Overconfidence and Health Insurance Participation among the Elderly[*]

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This study provides a new explanation to advantageous selection in the health insurance market: individuals may falsely realize their risk type. Investigating a representative sample of older people aged over 55 from the National Health and Nutrition Examination Survey, this paper uses height shrinkage as a health index and finds that those with poorer health are less likely to realize how unhealthy they are. People who fail to fully realize their health status are also less likely to participate in health insurance. The results emphasize the importance of subjective realization of health in the insurance market and contribute an important explanation for the advantageous selection puzzle.

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(First draft only for comments)

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I. Introduction

The classic theoretical model of health insurance has long emphasized the potential importance of private information about risk for efficient operation of the insurance market. The central prediction of the asymmetric information models is a phenomenon labeled "positive correlation," i.e. people with more insurance should be more likely to experience insured risk (Rothschild and Stiglitz 1976; Wilson 1977). However, many empirical papers have documented the phenomenon of "advantageous selection," i.e. people with more insurance appear to have the same or less insured risk than those with less insurance.[1] Some studies have provided potential explanations for this apparent contradiction. For example, by demonstrating that individuals may have private information not only about their risk type but also about preference-related characteristics such as risk aversion, Finkelstein and McGarry (2006) and argued that the existence of multiple dimensions of private information potentially explains no "positive correlation" in the long-term care insurance market. Cutler et al. (2008) showed that individual heterogeneous risk tolerance across different insurance markets potentially explains why the relationship between insurance coverage and risk occurrence can be of any sign. Fang et al. (2008) found that the sources of advantageous selection include income, education, longevity expectations, financial planning horizons, and cognitive ability, but interestingly not risk preferences. They did not discuss why such selection exists and provided no empirical evidence for any possible mechanisms.

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[1] This phenomenon of "advantageous selection" has been widely documented in both large insurance markets such as life insurance (Cawley and Philipson 1999, McCarthy and Mitchell 2003) and Medigap insurance (Hurd and McGarry 1997, Ettner 1997, Fang et al. 2008), and in extremely thin markets such as long-term care insurance (Finkelstein and McGarry 2006) and reverse mortgages (Davidoff and Welke 2007).

Our study provides a new possibility by introducing individual subjective bias, which is barely mentioned in previous literature. The subjective bias here refers to individual subjective biased information about their own risk type. The standard asymmetric information models assume that individuals have private information about their risk type and the *perceived or realized* risk type should be consistent with their *actual* risk type. But this may not be true.[2] Indeed, if those with high risk think themselves as with low risk, they may purchase less insurance *ex ante* but experience more insured risk *ex post*. Similarly, those with low risk but considering themselves as high risk will purchase more insurance *ex ante* but suffer less insured risk *ex post*.

This study provides empirical evidence for the above hypothesis. We first find a good measure for subjective bias. Because subjective bias is unobserved, it is rarely directly measured or collected from survey questionnaires or physical examinations. Ideally, the information should be derived from comparison between a subjective measure for health and its genuinely objective counterpart: the difference between the two measures would reflect the subjective bias. This study mainly uses the *unrealized height shrinkage* of people over 60 in the National Health and Nutrition Examination Survey (NHANES). Height shrinks mainly due to osteoporosis (bones losing density and becoming more fragile) as people age. Medical literature showed that osteoporosis – a "silent disease" strongly associated with bone fracture and disability in the future – is commonly unrealized, underdiagnosed and undertreated in both developed and

[2] Some empirical literature in health economics has shown that individuals may not understand or realize their health status perfectly. For example, Zhao et al. (2013) found that three quarters of respondents in China Health and Nutrition Survey had unrealized hypertension, i.e. suffering from hypertension but were never diagnosed or even noticed. After these people realized their hypertension issue, their food consumption became healthier, especially for the rich.

developing countries (Ali et al. 2009; Bilezikian et al. 1995; Feldstein et al. 2004). Height shrinkage is also strongly correlated with health status (Huang et al. 2013) and well predicts mortality (Huang 2014). We choose those aged over 60 because height shrinkage is a prevalent health phenomenon only among the elderly. Perhaps more importantly, the elderly are the most intensive consumers of health care in the United States; individuals over age 65 consume 36 percent of health care in the US (Centers for Medicaid and Medicare Services 2005; Chandra et al. 2010).

Using NHANES data, we first estimate the (biological) pre-shrinkage height following Huang et al. (2013) and then derive the actual height shrinkage by comparing the pre-shrinkage height to current measured height. This is our objective measure of height shrinkage. On the other hand, the NHANES questionnaire also asked respondents to report their height at age 25 as well as their current height. The difference between the two answers provides a subjective measure for height shrinkage and conveniently cancels away individual fixed bias in reporting. Reporting less shrinkage than actual implies over-confidence, and *vice versa*. A simple comparison shows that the reported height shrinkage is almost the half of the true value on average, revealing an overall underestimation in height shrinkage or over-confidence in health among the US population. Investigating the relationship between the subjective bias measure and Bone Material Density (BMD) and socio-economic status (SES) measures shows that higher SES or better bone density status is correlated with more accurate realization in shrinkage or less over-confidence. In other words, the results show that those who shrink more actually report less shrinkage; the over-confidence on health is more prevalent among those with lower SES and poorer health status. In addition, the measure of over-confidence based on height shrinkage is positively correlated with other measures such as unrealized hypertension and weight reporting bias. The latter two measures were stressed in Zhao et al. (2013) and Cawley and Burkhauser (2008).

The model in Fang et al. (2008) implies that a subjective bias would contribute to advantageous selection as long as the over-confidence satisfies two conditions: 1) negatively associated with better health status, and 2) negatively associated with insurance coverage. The above results support the first condition. We then establish the relationship of the subjective bias measure with insurance participation as well as healthcare usage and find consistency with the second condition. After controlling for the actual shrinkage and usual demographics, the results show that over-confidence is negatively associated with insurance participation, Medicare Advantage program enrollment and healthcare utilization frequency. Specifically, one standard deviation (SD) decrease in over-confidence is correlated with 1 percentage point increase in health insurance participation (4 percent of one SD), 3 percentage point increase in Medicare Advantage coverage (7 percent of one SD), and 13 percent of one SD increase in healthcare usage. We also assess the welfare loss brought by the subjective bias through estimating how much insurance participation is distorted due to the bias by comparing predicted insurance participation from the model with actual subjective bias and its counterpart under the assumption of no subjective bias. The results show that those with worse health status actually need more insurance.

This study builds on the current literature by providing a more fundamental explanation for the advantageous selection in health insurance market – the difference between individual subjective perceived health and objective actual health. Since individuals with actual higher risk are more likely to bias towards low risk type subjectively, thus less likely to enroll in insurance, the subjective bias is a factor contributing to the advantageous selection. As far as we are concerned, this study is the first one to offer such an explanation and provide empirical evidence for it. Although the phenomenon of advantageous selection is possibly relevant to individual risk aversion (Finkelstein and McGarry, 2006) or tolerance to risk (Cutler et al. 2008),[3] the difference between our proposal and earlier risk preference explanations is obvious. The subjective bias in health that we propose could stem from several possibilities, including overconfidence, lack of symptom salience, information avoidance and many other psychologies, and potentially plays a big role in health choices (Baicker, Mullainathan, and Schwartzstein, 2012). It emphasizes that even individuals themselves do not have the perfect information about their health.[4] But risk reversion, as mentioned in Finkelstein and McGarry (2006), is noticed perfectly by individuals but not by the insurers. Earlier preference-based explanations could be missing something fundamental if people do have subjective bias about their health information. The implications could be vastly different. The former suggests that the health insurance market would conduct less inefficiently through helping individuals realize their actual risk type accurately but the latter implies that the first-best equilibrium would be reached if the (competitive) insurers have perfect information of the consumers. In fact, our results suggest that the insurance market actually cannot reach first-best outcomes even under symmetric information if individual subjective bias exists.

[3] Yet as mentioned earlier, Fang et al. (2008) found that risk aversion seems not a relevant source for advantageous selection in the health insurance market.

[4] For example, there are several field experiments that tried to look at the effectiveness of behavioral interventions based on many psychologies mentioned and found that such nudges are effective. Volpp et al. (2008) studied the lottery incentives in increasing people's adherence to anti-stroke medication. Loewenstein, Brennan, and Volpp (2007) studied how to use decision errors to help people improve their health. Chandra, Gruber, and McKnight (2010) found that increases in cost sharing by a supplemental insurer can exert financial externalities in the Medicare program. Moreover, Baicker, Mullainathan, and Schwartzstein (2012) tried to provide a foundation for the behavioral moral hazard prevalent in health insurance.

Furthermore, this study potentially suggests a possible channel for enlarging SES-Health gradients and health inequality among the older people in US first mentioned in Deaton and Paxson (1998). Because those with higher SES realize their health status more accurately and are more likely to take pre-cautionary actions like insurance, it is easier for them to overcome unhealthy shocks, *ceteris paribus*.

II. Data

The data used in this study are from the National Health and Nutrition Examination Survey (NHANES), a program of studies designed to assess the health and nutritional status of adults and children in the United States. The survey is unique in combining interviews and physical examinations. We use the NHANES because this is the only existing survey – at least to our best knowledge – that provides reported pre-shrinkage height and current height, as well as variables like measured height and measured lengths of upper arm and upper legs that are important for predicting pre-shrinkage height, for all aged respondents. In other words, the NHANES is the only data set providing enough information to calculate or estimate biological shrinkage and reported shrinkage. We restrict the respondents with valid heights reported and measured and valid limb lengths measured. In addition, we also restrict the sample to those with bone mineral density (BMD) measured, that is roughly 80 percent of the sample, because BMD provides another objective measure that is very useful to testify biological and reported height shrinkages. Results in this study are robust with this sample restriction.

The NHANES also collects demographics such as gender, age and marital status, and SES variables including education levels and household income. Since our main variable of interest is based on height shrinkage, we also restrict the main sample for analysis to those aged over 60.

Appendix Table A1 reports the gender-specific means and standard deviations for the biomarkers, demographics, and SES variables.

III. Results

3.1 *Biological* Height Shrinkage and *Reported* Height Shrinkage

The first step is to estimate biological height shrinkage and compare it to reported height shrinkage. Following the methodology in Huang et al. (2013), we choose those aged between 30 and 40 the in NHANES and regress their measured height on limb length(s) and use the prediction as a measure of pre-shrinkage height for those aged over 60. This is a good measure because the limbs generally do not shrink as people age.[5] The results are reported in Appendix Table A2. Note that the R-squares in columns 1 and 3 are over 0.6, indicating fairly precise estimation. Consistent with Huang et al. (2013), the age terms and the interactions between age and limb lengths are also jointly insignificant (not reported), indicating the ratio of limb lengths to height does not change by cohorts. We then use the coefficients combined with the limb lengths of those aged over 60 to predict the pre-shrinkage height. The (biological) shrinkage is defined as the difference between pre-shrinkage height and measured height in the survey.

As mentioned above, the NHANES asked respondents about their height when they were 25 (Reported Pre-shrinkage height) and height as of now (Reported Height) respectively. We take the difference to derive the reported height shrinkage. Panel A of Appendix Table A1 also

[5] Lower leg length (Chumlea, Roche, and Steinbaugh 1985; Chumlea and Guo 1998), arm span from roughly the shoulder to the wrist (Kwok and Whitelaw 1991; Kwok, Lau, and Woo 2002), total arm length (Mitchell and Lipschitz 1982; Auyeung and Lee 2001), upper arm or humeral length, tibia length (Haboubi, Hudson, and Pathy 1990) and bula length (Auyeung and Lee 2001) have all been used to estimate pre-shrinkage stature.

reports the summary statistics for these variables. On average, men aged over 60 shrink 1.7 cm but they only report 0.9 cm; women shrink 2.4 cm but report only 1.4 cm. We plot the two measures of shrinkage against age by gender in Figure 1. The solid lines show the pattern of biological height shrinkage over age and the dashed lines show that of reported shrinkage. The dashed lines lie consistently below the solid ones for all the ages, indicating that people may not fully realize their shrinkage on average.

Appendix Table A2 compares the relationship of the two shrinkages with BMD and SES variables. Consistent with findings in Huang et al. (2013), the results show height shrinkage is negatively correlated with BMD and SES variables. However, the reported shrinkage is positively correlated with education and household income, though not significant for education. These results suggest that people with lower SES suffer more shrinkage but they are more over-confident with their health.

Based on these measures for heights, we construct a variable to measure subjective bias / over-confidence / health ignorance as below.

$$Subjective\ Bias = \frac{Preshrinkage\ Height}{Measured\ Height} \Big/ \frac{Reported\ Preshrinkage\ Height}{Reported\ Height}$$

The numerator measures the biological height shrinkage and the denominator captures the reported height shrinkage, and both of them are in ratios. Since individuals underestimate their height shrinkage, this measure for subjective bias is over one on average, as shown in Appendix Table A1. The higher the measure is, the more over-confident the respondent is on their height shrinkage.

This measure of subjective bias is not perfect for sure. Ideally, the bias information should be derived from comparison between a subjective measure for health and its objective counterpart. Take self-reported health as an example of more general health status. It is very difficult to find an objective counterpart for self-reported health because there could always be some unobserved factors that may be important for the individuals but are not captured by examinations or questions. From this perspective, height shrinkage can be much more precisely measured, subjectively and objectively as we suggest earlier. Perhaps more importantly, we want to understand what contributes to the subjective bias and whether the bias is relevant more generally for individual health status or overall life quality. One candidate could definitely be over-confidence on health: individuals have a better perception of their health status so they report less shrinkage. Another is ignorance or neglect: people may not notice their height shrinkage and potentially other health-related problems. Other hypotheses may also hold. We leave these issues open for future studies. In this paper, the subjective bias measure constructed here is interpreted interchangeably as over-confidence or health ignorance.

Appendix Table A4 shows the correlation between the subjective measure and other measures used in the literature. Zhao et al. (2013) show that many people in China do not know they are suffering hypertension, indicating a larger under-realization in hypertension among people, especially in developing countries. Cawley and Burkhauser (2008) show that people in the US report imprecisely on their weight. To link our measure to these, we use the NHANES data to construct an indicator whether people are suffering unrealized hypertension by comparing the reported hypertension status and the measured blood pressure. We also construct another measure for weight by dividing the difference between reported weight and measured weight to the measured weight. Appendix Table A4 shows the correlation of shrinkage subjective bias with the two mentioned in previous literature. The results show that over-confidence in shrinkage is consistently correlated with unrealized hypertension and reporting weight bias.

3.2 Subjective bias, SES and Health

We further argue that the subjective bias in health contributes to the advantageous selection in health insurance market. There are two conditions to be examined to make a such a conclusion according to Fang et al. (2008): 1) the subjective bias should be negatively associated with better health status, and 2) the subjective bias should be negatively associated with insurance coverage. This section examines the first condition by estimating the following equation.

$$(1)\ Subjective\ Bias_i = \alpha_0 + \alpha_1 BMD_i + \alpha X_i + \epsilon_i$$

The dependent variable is subjective bias of individual i as defined above. We use Bone Material Density (BMD) here as the actual health measure. Appendix Table A5 reports the significant negative correlation between mortality and bone material density with and without SES controlled for. We do not use the biological height shrinkage here because the components are directly used in the dependent variable of this equation. X_i denotes a series of control variables, including dummies for marital status, country of birth, ethnicity, age, survey year and interactions between survey year and age.

Table 1 reports the OLS estimates for equation (1). The results show that BMD is strongly correlated with the subjective bias, which means that those with denser bone material are less likely to underestimate their own height shrinkage. In other words, those with better health status are less likely to be over-confident in their own health. Figure 2 presents the non-parametric estimate for the association between subjective bias and BMD, which are fairly consistent with the results of Table 1.

Since the subjective bias is based on height shrinkage, we include another variable "whether you are notified by doctors that you are suffering osteoporosis." The estimates show that being notified by doctors helps better realize height loss. Including SES controls just reduces the magnitude of the coefficients but they are still statistically significant. The coefficients on SES also show that the higher SES is negatively correlated with subjective bias or over-confidence.

3.3 Subjective bias, Insurance Participation and Healthcare Usage

This section tests the second condition for advantageous selection that the subjective bias should be negatively associated with insurance coverage. We then estimate the following equation.

$$(2)\ Insurance_i = \beta_0 + \beta_1 Subjective\ Bias_i + \beta_2 Shrinkage_i + \beta X_i + \varepsilon_i$$

where the dependent variable, $Insurance_i$, can be whether the respondent is covered by any insurance. Because Medicare covers almost all the individuals over 65, we use two other outcomes: whether the respondent enrolls in both private insurance and Medicare (Medicare Advantage)[6] and the times of healthcare usage last year which varies from zero to five (i.e. it equals to zero if no usage, the higher value the more frequent). The sample is restricted to those covered by any health insurance when we use these two dependent variables. The subjective bias is constructed as above; the higher it is, the more over-confident the respondent is. Biological height shrinkage is controlled for to capture the health status and the results are robust dropping it. X_i has the same definition as above.

Negative β_1 in equation (2) provides empirical support for the second condition in Fang et al. (2008). Table 2 reports the OLS estimates for β_1; different panels show the results using

[6] NHANES does not provide Medicare Advantage Coverage directly. We assume that people with both Basic Medicare and private insurance are enrolled in Medicare Advantage Program.

different dependent variables. The first two columns use the full sample and the results consistently show that over-confidence is correlated with less insurance coverage as well as less healthcare usage. The magnitudes are not small; specifically, one standard deviation (SD) deduction in over-confidence is correlated with 1 percentage point increase in health insurance participation (4 percent of one SD), 3 percentage point increase in Medicare Advantage coverage (7 percent of one SD), and 13 percent of one SD increase in healthcare usage. Controlling for SES variables does not influence the associations much. Although those with higher SES better realize their shrinkage (Table 1) and they are more likely to participate in insurance (Table 2, but the coefficients are not reported), SES hardly explains all the correlation between subjective bias and insurance participation.

It is possible that people who are insured or go to the doctor frequently are more likely to know their health status by taking more examinations and getting alerts from their doctors. Thus the associations in first two columns may be driven by reverse causality. It is difficult to rule out this possibility. But the robustness checks by restricting the sample to those who are never notified by the doctors about osteoporosis yield very consistent results. Following the strategy in Card et al. (2009), we also did another set of regressions to use the large jump at 65 in the fraction who have Medicare as their primary insurer as an exogenous shock in health insurance coverage to see whether insurance helps people to realize their shrinkage. The results, not provided here, provide no evidence for this hypothesis.

3.4 Insufficient Insurance due to Subjective bias

Based on the estimates in Table 2, we are able to calculate how much distortion there is due to subjective bias and the distribution of such distortion over health status. First, we use the estimates in column 1 directly to predict insurance participation, Medicare Advantage enrollment and frequency of healthcare usage (Y_1). Then we update all the values of subjective bias to 1, which means full realization of height shrinkage in the population, and conduct the same procedure to predict the outcomes (Y_2). Finally, we take the difference between the two set of predicted outcomes (i.e. the difference between Y_1 and Y_2), which is interpreted as the gap of health insurance participation or healthcare usage, and plot the difference against bone material density, again a measure of health status.

Figure 3 represents the pattern. All the three figures are fairly consistent with each other; those with worse health (lower BMD) suffer more insufficient health insurance coverage and healthcare usage due to subjective bias in height shrinkage. The magnitude is not small either; those with low BMD (0.5-0.6) would have increased insurance participation by 0.25 percentage points and Medicare Advantage by 0.7 percentage points if they had fully realized their height shrinkage. The lines go down as BMD increases, implying that those with better health status are actually less insufficiently insured.

IV. Discussions and Conclusions

This study aims to provide a new explanation to the advantageous selection in health insurance market by hypothesizing that individuals may falsely realize their risk type. Investigating a representative sample from the National Health and Nutrition Examination Survey, we construct a subjective bias measure based on reported height shrinkage and biological height shrinkage. The results show that those with lower socio-economic status or poorer health are more over-confident about their health. Further investigation finds that those who are over-confident on their height shrinkage are also less likely to participate in health insurance. These results indicate that the subjective bias in health help explain the advantageous selection in the health insurance market.

This study also has some policy implications. Since the US government has spent great amount in healthcare, it is potentially cost saving to motivate people to accurately realize their own health status. The individuals may then choose more efficiently in the insurance market. The results also show that mandatory insurance may help reduce the welfare loss brought by subjective bias, especially for those with lower SES and worse health. This group are more likely to be over-confident in their health and thus less likely to enroll in health insurance program.

This study also suffers some pitfalls. One issue should be the measure for subjective bias. Since subjective bias is hardly directly measured or collected from survey questionnaire or physical examination, it is difficult to construct a perfect measure. It is still a question how people report height and what contributes to the difference between subjective and objective height measures. But height shrinkage also has some advantages. It is a “silent” phenomenon and people may not notice it directly even when they go to the doctors; other measures like unrealized hypertension and weight reporting bias can be easily attenuated when individuals get feedback from the doctors, thus the regressions in Table 2 are more likely to suffer reversal causality. In addition, any individual fixed bias in reporting height can be cancelled out by dividing or subtracting the reported pre-shrinkage height and current height.

It is also worthwhile to note here that all the results in this paper are correlations rather than causality. The regressions in this paper suffer endogeneity due to reversal causality and omitted variables. People could understand their health status better simply because they have health insurance thus go to hospital more frequently. Individuals with higher risk aversion may report more height shrinkage and more likely enroll the insurance program. This limitation can be potentially addressed in the future by some experiments which nudge people to fully realize their own health status and observe their insurance choices later on.

References

Ali, T., Lam, D., Bronze, M. S., & Humphrey, M. B. (2009). Osteoporosis in inflammatory bowel disease. *The American journal of medicine*, *122*(7), 599-604.

Auyeung, Tung Wai, and Jenny Shun Wah Lee. 2001. "Estimation of Height in Older Chinese Adults by Measuring Limb Length." *Journal of the American Geriatrics Society* 49 (5): 684–85.

Baicker, K., S. Mullainathan, and J. Schwartzstein. Behavioral Hazard in Health Insurance. NBER working paper no. 18468.

Bilezikian, J. P. (1999). Osteoporosis in Men 1. *The Journal of Clinical Endocrinology & Metabolism*, *84*(10), 3431-3434.

Burkhauser, R. V., & Cawley, J. (2008). Beyond BMI: the value of more accurate measures of fatness and obesity in social science research. *Journal of Health Economics*, *27*(2), 519-529.

Card, D., Dobkin, C., & Maestas, N. (2009). Does Medicare Save Lives? *Quarterly Journal of Economics*, *124*(2), 597-636.

Cawley, J., & Philipson, T. (1999). An Empirical Examination of Information Barriers to Trade in Insurance. American Economic Review, 89(4), 827-846.

Centers for Medicaid and Medicare Services National Health Expenditures. 2005. Website: www.cms.hhs.gov/NationalHealthExpendData/04_NationalHealthAccountsAgePHC.asp.

Chandra, A., Gruber, J., & McKnight, R. (2010). Patient cost-sharing and hospitalization offsets in the elderly. *The American Economic Review*, *100*(1), 193.

Chumlea, William C., Shumei S. Guo, K. Wholihan, D. Cockram, R. J. Kuczmarski, and C. L. Johnson. 1998. "Stature Prediction Equations for Elderly Non-Hispanic White, Non-Hispanic

Black, and Mexican-American Persons Developed from NHANES III Data." *Journal of American Diet Association* 98 (2): 137–42.

Chumlea, William C., Alex F. Roche, and Maria L. Steinbaugh. 1985. "Estimating Stature from Knee Height for Persons 60 to 90 Years of Age." *Journal of American Geriatrics Society* 33 (2): 116–20.

Cutler, D. M., Finkelstein, A., & McGarry, K. (2008). Preference Heterogeneity and Insurance Markets: Explaining a Puzzle of Insurance. *The American Economic Review*, 157-162.

Davidoff, T., & Welke, G. (2007). Selection and Moral Hazard in the Reverse Mortgage Market. Unpublished Manuscript.

Deaton, A. S., & Paxson, C. H. (1998). Aging and inequality in income and health. *American Economic Review*, 248-253.

Ettner, S. L. (1997). Adverse selection and the purchase of Medigap insurance by the elderly. *Journal of health economics*, *16*(5), 543-562.

Fang, H., Keane, M. P., & Silverman, D. (2008). Sources of Advantageous Selection: Evidence from the Medigap Insurance Market. *Journal of Political Economy*, *116*(2), 303-350.

Feldstein, A., Elmer, P. J., Smith, D. H., Herson, M., Orwoll, E., Chen, C., ... & Swain, M. C. (2006). Electronic medical record reminder improves osteoporosis management after a fracture: a randomized, controlled trial. *Journal of the American Geriatrics Society*, *54*(3), 450-457.

Finkelstein, A., & McGarry, K. (2006). Multiple dimensions of private information: evidence from the long-term care insurance market. *American Economic Review*, *96*(4), 938-958.

Finkelstein, A., & Poterba, J. (2004). Adverse selection in insurance markets: Policyholder evidence from the UK annuity market. *Journal of Political Economy*, *112*(1), 183-208.

Haboubi, N. Y., P. R. Hudson, and M. S. Pathy. 1990. “Measurement of Height in the Elderly.” *Journal of the American Geriatrics Society* 38 (9): 1008–10.

Huang, W., Lei, X., Ridder, G., Strauss, J., & Zhao, Y. (2013). Health, height, height shrinkage, and SES at older ages: evidence from China. *American Economic Journal: Applied Economics*, *5*(2), 86-121.

Huang W. (2014). Height Shrinkage, Health and Mortality: Evidence from ELSA. Unpublished Manuscript.

Hurd, M. D., & McGarry, K. (1997). Medical insurance and the use of health care services by the elderly. *Journal of Health Economics*, *16*(2), 129-154.

Kwok, T., E. Lau, and J. Woo. 2002. “The Prediction of Height by Armspan in Older Chinese People.” *Annals of Human Biology* 29 (6): 649–56.

Kwok, T., and M. N. Whitelaw. 1991. “The Use of Armspan in Nutritional Assessment of the Elderly.” *Journal of American Geriatrics Society* 39 (5): 492–96.

Loewenstein, G., T.A. Brennan, and K.G. Volpp. 2007. Asymmetric paternalism to improve health behaviors. *Journal of the American Medical Association*, 298 (20): 2415-17.

McCarthy, D., & Mitchell, O. S. (2003). *International adverse selection in life insurance and annuities* (No. w9975). National Bureau of Economic Research.

Mitchell, C. O., and David Lipschitz. 1982. “Arm Length Measurement as an Alternative to Height in Nutritional Assessment of the Elderly.” *Journal of Parenteral and Enteral Nutrition* 6 (3): 226–29.

Rothschild, M., & Stiglitz, J. E. (1976). Increasing Risk: A Definition." Journal of Economic Theory, Vol. 2 (1970), pp. 225-243. AND. *Equilibrium in Competitive Insurance Markets: An*

Essay on the Economics of Imperfect Information." Quarterly Journal of Economics, *90*, 629-649.

Volpp, K. G., G. Loewenstein, A. B. Troxel, J. Doshi, M. Price, M. Laskin, and S. E. Kimmel. 2008. A test of financial incentives to improve warfarin adherence. *BMC Health Service Research*, 8: 272.

Wilson, R. (1977). A bidding model of perfect competition. *The Review of Economic Studies*, 511-518.

Zhao, M., Konishi, Y., & Glewwe, P. (2013). Does information on health status lead to a healthier lifestyle? Evidence from China on the effect of hypertension diagnosis on food consumption. *Journal of Health Economics*, *32*(2), 367-385.

Table 1: Realization, SES and Notified by Doctors

VARIABLES	(1)	(2)
	Shrinkage Subjective Bias: (RPH/RH) / (PH/MH) * 100	
Bone Material Density	-1.711***	-1.418***
	(0.309)	(0.307)
Being notified Osteoporosis	-0.362***	-0.358***
	(0.126)	(0.125)
Male	0.136	0.120
	(0.103)	(0.102)
Education level: Reference group is Less than 12th Grade		
High School		-0.189*
		(0.112)
College +		-0.646***
		(0.104)
Logarithm of HH income		-0.451***
		(0.0895)
Constant	102.0***	102.4***
	(0.309)	(0.325)
Observations	8,359	8,359
R-squared	0.059	0.076
Covariates controlled for		
Basic Controls	Yes	Yes

Note: Data source is NHANES 1999 - 2009. Aged 60+. Weights are applied. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Basic controls in all columns include dummies for marital status, country of birth, ethnicity, age, survey year and interaction between age and survey year.

Table 2: Shrinkage Realization Bias and Health Insurance Enrollment

	(1)	(2)	(3)	(4)
Sample	Full sample		Not being notified Osteoporosis	
Panel A: Dependent variable is Covered by Insurance (Yes = 1)				
Shrinkage Subjective Bias	-0.341***	-0.241**	-0.408***	-0.275*
	(0.118)	(0.119)	(0.142)	(0.142)
Mean of dependent variable	0.92		0.92	
Observations	8,989	8,989	7,874	7,874
R-squared	0.109	0.127	0.111	0.131
Panel B: Dependent variable is Covered by Medicare & Private insurance (Yes = 1)				
Shrinkage Subjective Bias	-0.977**	-0.880**	-0.861*	-0.502
	(0.402)	(0.399)	(0.442)	(0.455)
Mean of dependent variable	0.35		0.34	
Observations	8,121	8,121	7,874	7,079
R-squared	0.246	0.254	0.270	0.264
Panel C: Dependent variable is Times of receiving Healthcare (0-5)				
Shrinkage Subjective Bias	-4.725***	-4.730***	-3.738***	-3.760***
	(1.104)	(1.102)	(1.291)	(1.288)
Mean of dependent variable	2.65		2.61	
Observations	8,430	8,430	7,356	7,356
R-squared	0.052	0.052	0.051	0.051
Covariates controlled for				
Basic Controls	Yes	Yes	Yes	Yes
Height Shrinkage	Yes	Yes	Yes	Yes
SES	No	Yes	No	Yes

Note: Data source is NHANES 1999 - 2009. Aged 60+. Weights are applied. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Basic controls in all columns include dummies for marital status, country of birth, ethnicity, age, survey year and interaction between age and survey year.

A1. Summary Statistics

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Male sample			Female sample		
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Panel A: Biomarkers						
Arm length	4566	39.03	2.34	4465	35.89	2.24
Leg length	4566	40.09	3.45	4465	36.09	3.55
Measured Height (MH)	4566	172.6	7.37	4465	158.7	6.89
Pre-shrinkage Height (PH)	4566	174.3	6.29	4465	161.1	5.42
Height Shrinkage (HS)	4566	1.66	4.80	4465	2.39	4.81
Reported height (RH)	4566	175.1	7.81	4465	160.7	7.21
Reported Pre-shrinkage height (RPH)	4566	176.0	7.88	4465	162.1	6.94
Reported height shrinkage (RHS)	4555	0.83	2.08	4460	1.36	2.46
BMD	4295	1.11	0.19	4059	0.92	0.16
Shrinkage Subjetive Bias (Ratio)	4566	1.01	0.03	4463	1.01	0.03
Panel B: Demographic and SES						
Married (Yes = 1)	4566	0.72	0.45	4465	0.44	0.50
Age	4566	71.20	7.30	4465	71.21	7.53
Logarithm of HH income	4566	1.81	0.53	4465	1.73	0.55
Education levels						
Less than 11th grade	4566	0.09	0.29	4465	0.09	0.28
High School Grad/GED or Equivalent	4566	0.22	0.42	4465	0.28	0.45
Some College or above	4566	0.41	0.49	4465	0.37	0.48
Missing	4566	0.00	0.03	4465	0.00	0.04

Note: Data source is NHANES 1999 - 2009. Weights are applied.

A2: Pre-shrinkage Height Prediction

	(1)	(2)	(3)	(4)
	Male		Female	
VARIABLES	Measured Height (cm)			
Arm length	-0.910	-0.945	3.265***	3.264***
	(0.958)	(0.958)	(0.853)	(0.853)
Leg length	2.036***	2.040***	0.919*	0.921*
	(0.607)	(0.607)	(0.505)	(0.506)
Arm square	0.0445***	0.0446***	0.00300	0.00307
	(0.0164)	(0.0164)	(0.0152)	(0.0152)
Leg square	-0.00179	-0.00199	0.0236***	0.0236***
	(0.00802)	(0.00802)	(0.00630)	(0.00630)
Arm*Leg	-0.0246	-0.0242	-0.0526***	-0.0527***
	(0.0176)	(0.0176)	(0.0155)	(0.0156)
Age		0.401		0.0105
		(0.285)		(0.257)
Age square		-0.523		-0.0211
		(0.407)		(0.368)
Constant	100.6***	93.41***	41.86***	41.73**
	(18.69)	(19.38)	(16.06)	(16.79)
Observations	2,575	2,575	2,947	2,947
R-squared	0.671	0.671	0.620	0.620
P value for limbs	0.000	0.000	0.000	0.000
P value for limb squares	0.046	0.044	0.000	0.000
P value for age terms		0.194		0.985

Note: Data source is NHANES 1999 - 2009. Those aged between 30 and 40 are selected. Estimates in columns 1 and 3 are used to predict pre-shrinkage height of the older (aged 60 and above). Standard errors in parentheses. Co-variates in all columns include dummies for country of birth, ethnicity and survey year.

A3: Height Shrinkage, BMD and SES

VARIABLES	(1) Preshrinkage Height/Measured Height * 100	(2) Reported Preshrinkage Heigh/Reported Height * 100
BMD	-1.630***	-0.523***
	(0.282)	(0.159)
Education level: Reference group is Less than 12th Grade		
High School	-0.167	0.0343
	(0.103)	(0.0568)
College +	-0.579***	0.0699
	(0.0950)	(0.0507)
Log(HH income)	-0.331***	0.117**
	(0.0804)	(0.0506)
Constant	103.3***	101.2***
	(0.291)	(0.175)
Observations	8,781	8,729
R-squared	0.126	0.107

Note: Data source is NHANES 1999 - 2009. Sample is restricted to those aged 60 and above. Weights are applied. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Covariates in all columns include dummies for marital status country of birth, ethnicity, age, survey year and interactions between age and survey year.

A4: Height Shrinkage Realization and Other Measures

VARIABLES	(1) Unrealized Hypertension (Yes = 1)	(2)	(3) Weight report bias (Diff/True Weight *100)	(4)
Mean of Dependent variables	0.19 (0.39)		2.85 (3.00)	
Shrinkage Subjective Bias	1.013**	1.014**	7.128**	6.156**
	(0.403)	(0.404)	(2.880)	(2.866)
Observations	6,225	6,225	8,940	8,940
R-squared	0.064	0.065	0.049	0.055
Covariates controlled for				
Basic Controls	Yes	Yes	Yes	Yes
Height Shrinkage	Yes	Yes	Yes	Yes
SES	No	Yes	No	Yes

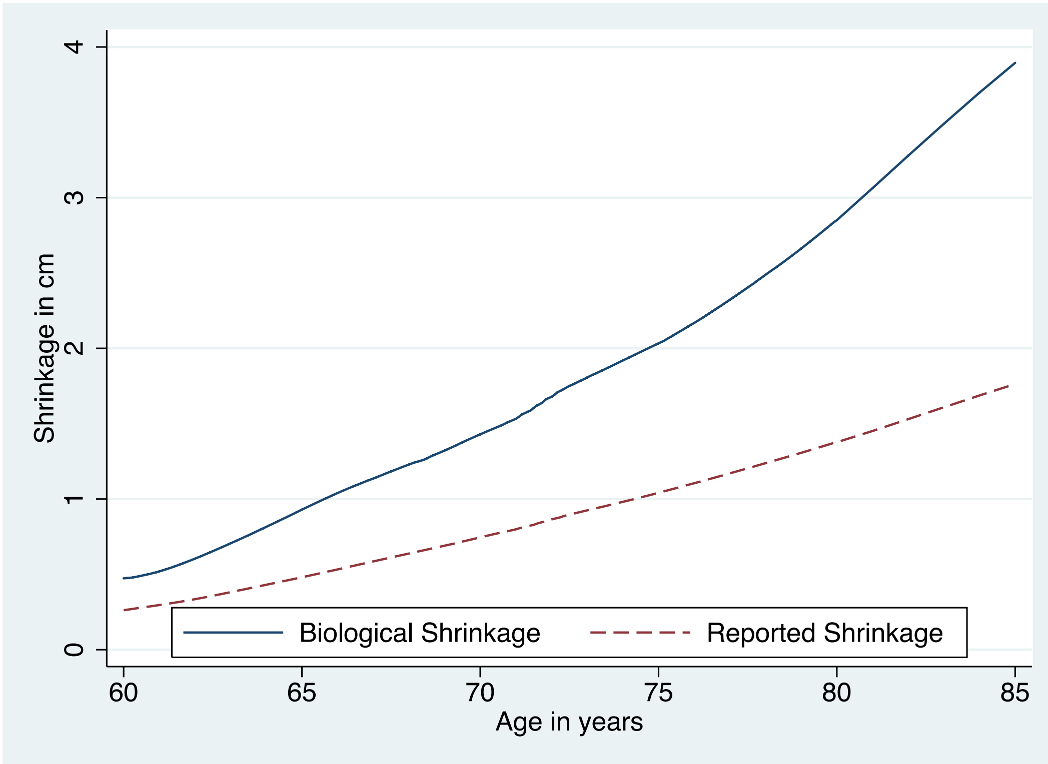
Note: Data source is NHANES 1999 - 2009. Aged 60+. Weights are applied. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Basic controls in all columns include dummies for marital status, country of birth, ethnicity, age, survey year and interaction between age and survey year.

A5. Mortality and BMD

	(1)	(2)
VARIABLES	Dead (Yes = 1)	
BMD	-0.150***	-0.129**
	(0.0511)	(0.0513)
Male	0.110***	0.107***
	(0.0161)	(0.0161)
Education level: Reference group is Less than 12th Grade		
High School		-0.0168
		(0.0169)
College +		-0.0219
		(0.0157)
Log(HH income)		-0.0384***
		(0.0143)
Constant	0.244***	0.284***
	(0.0509)	(0.0536)
Observations	4,789	4,789
R-squared	0.142	0.147
Covariates controlled for		
Basic Controls	Yes	Yes

Note: Data source is NHANES 1999 - 2004. Aged 60+. Weights are applied. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Basic controls in all columns include dummies for marital status, country of birth, ethnicity, age, suvery year and interaction between age and survey year.

a. Male



b. Female

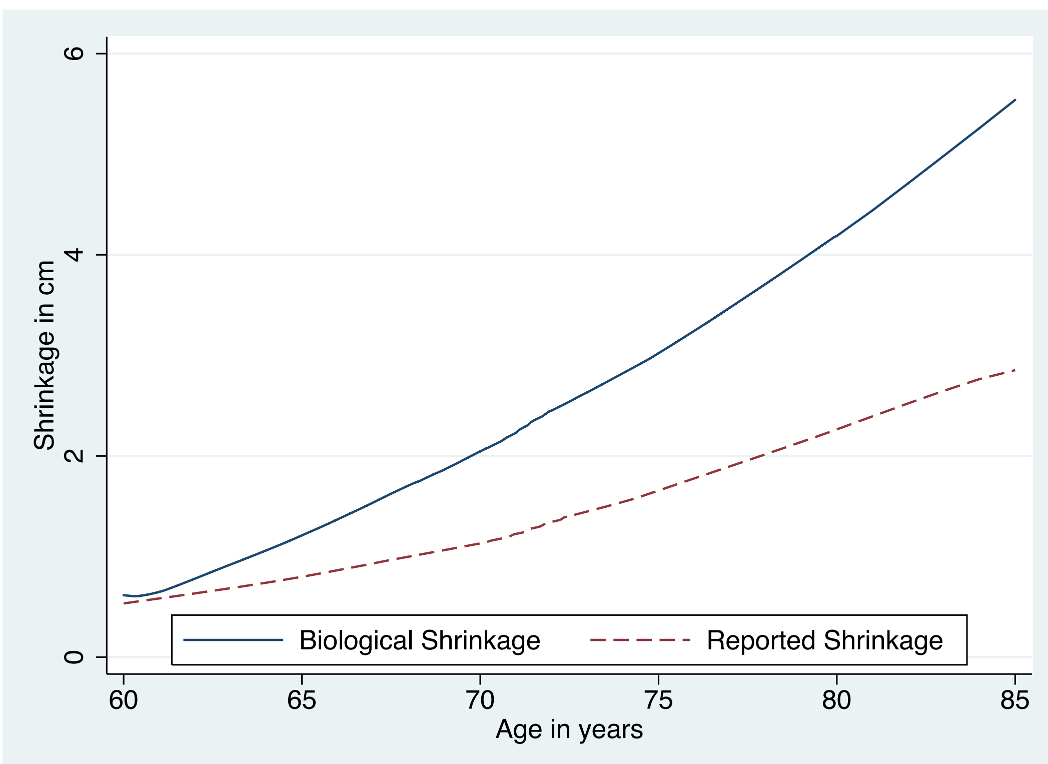


Figure 1. Estimated Shrinkage and Reported Shrinkage over Age, by Gender

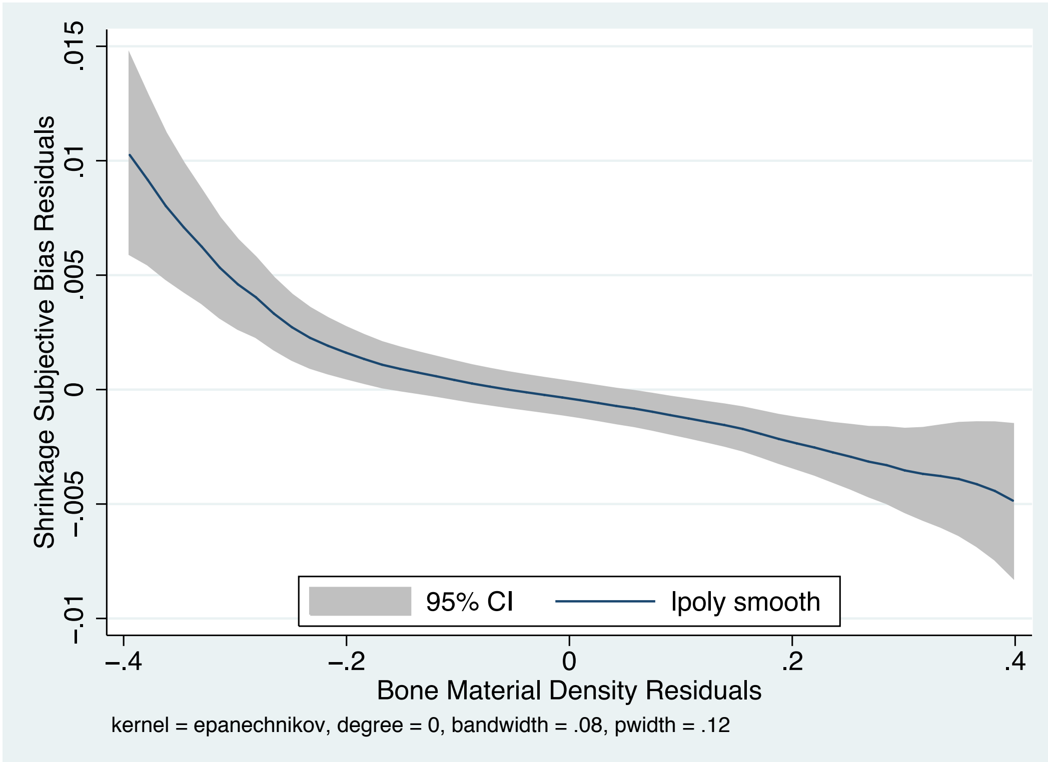
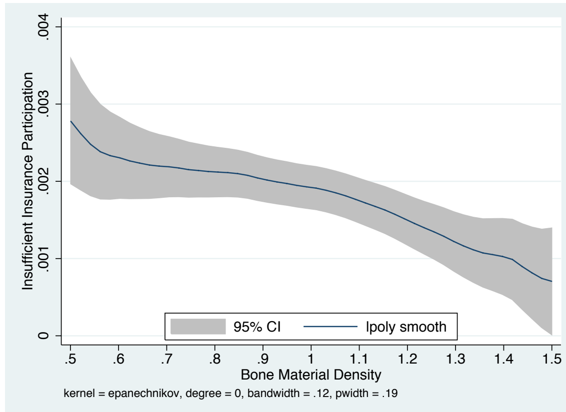


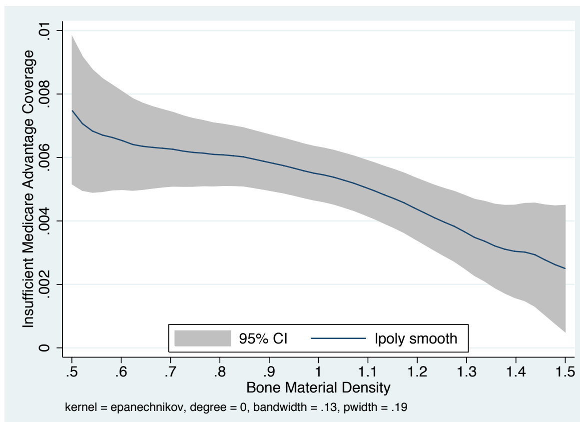
Figure 2. Residuals of Height Shrinkage Realization (Subjective Bias) over Residuals of Bone Material Density (Risk Type)

Note: The residuals of shrinkage realization and BMD are both derived from OLS regressions with controls for dummies for marital status, country of birth, ethnicity, age, survey year and interaction between age and survey year. Data source is NHANES.

a. Insurance Participation



b. Medicare Advantage



c. Times of Receiving Healthcare

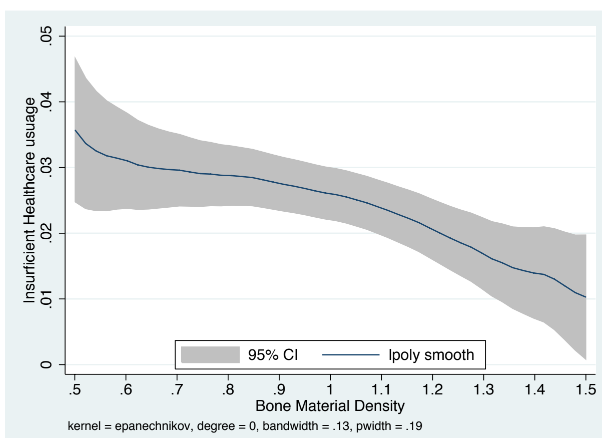


Figure 3. Insufficient Health Insurance or Healthcare usage due to Insufficient Realization in Height Shrinkage (Subjective Bias)

Note: Only BMD are between 0.5 (5^{th} percentile) and 1.5 (95^{th} percentile) are plotted. Data source is NHANES.