SES is a determinant of osteoporosis
How much do we know

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Abstract　Osteoporosis is becoming an increasing public health challenge as our population ages. Socioeconomic status　SES　is a major determinant of public health. Here　we conducted a literature review to investigate the influence of SES on osteoporosis. The result revealed that people with lower SES generally had higher incidence of osteoporosis and were less likely to obtain good care for the disease. While studies demonstrated a clear association between SES and osteoporosis prevalence　prevention　and treatment　the scope and depth of the research were limited. Future studies beyond education and income　the two convenient paradigms of SES　are necessary to expand our knowledge on this issue.

Key words　Osteoporosis　Socioeconomic status

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Introduction

Osteoporosis is a progressive bone disease characterized by low bone mass　structural deterioration and possible fractures later in life. Ten million Americans have osteoporosis and 34 million more with low bone mass are potential patients　68% of whom are women[1]. Worldwide　approximately 200 million people suffer from this disease[2]. Although osteoporosis can strike at any age　men over 50 and women after menopause are especially at high risk. Osteoporosis costs Americans approximately 14 billion dollars each year and an enormous social burden[1]. It is becoming an increasingly important public health challenge as the population ages.

Clinicians and public health professionals have been making great efforts and progress on understanding preventing and treating this disease. Researchers have identified the major risk factors such as age　gender bone size　sex hormones　calcium and vitamin D intake smoking　alcohol intake and life-style　etc. Preventive strategies have been established and recommended for high-risk populations. Clinically　several medications are now available　especially the cost-effective hormone replacement treatment for post-menopause women. Osteoporosis is a partially preventable and treatable disease at the present time.

Despite all the achievements　osteoporosis remains an unsolved problem threatening public health. While the

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search for better treatments continues studies to explore the prevention of the disease are nevertheless important. One of the areas aimed at improving the preventive strategies is the research for understanding the disparities in socioeconomic status SES among the osteoporosis patients. Although SES has been linked with many diseases including diabetes cardiovascular disease and cancer [3-5] relatively few studies have been carried out for osteoporosis. Some early studies of SES effect on bone mineral density BMD are inconsistent and not focused specifically on the patients [6] [7] . Recently evidence indicates that osteoporosis patients with low SES have less access to health care [8] and poorer health than other persons [9] [10] . The question is how good this evidence is and where the disparities are if they do exist

This paper is to review the current studies of SES in osteoporosis. The evidence supporting the association between SES and the disease will be divided into three categories prevalence prevention and treatment to detail the findings.

SES and Osteoporosis Prevalence

Knowing the prevalence of a disease is the first step to finally get control over it. Recently there was some research exploring the SES effect on prevalence of osteoporosis which opened the door for us to gain an insight into the unique disease prevalence in lower educated populations.

In a large cross sectional study Varenna et al. interviewed 6 160 postmenopausal Italian women at their first densitometric referral [11] . The sample was stratified by years of education. BMD was measured as the indicator of osteoporosis. The level of education was categorized according to the years of schooling. They found that the prevalence of osteoporosis was inversely associated with educational level 18.3% for most educated 27.8% for the least educated women . Furthermore compared with the lowest educated women a significant reduction of the risk of osteoporosis was found in the women with increasing educational level. The odds ratio OR for 6 ~ 8 years of schooling is 0.76 with 95% confident interval CI ranging from 0.65 to 0.90. For 9 or more years of schooling the OR was 0.68 CI 0.57-0.82 . This is the first large sample study showing

a link between the prevalence of osteoporosis and formal education level.

Ho et al. conducted a similar study with a relatively smaller sample of Chinese women. Six hundred eighty-five postmenopausal women aged between 48 and 63 years old were studied from October 1999 to January 2001 [12] . Subjects who had had hormone replacement therapy for at least 3 months or medications known to affect bone mass were excluded. The BMDs of the whole body and subsites including lumbase spine L_1-L_4 and the left hip site were measured. Education was classified into four levels i.e. no formal education Ⅰ primary school education Ⅱ secondary school education Ⅲ and college education or above Ⅳ . After adjustment for age years since menopause and body weight they found that not only were BMDs of individual subsites associated with levels of education but the whole body BMD as well. The later is more significant. The women without formal education had a much higher risk OR 3.5-8.6 to be osteoporotic compared with their college educated counterparts. The difference is dose-dependent.

Gur et al. studied 569 postmenopausal Turkish women between the ages of 45 and 86 [13] . The BMDs they measured were from the spine and hip including neck trochanter and ward's triangle. Education levels were divided according to the number of school years no education elementary 8 years or less high school 9-11 years and university 12 years or more . A standardized questionnaire was used at a follow-up visit to obtain other information such as demographic characteristics life-style and age of menopause etc. Similarly their data showed that spine BMD was the lowest in the no education group $P < 0.05$. The hip BMD at trochanter and Ward's triangle was the highest in the highest education group significantly different from the no education group. Consistent with the above two investigations this study demonstrates a significant correlation between osteoporosis and educational level.

SES and Osteoporosis Prevention

To prevent a disease is not only the health workers'job. Patients play a critical role in the success of a preventive strategy. According to the Stage of Change Model patients go through several stages including

perception taking action and maintaining in a health intervention. The result will be different if patients' responses differ in any given stage. The following studies demonstrate that there is difference between patients with osteoporosis mainly on perception stage.

Knowledge and awareness about osteoporosis are two critical components of the perception stage. One research by Drozdzowska and colleagues aimed at investigating the issue is the study carried out in a large sample of 1065 Polish female aged 16-72 years [14]. The influence of age level of education and personal experiences are three major interests of the investigation using a structured questionnaire including three questions which more than half of the subjects answered incorrectly i. e. "osteoporosis may be cured" "Osteoporosis is a minor health problem" and" Those with osteoporosis should not engage in physical activities". Education data was collected on the years of schooling less than 9 years 9-11 years finished high school 12 years and university education > 12 years . While the general knowledge about osteoporosis was high with 60-95% of questions correctly answered higher education along with younger age improved the knowledge.

Saw et al. conducted a population-based survey to determine the knowledge and awareness about osteoporosis in middle age Chinese women 45 years and above of whom the majority 68.8% were postmenopausal [15]. One thousand three hundred and seventy-six subjects were randomly selected and interviewed. A total of 58% of the participants reported that they had heard of osteoporosis. Consistent with the Drozdzowska's study women who were younger and better educated were more likely to have knowledge of an osteoporosis.

In a different location a multicenter study conducted in Turkey by Kutsal et al. provided evidence of SES effect on the awareness of osteoporosis patients [16]. Data from 540 women 93.8% and 36 men 6.3% were collected including BMD educational level and economic factors. Fifty-four percent of patients declared that they were aware of the disease. The awareness of the patients was positively associated with educational level and an economic factor modern clothing style . The study also found that calcium intake and level of physical activity were two good predictors of the awareness at a significant level.

Interestingly the evidence for calcium intake's association with SES was also shown in Islam and colleagues' study in a pre-menopausal population [17] . The authors randomly selected a total of 191 Bangladesh women aged 16-40 years from both low and high SES groups defined by monthly family income. Sub-groups were divided according to pregnancy and lactation. They found that the mean dietary calcium intake was significantly higher in all sub-groups of the high SES subjects compared with the corresponding sub-groups of low SES participants. Unfortunately no BMD measure or clinical diagnosis was given. A direct link between SES and osteoporosis can not be established although the authors suggested the relationship in their conclusion.

SES and Osteoporosis Treatment

Whether a patient can obtain needed treatment is determined by many factors. SES is certainly one of important determinants in the treatment of many diseases. Osteoporosis is not an exception as confirmed by several studies.

An elegant study conducted by Brennan et al. in a total of 945 women in New York investigated the SES association with osteoporosis from a unique angle [18]. All these subjects were unaware of their bone density before entering the study. The BMD screening detected 344 cases of osteoporosis. Of these women 72.7% discussed the disease with a health provider. However just over half of them 56.0% initiated treatment after the discussion. Multivariate logistic regression revealed that women with college education were 2.58 times more likely to start treatment. High family income had similar impact on the initiation of treatment OR = 2.06 .

Unson et al. examined the barriers to eligibility and enrollment in a clinical trial on osteoporosis among 904 women aged 65 years or above [19] . Fifty-seven point six percent of these women were eligible for the clinical trial of which just 32% enrolled. Interestingly although high-income area residents were more likely to be eligible than their low-income counterparts minority residents of low-income areas were more likely to enroll than minority residents of high-income areas. Race is a determinant here. It also suggests that although many low SES persons

were not eligible for the trial, those who were eligible were more likely to enroll than their high SES counterparts, which implies an effect of SES.

In a separate study, Unson et al. also examined the osteoporosis medications used by older African-American women[20]. A total of 102 subjects aged 60 years or older were randomly selected in a New England city with predominantly African-American residents. Thirty-eight of the total 102 women had participated on at least one educational talk or osteoporosis screening activity. SES indicators included years of education and household income. BMD was measured. Their result suggested that knowledge of osteoporosis was a direct determinant to ever using hormone therapy by these women. SES had an

indirect impact on the hormone therapy through mediating the knowledge of osteoporosis.

1　Summary

Since initial studies attempting to evaluate the influence of SES on osteoporosis were conducted in early 1990s, clear evidence has been established that there is an association between SES and osteoporosis. Most of the findings were reproducible in different settings and with different races. The differences between different SES groups can be minor or as large as 8.6 times[12]. Generally, persons with lower income/education have higher incidence of osteoporosis and less likely obtain good care for the disease (Table 1, Figure 1).

Table 1　Effect of SES on osteoporosis prevalence, prevention, and treatment(%)

| Author, year	Education						Income		Housing			Note
	No education	Primary school	Middle school	High school	College education	Graduate school	Low	High	1-4 rooms	>=5 rooms	Private property	
Prevalence												
Varenna 1999[11]		27.8	20.6	18.3								
Ho 2005[12]	27.1	23.4	19.7		11.1							
Gur 2004[13]	34.4	27.9		21.5	18.6							
Prevention												
Drozdzowska 2004[14]			68.9	67.5	75.1							Knowledge of osteoporosis
Saw 2003[15]	30.9	70.6							52.8	62.4	76.5	Awareness of osteoporosis
Kutsal 2005[16]		43.7	62.3	83.7								Awareness of osteoporosis
Islam 2003[17]							5	53				Calcium intake > 400 mg/d
Treatment												
Brennan 2004[18]				44.4	57.9	62.5	51.3	66.1				Initiation of treatment
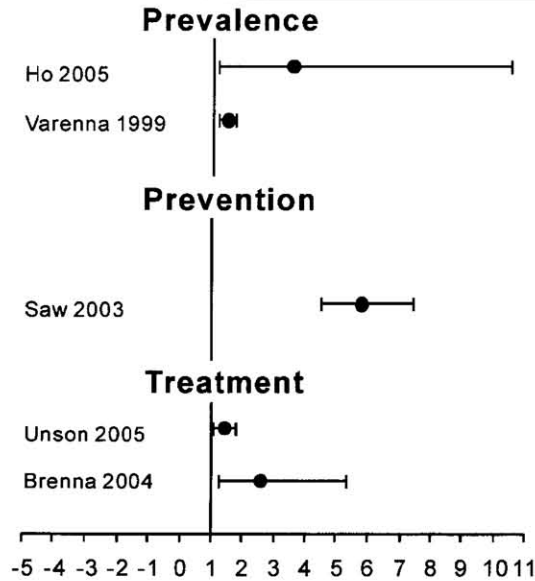
Fig.1　Odds ratios and 95% confidence intervals of osteoporosis prevalence, prevention, and treatment among persons with different SES

While these findings certainly help us understand the disparity between different populations, the interpretation needs to be cautious because of some limitations of the current studies. First, almost all of the studies are cross sectional and completed in a short period of time, typically 1-2 years. A one time measure of BMD usually was used to link to different predictors. It is understandable that BMD does not change much in short time and the test for BMD is not widely available. A longitudinal study by following patients for more years with several BMD measures will provide dynamic data and more convincing results.

Second, education and income are the predominantly used SES indictors in these studies. Occasionally, some other economic indicators such as modern style clothing are applied[16]. These factors are relatively easy to assess and certainly important in most cases. Because osteoporosis mainly strikes an older age population,

financial assets a dimension of SES are especially important at old ages [21] and need to be taken into consideration. Also the social aspect of SES is an area lacking in depth of research. Frequently priority is given to the economic part of SES typically income. The social part of SES is influenced by many factors thus difficult to evaluate. However sometimes it is particularly important. The economic indicators do not represent the whole picture of SES especially when comparing the same economic level populations of different races or locations. A better understanding of SES effect on osteoporosis depends on the combined evidences from both parts. More efforts need to be made in the social component of SES in the future.

The other common phenomena using SES indicators is that most studies apply just one indicator. While focusing on the major interest is necessary evaluating other predictors gives helpful information in most cases. For SES many indictors are closely related. Findings from a group of them allow a better understanding and interpretation of results.

The target population of the studies is one more area that needs to improve. Postmenopausal women are the major target populations of these studies. Very few studies target or include men even old men who are actually a high-risk population. Given the fact that osteoporosis can strike at many age it is meaningful to conduct studies in any age groups. In terms of race Caucasians Asians and African-Americans are three subpopulations to which most attention has been paid. Other races such as Hispanic have not been heavily involved yet. Even within each race on which the majority of studies have focused not much has been explored within the subpopulations of each race. Also only one SES indicator is usually studied in each research. The small sample size of some studies N < 100 is another concern. Such a sample size may not be able to detect some disparities when under certain conditions or using indicators prone to bias.

Technically most studies now use BMD as the indicator for osteoporosis. Most of the time this should be the right standard for the diagnosis. However clinical evidence should be used as reference for the diagnosis and not be ignored completely. Some research only depended on the BMD test no clinical validations were performed.

It may lead to include patients suffering from other diseases that share similar signs of BMD changes although the chance is small.

Finally the reason that the studies of the association between SES and osteoporosis have not obtained the attention they deserve may be due to the fact that reliable BMD measure the solid evidence for osteoporosis diagnosis was not available before the dual-energy x-ray absorptiometry technology was introduced into clinical medicine and osteoporosis research in late 1980s. In addition the test itself is moderately expensive so that it hinders the accessibility to the general population. The other potential factor that may negatively influence on the research is that SES is generally used as a variable for adjustment in order to identify the major interest of a study. It might lead to the tendency that SES is not analyzed independently. Such a predisposition is certainly not necessarily right. Knowing SES in osteoporosis not only provides critical information for understanding disparities among different people so that a specific preventive strategy or treatment agenda can be developed for a special population it also helps find the roles of other factors in the disease after accurately adjusting for the real effect of SES.

Taken together only limited studies have been performed in terms of SES effects on osteoporosis. Although the current evidence suggests that the association exists the scope and depth of the studies are not good enough to generalize findings to different populations and settings. We do not know very much about SES as a determinant of osteoporosis at this point. More research especially long time cohort studies with large sample and multiple indicators is necessary to generate a comprehensive knowledge on this issue.

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