of 26) for our cohort (Table 2), and lower education was associated with lower knowledge scores for all items. Overall self-efficacy scores were moderately high with significantly higher self-efficacy scores for calcium intake than physical activity (72.1 ± 23.6 v. 62.1 ± 26.6 , $p<0.001$), a difference that was seen across all subgroups of age, sex, BMI, education level, and baseline CD4⁺ count. Regarding the seven OHBS domains, we found moderately low perception of susceptibility (16.0 ± 4.2), barriers to exercise (16.2 ± 4.1) and barriers to dietary calcium intake (16.3 ± 3.8). Participants felt neutral regarding the seriousness of osteoporosis (18.5 ± 4.0), and reported moderately high perceived benefits to exercise (22.5 ± 4.1) and calcium intake (21.8 ± 3.6), and health motivation (22.7 ± 3.6). Women perceived slightly greater barriers to exercise and calcium intake compared with men and individuals with lower education levels perceived fewer benefits to exercise, and greater barriers to exercise and calcium intake (Table 2).

Associations between Physical Activity and Knowledge, Self-Efficacy and Health Beliefs

In the unadjusted analysis, higher levels of physical activity were significantly associated with greater self-efficacy related to exercise ($p=0.002$), greater perceived benefits of exercise ($p=0.012$), lower perceived barriers to exercise ($p=0.011$), greater health motivation ($p=0.002$), lower education ($p=0.024$), and higher likelihood of manual labor versus non-manual labor occupation ($p=0.002$; Table 3). In the multivariable model, higher levels of physical activity remained significantly associated with fewer perceived barriers to exercise ($p=0.010$), greater health motivation ($p=0.001$), and increased likelihood of manual labor versus non-manual labor occupation ($p=0.028$).

Associations between Dietary Intake and Knowledge, Self-Efficacy and Health Beliefs

In unadjusted analysis, higher levels of dietary intake were significantly associated with greater knowledge ($p<0.001$) and self-efficacy ($p<0.001$) regarding calcium intake, lower perceived seriousness of osteoporosis ($p=0.024$), greater perceived benefits ($p=0.005$) and lower perceived barriers to calcium intake ($p<0.001$), greater health motivation ($p=0.003$), and use of calcium or vitamin D supplements ($p=0.037$; Table 3). In the multivariate model, higher levels of dietary intake remained significantly associated with greater knowledge ($p=0.001$) and self-efficacy ($p=0.001$) regarding calcium intake, as well as lower perceived seriousness of osteoporosis ($p=0.027$).

DISCUSSION

In this study of Chinese patients with HIV, participants demonstrated universally low levels of knowledge regarding osteoporosis and the role of physical activity and dietary calcium intake in preventing osteoporosis. We found that higher levels of self-efficacy correlated with higher levels of engagement in preventive behaviors, and that individuals with lower levels of education perceived greater barriers to adopting preventive behaviors. To our knowledge, this is the first study to explore the relationships between behavioral factors related to osteoporosis and key modifiable preventive health behaviors in patients with HIV.

Our findings are consistent with prior studies from China and Hong Kong demonstrating low levels of knowledge regarding osteoporosis among Chinese men and women across different age groups [15,19,20,24,27,40]. As in previous studies, knowledge scores in our cohort were directly correlated with education levels [27,41], however even among participants with higher education levels in our cohort, mean knowledge scores were still lower than that reported among most studies from the U.S., Canada and New Zealand that were conducted primarily among Caucasian cohorts [14,16–19,42]. It is not clear whether this lack of knowledge is related to low prioritization of osteoporosis among other health conditions in China, or inaccurate or ineffective dissemination of information regarding osteoporosis-related risk factors and preventive measures.

Although knowledge can inform behaviors, extensive work surrounding the concept of self-efficacy has demonstrated that expectations regarding one's own competence to perform a given behavior play a pivotal role in the actual adoption and/or maintenance of that behavior [43]. The moderately high self-efficacy scores reported by our participants paralleled levels found among other populations within China and in other countries [24,16,36,44]. In addition, other studies have also found somewhat higher self-efficacy scores related to dietary calcium intake than exercise [13,36,44], perhaps reflecting a greater degree of confidence regarding changing dietary habits compared with exercise behaviors. Wallace *et al.*, examined self-efficacy and health beliefs among college-age women and found clear correlations between higher self-efficacy scores and higher levels of both physical activity and calcium intake [45]. In terms of interventions however, the few studies that have measured change in self-efficacy before and after osteoporosis educational programs have shown that interventions solely aimed at increasing knowledge do not show improvement in self-efficacy scores [46]. Rather, targeted and interactive content focusing on empowering patients to change behavior has yielded better results [24,47]. Because individuals least engaged in preventive behaviors also appear to be those with lowest self-efficacy, the importance of attention to increasing confidence and competence surrounding these behaviors cannot be overlooked.

In addition to evaluating knowledge and self-efficacy, understanding the osteoporosis-related health beliefs of an individual can help guide development of more effective interventions by indicating how primed an individual is for change (susceptibility, seriousness, and health motivation), and what paths to change may be most feasible (perceived benefits and barriers to behavior) [48]. Studies have shown that bone loss in the setting of HIV is multifactorial, including factors related to HIV viral infection itself,

increased prevalence of traditional risk factors for osteoporosis (e.g. tobacco use, sedentary lifestyle, poor nutrition leading to low weight, low vitamin D, and hypogonadism), as well as ART-related factors [4]. However, not only do patients with HIV lack awareness of their increased susceptibility to osteoporosis, but they are faced with prioritizing preventive health concerns relative to the stability of their primary condition.

Similar to other individuals who are at risk for secondary osteoporosis, individuals living with HIV tend to differ demographically from those targeted by traditional health campaigns regarding osteoporosis, which largely focus on post-menopausal women. Therefore the preventive messages conveyed through these channels are unlikely to reach patients living with HIV. Instead, tailored programs need to be developed that take into account the younger age range, lifestyle differences, and other quality of life concerns of this population. Interestingly, in our study, low dietary calcium intake was associated with higher perceived seriousness of osteoporosis, which on the surface appears contradictory. However, low dietary calcium intake was also associated with lower knowledge and self-efficacy scores regarding dietary calcium intake, highlighting a fundamental lack of knowledge and empowerment among this subgroup regarding dietary methods for mitigating osteoporosis risk. As a result, these individuals may actually perceive osteoporosis as more serious relative to individuals who are more knowledgeable and feel more empowered in this regard. Our findings therefore suggest that interventions aimed at improving dietary intake behaviors among patients with HIV would benefit from components focused on improving knowledge and self-efficacy. Finally, our data suggest that exercise related interventions should focus on identifying patients who work in more sedentary professions or have low health motivation, as well as assessing perceived barriers to exercise among this group and providing mechanisms to enable patients to overcome those barriers.

Our study has some important limitations. First, our specific findings are not generalizable to individuals living with HIV outside of China due to the cultural nuances and environmental factors that influence the results. However, all studies hoping to inform behavioral interventions require direct input from the specific target population. Therefore our overarching goal was not to suggest our findings would translate to all populations with HIV, but rather to demonstrate the richness, relevance, and utility of employing a behavioral approach to osteoporosis prevention for populations with HIV utilizing a well-established theoretical model and validated tools. Second, our cohort included only patients who have been participating in a randomized clinical trial since 2009. Therefore, their perceptions and health behaviors are not representative of all Chinese individuals with HIV. However we feel that this cohort is clinically relevant to the objectives of this study because of the increased risk for bone disease associated with continuous ART. In addition, patients who have established care providers and well controlled HIV are in a position to maximally engage in preventive health interventions and therefore understanding how to best tailor such an intervention to this population is a critical first step in addressing osteoporosis and fracture risk. Finally, lack of uniform access to dual-energy x-ray absorptiometry machines limited our ability to measure bone density as an outcome in this study, and we did not have a large enough sample to measure rates of fracture. However, because physical activity and dietary calcium and vitamin D intake are low-cost and modifiable behaviors that form the

cornerstone of prevention efforts for osteoporosis, they are highly important outcomes to examine in the context of resource-limited settings.

In summary, as the number of individuals with HIV on ART continues to increase worldwide, refining the approach to primary prevention of osteoporosis in this population is increasingly important. Behavioral frameworks such as the HBM can provide important insight into how to promote adoption and maintenance of osteoporosis-related preventive behaviors among individuals with HIV. Applying these concepts in a population of Chinese individuals with HIV at high risk for bone loss, we identified key relationships between knowledge, self-efficacy and health beliefs pertaining to physical activity and dietary calcium intake, two key modifiable preventive measures for osteoporosis. Targeted educational efforts are needed to increase knowledge specific to the effects of HIV on bone and prevention measures, coupled with strategies to increase self-efficacy for adopting preventive behaviors. Methods to identify patients who may have more challenges adopting behavioral interventions (e.g. sedentary occupation, low dietary calcium intake, high perceived barriers) should be incorporated. Finally, further research is needed to elucidate the specific nature of the barriers to osteoporosis preventive measures perceived by patients with HIV, competing primary care concerns for patients and providers, gaps between patient and provider perceptions regarding osteoporosis knowledge and health behavior, and ultimately, feasibility and efficacy of targeted behavioral interventions.

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REFERENCES

1. Cooper C, Campion G, Melton LJ III. Hip fractures in the elderly: a worldwide projection. *Osteoporos Int.* 1992; 2:285–289. [PubMed: 1421796]
2. Lippuner K, von Overbeck J, Perrelet R, et al. Incidence and direct medical costs of hospitalizations due to osteoporotic fractures in Switzerland. *Osteoporos Int.* 1997; 7(5):414–425. [PubMed: 9425498]
3. Osteoporosis prevention, diagnosis, and therapy. NIH Consensus Statement. 2000; 17(1):1–36.

4. McComsey GA, Tebas P, Shane E, et al. Bone Disease in HIV Infection: A practical review and recommendations for HIV care providers. *Clin Infect Dis*. 2010; 51:937–946. [PubMed: 20839968]
5. Guerri-Fernandez R, Vestergaard P, Carbonell C, et al. HIV infection is strongly associated with hip fracture risk, independently of age, gender and comorbidities: a population-based cohort study. *J Bone Miner Res*. 2013; 28:1259–1263. [PubMed: 23362011]
6. Hansen AB, Gerstoft J, Kronborg F, et al. Incidence of low and high-energy fractures in persons with and without HIV infection: a Danish population-based cohort study. *AIDS*. 2012; 26:285–293. [PubMed: 22095195]
7. Womack JA, Goulet JL, Gibert C, et al. Increased risk of fragility fractures among HIV infected compared to uninfected male veterans. *PLoS One*. 2011
8. Triant VA, Brown TT, Lee H, Grinspoon SK. Fracture prevalence among human immunodeficiency virus (HIV)-infected versus non-HIV-infected patients in a large U.S. healthcare system. *J Clin Endocrinol Metab*. 2008; 93:3499–3504. [PubMed: 18593764]
9. McLeod KM, Johnson CS. A systematic review of osteoporosis health beliefs in adult men and women. *J Osteoporos*. 2011; 2011:197454. [PubMed: 21941678]
10. Glanz, K.; Rimer, BK.; Viswanath, V., editors. *Health Behavior and Health Education: Theory, Research, and Practice*. Fourth Edition. San Francisco: Jossey-Bass, Inc.; 2008.
11. Bandura A. Self-Efficacy: Toward a unifying theory of behavioral change. *Psychological Review*. 1977; 84:194–215.
12. Rosenstock IM, Strecher VJ, Becker MH. Social learning theory and the health belief model. *Health Education Quarterly*. 1988; 15(2):175–183. [PubMed: 3378902]
13. Kim, KK.; Horan, ML.; Gendler, P. *Osteoporosis Knowledge Test, Osteoporosis Health Belief Scale, and Osteoporosis Self-Efficacy Scale*. Allendale, MI: 1991.
14. Johnson CS, McLeod W, Kennedy L, McLeod K. Osteoporosis health beliefs among younger and older men and women. *Health Education and Behavior*. 2008; 35(5):721–733. [PubMed: 17602100]
15. Tan S, Ji L, Tsai J, et al. Greater osteoporosis educational outreach is desirable among Chinese immigrants in Chinatown, Chicago. *Osteoporosis International*. 2009; 20:1517–1522. [PubMed: 19148565]
16. Gammage KL, Klentrou P. Predicting osteoporosis prevention behaviors: health beliefs and knowledge. *Am J Health Behav*. 2011; 35(3):371–382. [PubMed: 21683025]
17. Doheny MO, Sedlak CA, Estok PJ, Zeller RA. Bone density, health beliefs, and osteoporosis preventing behaviors in men. *Orthop Nurs*. 2011; 30(4):266–272. [PubMed: 21799384]
18. Endicott RD. Knowledge, health beliefs, and self-efficacy regarding osteoporosis in perimenopausal women. *Journal of Osteoporosis*. 2013
19. Ford MA, Bass M, Zhao Y, Bai JB, Zhao Y. Osteoporosis knowledge, self-efficacy, and beliefs among college students in the USA and China. *Journal of Osteoporosis*. 2011
20. Zhang YP, Li XM, Wang DL, Guo XY, Guo X. Evaluation of educational program on osteoporosis awareness and prevention among nurse students in China. *Nursing and Health Sciences*. 2012; 14:74–80. [PubMed: 22303915]
21. Sayed-Hassan R, Bashour H, Koudsi A. Osteoporosis knowledge and attitudes: a cross-sectional study among female nursing school students in Damascus. *Arch Osteoporos*. 2013; 8:149. [PubMed: 23999904]
22. Nadler M, Alibhi S, Catton P, Catton C, To MJ, Jones JM. Osteoporosis knowledge, health beliefs, and healthy bone behaviours in patients on androgen-deprivation therapy (ADT) for prostate cancer. *BJU Journal*. 2013; 111:1301–1309.
23. Elliott JO, Jacobson MP, Seals BF. Self-efficacy, knowledge, health beliefs, quality of life, and stigma in relation to osteoprotective behaviors in epilepsy. *Epilepsy and Behavior*. 2006; 9:478–491. [PubMed: 16935031]
24. Ha M, Hu J, Petrini MA, McCoy TP. The effects of an educational self-efficacy intervention on osteoporosis prevention and diabetes self-management among adults with type 2 diabetes mellitus. *Biol Res Nurs*. 2014; 16:357. [PubMed: 24413898]
25. UNAIDS. AIDS by the numbers. 2013 http://www.unaids.org/en/media/unaids/contentassets/documents/unaidspublication/2013/JC2571_AIDS_by_the_numbers_en.pdf.

26. International Osteoporosis Foundation. The Asian Audit: Epidemiology, costs and burden of osteoporosis in Asia. 2009 http://www.iofbonehealth.org/sites/default/files/PDFs/Audit%20Asia/Asian_regional_audit_2009.pdf.
27. Chen YP, Liu XQ, Cai DH. Reliability and validity of the osteoporosis knowledge tests. *Chin J Osteoporos*. 2005; 11(3):339–341.
28. He YN, Zhai FY, Wang ZH, Hu YS, Yu WT, Yang XG. Status of dietary calcium intake of Chinese residents. *J Hyg Res*. 2007 Sep; 36(5):600–602.
29. Chan R, Leung J, Woo J. A Prospective Cohort Study Examining the Associations of Dietary Calcium Intake with All-Cause and Cardiovascular Mortality in Older Chinese Community-Dwelling People. *PLoS ONE*. 2013; 8(11):e80895. [PubMed: 24224062]
30. Kou H, Du X, Li Y, et al. Comparison of Nevirapine Plasma Concentrations between Lead-In and Steady-State Periods in Chinese HIV-Infected Patients. *PLoS ONE*. 2013
31. Willis G. Reducing survey error through research on the cognitive and decision processes in surveys. Meeting of the American Statistical Association. 1999
32. Craig CL, Marshall AL, Sjoström M, et al. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc*. 2003; 35(8):1381–1395. [PubMed: 12900694]
33. MacFarlane DJ, Lee CCY, Ho EYK, et al. Reliability and validity of the Chinese version of IPAQ (short, last 7 days). *J of Sci and Med in Sport*. 2007; 10:45–51. [PubMed: 16807105]
34. International Physical Activity Questionnaire. Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire. 2005 <http://www.ipaq.ki.se/scoring.pdf>.
35. Horan ML, Kim K, Gendler P, Froman RD, Patel MD. Development and evaluation of osteoporosis self-efficacy scale. *Research in Nursing and Health*. 2001; 21(5):395–403. [PubMed: 9761137]
36. Chen YP, Liu XQ. Reliability and validity of the osteoporosis self-efficacy scale. *Nurs J Chin PLA*. 2005; 22(8):38–39.
37. Kim KK, Horan ML, Gendler P, Patel MK. Development and evaluation of the Osteoporosis Health Belief Scale. *Research Nurs Health*. 1991; 14(2):155–163.
38. Chen YP, Liu XQ, Cai DH. Evaluation of the reliability and validity of the osteoporosis health belief scale. *Chinese Journal of Clinical Rehabilitation*. 2005; 9(3):196–197.
39. Sauerbrei W, Royston P, Binder H. Selection of important variables and determination of functional form for continuous predictors in multivariable model building. *Statist. Med*. 2007; 26:5512–5528.
40. Lee LYK, Lai EKF. Osteoporosis in older Chinese men: knowledge and health beliefs. *Journal of Clinical Nursing*. 2006; 15:353–355. [PubMed: 16466485]
41. Werner P. Knowledge about osteoporosis: assessment, correlates and outcomes. *Osteoporosis International*. 2005; 16:115–127. [PubMed: 15517187]
42. Von Hurst PR, Wham CA. Attitudes and knowledge about osteoporosis risk prevention: a survey of New Zealand women. *Public Health Nutrition*. 2007; 10(7):747–753. [PubMed: 17381949]
43. Bandura, A. Self-efficacy: The exercise of control. New York: W.H. Freeman; 1997.
44. Swaim RA, Barner JC, Brown CM. The relationship of calcium intake and exercise to osteoporosis health beliefs in postmenopausal women. *Res Soc Admin Pharm*. 2008; 4:153–163.
45. Wallace LS. Osteoporosis prevention in college women: application of the expanded health belief model. *Am J Health Behavi*. 2002; 6(3):163–172.
46. Tung WC, Lee IFK. Effects of an osteoporosis educational programme for men. *Journal of Advanced Nursing*. 2006; 56(1):26–34. [PubMed: 16972915]
47. Qi BB, Resnick B, Smeltzer SC, Bausell B. Self efficacy program to prevent osteoporosis among Chinese immigrants. *Nurs Res*. 2011; 60(6):393–404. [PubMed: 22048557]
48. Janz NK, Becker MH. The Health Belief Model: A decade later. *Health Education Quarterly*. 1984; 11(1):1–47. [PubMed: 6392204]
49. Hsieh E, Fraenkel L, Bradley E, et al. Osteoporosis knowledge, self-efficacy, and health beliefs among Chinese men and women with HIV. *Ann Rheum Dis*. 2014; 73(Suppl 1):A62–A63.

Table 1

Sociodemographics, Clinical Characteristics and Outcomes, Entire Cohort and Stratified by Sex

Variable	Entire Cohort	Sex	
		Men	Women
Sociodemographic and Clinical Characteristics			
Age <i>mean</i> ± <i>SD</i>	38.4±9.8	38.2±10.1	39.3±9.1
Body mass index <i>mean</i> ± <i>SD</i>	21.6±2.6	21.7±2.5	21.4±2.8
Han ethnicity <i>n</i> / <i>N</i> (%)	247/263 (93.9)	187/200 (93.5)	60/63 (95.2)
Manual labor occupation <i>n</i> / <i>N</i> (%)	70 (26.6)	49 (24.5)	21 (33.3)
High school education or beyond <i>n</i> / <i>N</i> (%)	153 (58.2)	138 (69.0)	15 (23.8)[‡]
Months since HIV diagnosis <i>median</i> (<i>IQR</i>)	47 (45–54)	47 (44–53)	48 (45–57)
Baseline CD4 ⁺ cell count <i>median</i> <i>cells/mm</i> ³	190 (106–259)	180 (96–252)	219 (138–286)[*]
Baseline HIV viral load <i>median</i> <i>copies/mL</i>	39732 (11870–113877)	43692 (15466–131733)	18594 (6725–74526)[‡]
Route of transmission <i>n</i> / <i>N</i> (%)			
Sexual	236/263 (89.7)	178 (89.0)	58 (92.1)
Blood–borne	6/263 (2.3)	4 (2.0)	2 (3.2)
Other	1/263 (0.4)	1 (0.5)	0 (0.0)
Not certain	20/263 (7.6)	17 (8.5)	3 (4.8)
Smoking, ever <i>n</i> / <i>N</i> (%)	98/247 (39.7)	93/190 (49.0)	5/57 (8.8)[‡]
Current alcohol use <i>n</i> / <i>N</i> (%)	59/251 (23.5)	52/194 (26.8)	7/57 (12.3)[*]
Fall within past year <i>n</i> / <i>N</i> (%)	18/262 (6.9)	7/199 (3.5)	11/63 (17.5)[*]
Parental history of fracture <i>n</i> / <i>N</i> (%)			
Yes	5/258 (1.9)	5/198 (2.5)	0/60 (0.0)
No	188/258 (72.9)	144/198 (72.7)	44/60 (73.3)
Don't know	65/258 (25.2)	49/198 (24.8)	16/60 (26.7)
History of prior fracture <i>n</i> / <i>N</i> (%)	28/263 (10.7)	23/200 (11.5)	5/63 (7.9)
Prior bone density test <i>n</i> / <i>N</i> (%)	14/258 (5.4)	12/198 (6.1)	2/58 (3.3)
Calcium or vitamin D supplement use <i>n</i> / <i>N</i> (%)	39/245 (8.6)	28/187 (7.5)	11/60 (12.1)
Physical Activity			
	N=226	N=170	N=56
Low <i>n</i> (%)	67 (29.7)	51 (30.0)	16 (28.6)
Moderate <i>n</i> (%)	96 (42.5)	71 (41.8)	25 (44.6)
High <i>n</i> (%)	63 (27.9)	48 (28.2)	15 (26.8)
Dietary Intake			
	N=257	N=195	N=62
Individual Food Category Scores ^a			
Dairy Products <i>mean</i> ± <i>SD</i>	5.5±2.0	5.5±1.9	5.5±2.2
Soy Products <i>mean</i> ± <i>SD</i>	5.9±1.5	5.8±1.4	6.2±1.7
Leafy Green Vegetables <i>mean</i> ± <i>SD</i>	6.8±1.6	6.7±1.6	7.1±1.5[*]
Nuts <i>mean</i> ± <i>SD</i>	5.1±1.8	5.1±1.6	5.1±2.2

Variable	Entire Cohort	Sex	
		Men	Women
Seafood <i>mean±SD</i>	5.1±1.6	5.1±1.5	5.0±1.9
Vitamin D Rich Products <i>mean±SD</i>	6.0±1.6	5.9±1.5	6.3±1.6
Total Intake Score <i>mean±SD</i> ^b	34.4±7.1	34.1±6.7	35.3±8.0

^a Individual Food Category Scores were reported by each participant on a scale of 1 to 9 (1=never; 2=once per year; 3= multiple times per year; 4=once per month; 5= multiple times per month; 6=once per week; 7= multiple times per week; 8=once per day; 9=multiple times per day).

^b Total Food Score represents the sum of all individual food category scores for each participant (score range: 6–54).

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p 0.05;

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p 0.01;

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p 0.001

Table 2
Knowledge, Self-Efficacy, and Health Beliefs, Entire Cohort and Stratified by Education Level

Scale	Entire Cohort		Education < High School		High School	
	N	Mean±SD	N	Mean±SD	N	Mean±SD
Knowledge^a						
Exercise	223	6.1±3.5	93	5.4±3.6	130	6.7±3.3 [‡]
Calcium	225	6.6±3.3	94	5.8±3.4	131	7.1±3.2 [‡]
Total	217	9.4±4.7	92	8.2±4.7	125	10.3±4.4 [‡]
Self-Efficacy^b						
Exercise	255	62.1±26.6	107	60.9±28.8	148	62.9±25.0
Calcium	255	72.1±23.6	107	70.5±25.1	148	73.2±22.4
Health Beliefs^c						
Susceptibility	257	16.0±4.2	109	15.8±4.1	148	16.1±4.3
Seriousness	254	18.5±4.0	102	18.3±3.9	152	18.6±4.1
Benefits Exercise	260	22.5±4.1	107	21.9±4.4	153	22.9±3.8 [*]
Benefits Calcium	254	21.8±3.6	105	21.3±3.8	149	22.1±3.3
Barriers Exercise ^d	257	16.2±4.1	106	17.1±3.5	151	15.5±4.4 [‡]
Barriers Calcium ^d	257	16.3±3.8	107	17.2±3.5	150	15.7±3.9 [‡]
Health Motivation	259	22.7±3.6	108	22.3±3.4	151	22.9±3.8

^a Osteoporosis Knowledge Test ranges: Exercise Score: 0 (lowest) to 18 (highest); Calcium Score: 0 (lowest) to 26 (highest)

^b Osteoporosis Self-Efficacy Scale range: 0 (not at all confident) to 100 (very confident)

^c Osteoporosis Health Beliefs Scale range: 6 (strongly disagree) to 30 (strongly agree)

^d Women reported higher scores compared to men for perceived barriers to exercise (15.8±4.2 vs. 17.4±3.8, p=0.010) and perceived barriers to calcium intake (16.0±3.8 vs. 17.3±3.7, p=0.014).

^{*} p 0.05;

[‡] p 0.01;

1000 d
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Table 3
Unadjusted and Adjusted Logistic Regression Models for Physical Activity and Dietary Intake

Independent Variables	Physical Activity				Dietary Intake			
	Unadjusted		Adjusted		Unadjusted		Adjusted	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Knowledge								
Exercise	1.07	0.98 to 1.17	--	--	--	--	--	--
Calcium	--	--	--	--	1.21	1.10 to 1.33[‡]	1.20	1.08 to 1.32[‡]
Self-Efficacy								
Exercise	1.02	1.01 to 1.03[‡]	--	--	--	--	--	--
Calcium	--	--	--	--	1.03	1.01 to 1.04[‡]	1.02	1.01 to 1.04[‡]
Health Beliefs								
Perceived Susceptibility	0.99	0.93 to 1.06	--	--	0.98	0.92 to 1.04	--	--
Perceived Seriousness	0.98	0.91 to 1.05	--	--	0.92	0.86 to 0.99[*]	0.90	0.83 to 0.99[*]
Perceived Benefits of Exercise	1.09	1.02 to 1.17[*]	--	--	--	--	--	--
Perceived Benefits of Calcium	--	--	--	--	1.12	1.03 to 1.21[‡]	--	--
Perceived Barriers to Exercise	0.91	0.84 to 0.98[*]	0.90	0.83 to 0.97[‡]	--	--	--	--
Perceived Barriers to Calcium	--	--	--	--	0.88	0.81 to 0.94[‡]	--	--
Health Motivation	1.15	1.05 to 1.25[‡]	1.49	1.07 to 1.28[‡]	1.12	1.04 to 1.21[‡]	--	--
Sociodemographic and Clinical Characteristics								
Age	1.02	0.99 to 1.05	1.03	0.997 to 1.07	0.99	0.97 to 1.03	1.01	0.98 to 1.05
Sex	1.07	0.55 to 2.09	0.85	0.38 to 1.91	1.61	0.85 to 3.05	1.73	0.80 to 3.75
BMI	0.98	0.88 to 1.09	0.93	0.82 to 1.06	1.00	0.91 to 1.11	1.01	0.89 to 1.16
High school education or beyond	0.50	0.27 to 0.91[*]	0.51	0.24 to 1.10	0.99	0.59 to 1.67	--	--
Manual labor occupation	2.02	1.01 to 4.03[*]	2.40	1.10 to 5.24[*]	--	--	--	--

Independent Variables	Physical Activity				Dietary Intake			
	Unadjusted		Adjusted		Unadjusted		Adjusted	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Smoking (ever)	1.49	0.81 to 2.77	--	--	1.15	0.67 to 1.98	--	--
Alcohol use (current)	1.56	0.75 to 3.21	--	--	1.42	0.74 to 2.72	--	--
Baseline CD4 ⁺ count	1.00	0.998 to 1.00	--	--	1.00	0.998 to 3.14	--	--
Months since HIV diagnosis	1.01	0.985 to 1.03	--	--	1.01	0.99 to 1.03	--	--
Calcium or vitamin D supplement use	--	--	--	--	2.52	1.06 to 5.99*	--	--

OKT = osteoporosis knowledge test; OSES = osteoporosis self-efficacy scale; BMI = body mass index; HIV = human immunodeficiency virus

* p 0.05;
p 0.01;
¥ p 0.001