HHS Public Access
Author manuscript
J Clin Hypertens (Greenwich). Author manuscript; available in PMC 2016 January 01.

Published in final edited form as:
J Clin Hypertens (Greenwich). 2015 January ; 17(1): 39–45. doi:10.1111/jch.12443.

The Effect of Numeracy Level on Completeness of Home Blood Pressure Monitoring

Vishal N. Rao, MPH[1,*], **Laura A. Tuttle, MA**[2,3], **Stacey L. Sheridan, MD, MPH**[1,4], **Feng-Chang Lin, PhD**[2,5], **Daichi Shimbo, MD**[6], **Keith M. Diaz, PhD**[6], **Alan L. Hinderliter, MD**[7], and **Anthony J. Viera, MD, MPH**[1,2,3]

[1]MD-MPH Program, UNC School of Medicine and Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

[2]Department of Family Medicine, UNC School of Medicine, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

[3]Hypertension Research Program, University of North Carolina at Chapel Hill, Chapel Hill, NC

[4]Division of General Medicine and Clinical Epidemiology, Center for Health Promotion and Disease Prevention, and Cecil G. Sheps Center for Health Services Research, UNC School of Medicine, University of North Carolina, Chapel Hill

[5]Department of Biostatistics, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

[6]Department of Medicine, Center for Behavioral Cardiovascular Health, Columbia University Medical Center, New York, NY, USA

[7]Department of Medicine, Division of Cardiology, UNC School of Medicine, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina

Abstract

Home blood pressure monitoring (HBPM) readings predict the increased risks of cardiovascular events and end-organ damage independent of office blood pressure (BP). Numeracy (the ability to handle numbers) may limit the feasibility of patients' performing HBPM. We analyzed data from 409 adults from 12 North Carolina primary care clinics who completed a 3-item numeracy assessment, the REALM-SF health literacy assessment, and HBPM over two weeks. Among the 409 participants, 73% were college graduates and 69% had adequate numeracy. Completion of HBPM was greater among those with adequate numeracy (96.2% vs. 93.7%; P=0.009) and did not correlate with health literacy scores. More participants with adequate numeracy reported completion of ≥85% of readings than those with low numeracy (95% vs. 88%; P=0.018). Adequate numeracy, but not high literacy, is associated with more complete reporting of HBPM. Whether higher numeracy is associated with more accurate self-reported readings is an area of future research.

*Address correspondence to: Vishal N. Rao, 509 Perry Creek Drive, Chapel Hill, North Carolina, 27514, USA. Phone: 919.423.1829; Fax: ***; vishal_rao@med.unc.edu.

Conflict of Interest: No authors have any conflicting relationships to declare.

Keywords

Numeracy; Health Literacy; Home Blood Pressure Monitoring; Patient Education

Introduction

Hypertension increases the risk of cardiovascular disease (CVD) and stroke-related morbidity and mortality.[1–3] It is highly prevalent in the United States, and accounts for $46.4 billion annually in direct and indirect health-related costs.[4] Between 2003 and 2010, nearly 70 million Americans had hypertension, and among those, about one-half had it under control.[5] Appropriate identification and treatment of high blood pressure (BP) is an important public health issue as it may significantly reduce cardiovascular comorbidity and mortality.

Traditionally, clinicians diagnose and manage hypertension using BP measurements performed in the office setting. Self-measured BP at home, or home blood pressure monitoring (HBPM), is a useful strategy for providing clinicians with out-of-office measurements of BP. Furthermore, HBPM readings predicts risks of cardiovascular events and end-organ damage independent of office BP.[6–8] With HBPM, the patient uses a portable device in the home setting to ideally record two sets of multiple BP measurements during a day for consecutive days.[9] However, its use is limited by patient effort and understanding.

Health literacy is the ability by which an individual can attain, process, and understand health information to make educated health decisions.[10] In particular, numeracy, one component of overall health literacy, may affect the way patients process numerical information or the patient's ability to successfully complete health-related tasks in and out of the medical setting.[11–14] Low numeracy skills have been shown to interfere with patients' self-efficacy and health-related skills.[15] Numeracy level has been shown to vary even in highly educated and literate populations,[11,16] and because some home BP monitors require patients to measure and record BP values with time, numeracy level may be more relevant to the successful completion of HBPM and may be more relevant than print literacy alone. To our knowledge, the association of numeracy with quality and completeness of home BP monitoring has not been examined.

The purpose of this study is to investigate the relationship between numeracy level and completeness of home blood pressure reporting, and identify factors that mediate this possible relationship with a specific focus on demographic and socioeconomic characteristics.

Methods

Overall Design and Study Participants

This cross-sectional study was nested in a larger study for which we recruited 420 participants from twelve primary care clinics that participate with a University of North Carolina-led Research Consortium and via flyers posted in a clinical research center in central North Carolina between October 2010 and June 2013. Participants had to be at least

30 years of age, with most recent clinic systolic BP between 120 and 149 mmHg and diastolic BP between 80 to 95 mmHg, able to read and speak English, and able to attend study visits. We enrolled participants 30 years and older since they would potentially have elevated BPs that may lead to meaningful clinical outcomes or would have absolute cardiovascular risk high enough to justify risk-reducing therapies. We excluded patients who were pregnant, had persistent atrial fibrillation or other arrhythmias, had known heart disease including coronary artery disease, had a history of dementia or cognitive disorders, had a diagnosis of diabetes, took anti-hypertensive medications, or had systolic BP ≥ 160 mmHg or ≤ 110 mmHg or diastolic BP ≥ 100 mmHg or ≤ 70 mmHg. This study was approved by the University of North Carolina Institutional Review Board (IRB), and informed consent was obtained from each participant. The study complied with all aspects of the Health Insurance Portability and Accountability Act (HIPAA).

Health Literacy and Numeracy Assessment

We assessed participant health literacy using the Rapid Estimate of Adult Literacy in Medicine–Short Form (REALM-SF)[17] and numeracy using the 3-item numeracy measure commonly used in practice.[18] Each of these measurement tools has been previously validated and widely reported.[17,18] Participant literacy scores were determined by the pronunciation of and time to read medical words (e.g. Menopause, Antibiotics, Exercise, Jaundice, Rectal, Anemia, and Behavior). A score of 0 corresponded with a third grade reading level or below, while a score of 7 corresponded with at least high school education and an ability to read most patient education materials.[17] Participant numeracy scores were calculated by answering three questions that assessed basic familiarity with probability, ability to convert a percentage into a proportion, and ability to convert a proportion back into a percentage.[18] Higher numeracy scores correspond with greater accuracy in interpreting numerical information and applying risk reduction by this measure.[18] These measurements were conducted following initial research office BP measurements in order to avoid the possibility of influencing BP. They were also conducted on separate visits to minimize questionnaire burden. Using the 3-item numeracy scale, we defined “Adequate Numeracy” as a score of 2 or 3 and “Low Numeracy” as a score of 0 or 1.

Office Blood Pressure Measurements

We obtained three research office BP measurements at one visit from the non-dominant arm with the participant seated with feet on the floor. We used an automatic oscillometric monitor to record measurements at one-minute intervals using an appropriate cuff size after an initial 5 minutes of rest to minimize variability in measurements.[19]

Home Blood Pressure Monitoring

We asked participants to perform out-of-office BP measurements in between office visits during two nonconsecutive weeks. We used the Omron 705 CP, an independently validated automatic monitor, for all home BP measurements.[20,21] Participants wore the BP cuff on the non-dominant arm with the proper cuff size determined by upper arm circumference. If the participant’s arm circumference was too large and could not be accommodated by the available BP cuffs, he or she was provided with a Braun Vital Scans Plus wrist BP monitor to obtain home measurements.[22] An in-office test measurement was performed to demonstrate adequate fit and comfort, and participants were observed using the monitor. All subjects were given standardized oral and written instructions on how to the use the BP device. They were instructed to rest in the seated position for five minutes, and then make three measurements at one-minute intervals, and to record values in the mornings and evenings for five consecutive days.[9,23] For every measurement, participants were asked to record the date, time, and systolic and diastolic BP readings onto a pre-printed form. Although participants received education on how to use the home BP monitor, neither teach back education nor any further quality control methods were used. “Completeness” of home BP measurements was calculated as the percentage of total number of recorded measurements that were supposed to be taken by the participant over the two week period that participants performed HBPM. Thus, a participant who reported 60 systolic and 60 diastolic BPs over 2 weeks would have 100% completeness

$$\left(\frac{2\ \textit{measures}\ (1\text{SBP}+1\text{DBP})\times 3\ \text{iterations}\times \text{twice a day}\times 5\ \text{days}\times 2\ \text{measurement periods}}{120\ \text{total possible measurements}}\right).$$

Other Measures

We collected information on race, ethnicity, marital status, education, health status, employment status, and household income using a questionnaire at one visit.

Statistical Analysis

For primary analyses, participants were grouped according to their numeracy score as adequate numeracy or low numeracy (defined above). Participant characteristics were calculated by numeracy level. We then used analysis of covariance (ANCOVA) to assess group differences in completeness of HBPM among individuals with “low” and “adequate” numeracy levels. In an initial model we adjusted for several potential confounders with numeracy level as the exposure and mean percentage of home BP recordings complete as the outcome. There was a strong correlation between education levels and participant numeracy scores (Supplemental Table 1; Goodman and Kruskal’s $\gamma = 0.63$; Pearson’s $\chi^2 = 92.6$, $p<0.001$). Given this correlation, we did not include education in our model as it may serve as an explanatory factor between numeracy and HBPM. In our final adjusted model, we omitted covariates that had relatively equal distribution among those with adequate and low numeracy and covariates that did not have a meaningful effect on adjusted home BP reporting percentages (i.e. statistically not significant or clinical difference less than 0.05%) by numeracy level. Covariates in the final model included gender, race, marital status, health status, income level, and literacy level.

To further evaluate the relationship of numeracy level with HBPM completeness, individuals were stratified with the outcome of ≥85% vs. <85% of completeness of home BP reporting. Although studies indicate variable numbers of minimum HBPM measurements needed to make a clinical decision,[9] we selected this threshold to provide an average estimate of home BPs while minimizing reporting bias by participants. The odds ratios for having completeness of BP <85% was then calculated using logistic regression in unadjusted and adjusted models as described above.

As a secondary analysis, we also assessed the correlation between health literacy and numeracy scores, and analyzed the relationship between health literacy scores and completion of HBPM reporting using simple linear regression. The differences in completed HBPM reporting by low health literacy (score of 5 or less) and high health literacy (score 6 or 7) were compared post hoc using Student's t-test. We also assessed the difference in reported numerical home BP values between numeracy groups. We compared the outcomes mentioned above between participants with low numeracy level to those with adequate numeracy level using the two-sample Student's t-test for continuous variables or Chi-square for categorical variables. All statistical analyses were performed using Stata 13 (StataCorp LP, College Station, Texas).

Power Estimation

This study sample of 420 participants was available as part of a larger BP measurement study. This gave us an 80% power to detect a 5% difference in the effect of numeracy groups on completeness of blood pressure measurement, assuming normal distribution of numeracy scores across the sampled population.

Results

Characteristics of Sample

A total of 409 participants performed both HBPM and completed the numeracy level assessment (99.5%). The other eleven participants did not perform the numeracy assessment and thus were not included in the analysis. Fourteen participants (3%) required a wrist BP monitor for home BP measurements. The mean age of all participants was 47.9 years (Table 1). In this study population, 31% had low numeracy. More participants in the low numeracy group than the adequate numeracy group were female (79% vs. 45%) and black (44% vs. 17%), and the distribution in education levels was lower in the low numeracy group with fewer college graduates than in the adequate numeracy group (51 vs. 84%). The mean research office BP was 125/78 mmHg (±34/32 mmHg) among those with low numeracy level and 129/81 mmHg (±25/23 mmHg) among those with adequate numeracy level. Reported morning home BPs were 128/80 mmHg (±10/7 mmHg) among those with adequate numeracy vs. 129/80 mmHg (±11/11 mmHg) among those with low numeracy (ΔBP of −1/0 mmHg; p=0.5/0.6; Table 2). Home BPs reported in the evening were 130/80 mmHg (±10/8 mmHg) in the adequate numeracy group vs. 131/81 mmHg (±11/8 mmHg) in the comparison group (ΔBP of −1/−1 mmHg; p=0.7/0.1).

Home Blood Pressure Reporting

The home blood pressure reporting averages are shown in Table 3. The unadjusted mean completeness of HBPM reporting among those with low numeracy level was 93.7% vs. 96.2% among the adequate numeracy group. After adjusting for gender, race, marital status, health status, income level, and literacy level, the difference in mean completeness of HBPM reporting between both groups was 93.6% vs. 96.2% (p=0.02). There was no relationship between completeness of HBPM reporting and health literacy scores (r=0.0002, p=0.8), and when stratified by low vs. high literacy scores, completion rates between groups were not significantly different (99 vs. 95%, p=0.09).

Participants completing a minimum of 85% of reported HBPM are shown in Table 4. Of those with low numeracy level, 11.9% did not complete at least 85% of HBPM reporting compared to 5.9% in the adequate numeracy level group (p=0.018), with an odds ratio of 2.41 (95% CI: 1.14, 5.11).

Discussion

In this cross-sectional study, we examined how adults who were not on BP medications performed on a numeracy assessment and home BP reporting. Participants with lower numeracy scores completed home BP reporting less often than those with higher numeracy scores, which held true after adjusting for gender, race, marital status, health status, income level, and literacy level. One-third of our participants exhibited low numeracy despite having overall high literacy scores and education levels, which is consistent with other studies characterizing numeracy deficits in educated populations.[11,16] Although the absolute difference in completed home BP reporting by numeracy level was 3%, there was no difference in blood pressure in low and high numeracy groups. Further, within our study population, we found no clear relationship between health literacy scores and completion of home BP reporting.

This must be interpreted in the context of our sample in which college graduates comprised 51% and 84% of subjects in the low and adequate numeracy groups, respectively. These levels of educational attainment among the numeracy groups are higher than compared to the general United States population, in which 34% of those aged 25–29 years have a college degree.[24] The difference in home BP completion rates by numeracy level may be substantially higher in cohorts that are more representative of the US population.

Numeracy has more recently been studied alongside literacy as a set of essential skills that may play a role in the patient's understanding of health risks, knowledge, and medical decision-making.[11–13] Although most studies have assessed numeracy in the context of oral and written communication, data examining the relationship between numeracy and the patient's ability to perform health-related tasks is insufficient.[15] Our study findings suggest that low numeracy may be an additional barrier to successful HBPM completion. We hypothesize that the association between low numeracy level and less HBPM completion could, in part, be attributed to a fear of working with numbers. Existing studies report other barriers to successful HBPM completion include failure of recognized benefits, lack of knowledge of cuff use, time required for monitoring, forgetfulness, lack of personal assistance, and misunderstanding of how to report.[25,26] Future studies are needed to further elucidate these potential explanations. We did not collect data to distinguish among them.

Low health literacy has been associated with poorer ability to take medications appropriately, more difficulty interpreting health messages, reduced use of some preventive health services, increased emergency department visits and hospitalizations, and increased mortality among older populations.[15,27] Health literacy has also been shown to play a role in increased prevalence of hypertension and reduced hypertension-related knowledge.[28–30] Within our study population, we found no clear relationship between health literacy scores and completion of home BP reporting. Although differences in health literacy scores were statistically significant between the numeracy groups, both groups averaged at or above a high school reading level, minimizing the likelihood that a clinical difference in participant ability to read the health education materials explains the difference in home BP reporting.

Incomplete reporting of HBPM potentially limits the accurate identification of uncontrolled or masked hypertension in patients who would benefit from anti-hypertensive therapy,[6,31] limits monitoring of the effectiveness of therapy in treated uncontrolled patients to prevent secondary complications of chronic hypertension,[6–8] and may lead to misclassification and potential overtreatment among patients with acceptable out-of-office blood pressures. Addressing barriers such as numeracy level may improve HBPM adherence and appropriate classification of patients with borderline high blood pressures.

Previous studies have determined that approximately 43% of primary care patients with hypertension perform HBPM, and of these, the primary reasons for self-measuring BP were out of curiosity to know their blood pressures (55.2%) or under advisement or oversight by a physician (29.6–35.2%).[32,33] Those who were more likely to perform HBPM were older, had a history of transient ischemic attack or stroke, or had higher hypertension knowledge.[33] In one study of primary care patients with hypertension, approximately one-third reported using their monitor at least a few times per month, less than 30% reported using it every day, and some measured their BP only when they had certain symtoms.[33] Less than one-third indicated that they reported the BP measurements to their physician.[32] The inconsistent use of HBPM may diminish effective management of hypertension among patients who are not yet at their target BP compared to its demonstrated effective use in other studies.[34] Part of the problem may lie in patient understanding and manipulation of numerical BP values in the management of hypertension. It is worth noting that studies demonstrating the utility of home BP monitoring have utilized specific measurement protocols, and to assume that less regimented home monitoring contributes to better management may not be justified.

In interpreting results, readers should be aware that our study has several limitations. We included only untreated patients with borderline elevated BPs, and the results may not be generalizable to populations with a more uniform distribution of clinic BPs or to patients with treated hypertension. HBPM was also performed over two separate weeks, and participants could have gained knowledge and skills when performing the health-related task during the first week that may have influenced completion rates during the second week (Supplemental Table 2). Participants were recruited from primary care clinics that participate in a research consortium, and the education on HBPM use in these clinics may have been more intense and thorough than in other health care practices. Also, by participating in this research study about BP, participants may have been more motivated to complete home BP measurements. With regards to our numeracy assessment, we administered a 3-item widely used measure to categorize our study population into low and adequate numeracy groups. The outcome of home BP measurement completion may differ by use with other assessment tools and numeracy level stratifications. Regarding the quality of home BP measurements, we were unable to assess accuracy of reported home BPs due to the limited number of measurements that could be stored on the home BP monitor device memory.

To our knowledge, this is the first study to report that higher numeracy level is associated with more complete reporting of home blood pressures. In this relatively well-educated cohort, home monitoring was successfully accomplished even in those with low numeracy. Given the differences in demographic characteristics between our numeracy groups, numeracy level may also play a role in disparities among race, marital status, health status, and household income level. Numeracy may also serve as a predictor of poorer completion of other health-related skills involving numerical information, and addressing low numeracy may help overcome similar barriers that also affect completion of HBPM. Furthermore, those with low numeracy may benefit from using home BP monitors with device memory automatically record BPs for the physician to review.

In conclusion, adequate numeracy, but not high literacy, is associated with more complete reporting of HBPM, although the difference is small. Further studies are required to examine the relationship between numeracy level and the quality of home blood pressure monitoring in order to assess whether numeracy level is associated with accuracy of reporting and other health outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Financial Support: Grant R01 HL098604 from the National Heart Lung and Blood Institute (to AJV), Grant UL1 RR025747 from the National Institutes of Health (to AJV), and Grant P01-HL047540 from the National Heart Lung and Blood Institute (to DS).

The authors would like to acknowledge Emily Olsson and Kristin Stankevitz for providing valuable research assistance. This study was supported by Grant R01 HL098604 from the National Heart Lung and Blood Institute, with additional support provided through grant UL1 RR025747 from the National Institutes of Health. Vishal N. Rao had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

References

1. Lewington S, Clarke R, Qizilbash N, et al. Prospective Studies Collaboration, Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. Lancet. 2002; 360(9349):1903–13. [PubMed: 12493255]
2. Pastor-Barriuso R, Banegas JR, Damián J, Appel LJ, Guallar E. Systolic Blood Pressure, Diastolic Blood Pressure, and Pulse Pressure: An Evaluation of Their Joint Effect on Mortality. Annals of Internal Medicine. 2003; 139(9):731–9. [PubMed: 14597457]
3. Law MR, Morris JK, Wald NJ. Use of blood pressure lowering drugs in the prevention of cardiovascular disease: meta-analysis of 147 randomised epidemiological studies. British Medical Journal. 2009; 338(b1665):1–19.
4. Go AS, Mozaffarian D, Roger VL, et al. Heart Disease and Stroke Statistics--2014 Update: A Report from the American Heart Association. Circulation. 2014; 129(3):e28–e292. [PubMed: 24352519]
5. CDC: Centers for Disease Control and Prevention. Awareness and Treatment of Uncontrolled Hypertension Among Adults — United States, 2003–2010. Morbidity and Mortality Weekly Report (MMWR). 2012; 61(35):703–709. Available at: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6135a3.htm. [PubMed: 22951452]

6. Hodgkinson J, Mant J, Martin U, et al. Relative effectiveness of clinic and home blood pressure monitoring compared with ambulatory blood pressure monitoring in diagnosis of hypertension: systematic review. British Medical Journal. 2011; 342(d3621):1–17.

7. Tsunoda S, Kawano Y, Horio T, Okuda N, Takishita S. Relationship between home blood pressure and longitudinal changes in target organ damage in treated hypertensive patients. Hypertension Research. 2002; 25(2):167–73. [PubMed: 12047030]

8. Mulè G, Caimi G, Cottone S, et al. Value of home blood pressures as predictor of target organ damage in mild arterial hypertension. Journal of Cardiovascular Risk. 2002; 9(2):123–9. [PubMed: 12006920]

9. Verberk WJ, Kroon Aa, Kessels AGH, de Leeuw PW. Home Blood Pressure Measurement: A Systematic Review. Journal of the American College of Cardiology. 2005; 46(5):743–51. [PubMed: 16139119]

10. Nielsen-bohlman, L.; Panzer, AM.; Kindig, DA. Institute of Medicine of the National Acadmies. 2004. Health Literacy A Prescription to End Confusion; p. 1-41.

11. Rothman RL, Montori VM, Cherrington A, Pignone MP. Perspective: The Role of Numeracy in Health Care. Journal of Health Communication. 2008; 13(6):583–95. [PubMed: 18726814]

12. Chen Y, Feeley TH. Numeracy, Information Seeking, and Self-Efficacy in Managing Health: An Analysis Using the 2007 Health Information National Trends Survey (HINTS). Health communication. 2013 Feb.:37–41.

13. Reyna VF, Nelson WL, Han PK, Dieckmann NF. How numeracy influences risk comprehension and medical decision making. Psychological Bulletin. 2009; 135(6):943–73. [PubMed: 19883143]

14. Ciampa PJ, Osborn CY, Peterson NB, Rothman RL. Patient Numeracy, Perceptions of Provider Communication and Colorectal Cancer Screening Utilization. Journal of Health Communication. 2010; 15(Suppl 3):157–168. [PubMed: 21154091]

15. Berkman ND, Sheridan SL, Donahue KE, et al. Health Literacy Interventions and Outcomes: An Updated Systematic Review. Evidence report/technology assessment. 2011; (199):1–941. [PubMed: 23126607]

16. Lipkus IM, Samsa G, Rimer BK. General Performance on a Numeracy Scale among Highly Educated Samples. Medical Decision Making. 2001; 21(1):37–44. [PubMed: 11206945]

17. Arozullah AM, Yarnold PR, Bennett CL, et al. Development and Validation of a Short-Form, Rapid Estimate of Adult Literacy in Medicine. Medical Care. 2007; 45(11):1026–33. [PubMed: 18049342]

18. Schwartz LM, Woloshin S, Black WC, Welch HG. The role of numeracy in understanding the benefit of screening mammography. Annals of Internal Medicine. 1997; 127(11):966–72. [PubMed: 9412301]

19. O'Brien E, Pickering T, Asmar R, et al. O'Brien 2002.pdf. Blood Pressure Monitoring. 2002; 7(1): 3–17. [PubMed: 12040236]

20. Artigao L, Llavador J, Puras A, et al. Evaluation and validation of Omron Hem 705 CP and Hem 706/711 monitors for self-measurement of blood pressure. Aten Primaria. 2000; 25(2):96–102. [PubMed: 10736939]

21. Iglesias Bonilla P, Mayoral Sánchez E, Lapetra Peralta J, et al. Validation of two systems of self-measurement of blood pressure, the OMRON HEM-705 CP and OMRON M1 (HEM 422C2-E) models. Aten Primaria. 2002; 30(1):22–28. [PubMed: 12106576]

22. Nolly H, Osso P, Nolly A, et al. Self-measurement of blood pressure: validation of the Braun BP VitalScan Plus 1650 monitor according to the European Society of Hypertension International Protocol. Blood pressure monitoring. 2008; 13(2):101–6. [PubMed: 18347444]

23. Verberk WJ, Kroon Aa, Kessels AGH, et al. The optimal scheme of self blood pressure measurement as determined from ambulatory blood pressure recordings. Journal of Hypertension. 2006; 24(8):1541–8. [PubMed: 16877956]

24. U.S. Department of Education NC for ES. The Condition of Education: Educational Attainment. 2014. p. 1Available at: http://nces.ed.gov/programs/coe/indicator_caa.asp

25. Huff LS, Zittleman L, DeAlleaume L, et al. What Keeps Patients from Adhering to a Home Blood Pressure Program? Journal of the American Board of Family Medicine: JABFM. 2011; 24(4):370–9. [PubMed: 21737761]

26. Tan NC, Khin LW, Pagi R. Home blood-pressure monitoring among hypertensive patients in an Asian population. Journal of Human Hypertension. 2005; 19(7):559–64. [PubMed: 15944723]
27. Bostock S, Steptoe A. Association between low functional health literacy and mortality in older adults: longitudinal cohort study. British Medical Journal. 2012; 344(e1602):1–10.
28. Pandit AU, Tang JW, Bailey SC, et al. Education, literacy, and health: Mediating effects on hypertension knowledge and control. Patient Education and Counseling. 2009; 75(3):381–5. [PubMed: 19442477]
29. Shibuya A, Inoue R, Ohkubo T, et al. The relation between health literacy, hypertension knowledge, and blood pressure among middle-aged Japanese adults. Blood pressure monitoring. 2011; 16(5):224–30. [PubMed: 21857504]
30. Gazmararian, Ja; Williams, MV.; Peel, J.; Baker, DW. Health literacy and knowledge of chronic disease. Patient Education and Counseling. 2003; 51(3):267–75. [PubMed: 14630383]
31. Pierdomenico SD, Cuccurullo F. Prognostic Value of White-Coat and Masked Hypertension Diagnosed by Ambulatory Monitoring in Initially Untreated Subjects: An Updated Meta-Analysis. American Journal of Hypertension. 2011; 24(1):52–8. [PubMed: 20847724]
32. Viera AJ, Cohen LW, Mitchell CM, Sloane PD. How and why do patients use home blood pressure monitors? Blood Pressure Monitoring. 2008; 13(3):133–7. [PubMed: 18496286]
33. Viera AJ, Cohen LW, Mitchell CM, Sloane PD. Use of Home Blood Pressure Monitoring by Hypertensive Patients in Primary Care: Survey of a Practice-Based Research Network Cohort. Journal of Clinical Hypertension. 2008; 10(4):280–6. [PubMed: 18401225]
34. Agarwal R, Bills JE, Hecht TJW, Light RP. Role of Home Blood Pressure Monitoring in Overcoming Therapeutic Inertia and Improving Hypertension Control: A Systematic Review and Meta-Analysis. Hypertension. 2011; 57(1):29–38. [PubMed: 21115879]

Table 1

Study Participant Characteristics by Numeracy Level

Demographics	Total (N = 409)	Numeracy Level		p-value[1]
		Low (0–1) (N = 126)	Adequate (2–3) (N = 283)	
Age in years, mean (SD)	47.9 (12.0)	47.9 (11.7)	47.9 (12.1)	0.99
Female, n (%)	228 (56)	100 (79)	128 (45)	<0.001
Race, n (%)				<0.001
White	306 (75)	71 (56)	235 (83)	<0.001
Black	87 (21)	51 (40)	36 (13)	<0.001
Asian	11 (3)	2 (2)	9 (3)	0.36
Other	5 (1)	2 (2)	3 (1)	0.65
Ethnicity, n (%)				
Hispanic	16 (4)	8 (6)	8 (3)	0.09
Non-Hispanic	393 (96)	118 (94)	275 (97)	
Marital Status, n (%)				0.002
Married	237 (58)	57 (45)	180 (64)	0.001
Widowed	9 (2)	6 (5)	3 (1)	0.018
Living with partner	30 (7)	15 (12)	15 (5)	0.018
Separated/Divorced	73 (18)	27 (21)	46 (16)	0.2
Never Married	60 (15)	21 (17)	39 (14)	0.4
Education, n (%)				<0.001
Some high school	5 (1)	4 (3)	1 (0)	0.017
High school grad	24 (6)	17 (13)	7 (2)	<0.001
Some college	79 (19)	41 (33)	38 (13)	<0.001
College Grad	301 (74)	64 (51)	237 (84)	<0.001
Health, n (%)				<0.001
Excellent	79 (19)	19 (15)	60 (21)	0.15
Very Good	198 (48)	49 (39)	149 (53)	0.010
Good	109 (27)	44 (35)	65 (23)	0.012
Fair	22 (5)	13 (10)	9 (3)	0.003
Poor	1 (0)	1 (0)	0 (0)	0.13
Employed, n (%)	321 (78)	92 (73)	229 (81)	0.073
Household Income, n (%)				<0.001
<$15,000	25 (6)	14 (11)	11 (4)	0.005
$15,000–19,999	9 (2)	6 (5)	3 (1)	0.018
$20,000–24,999	15 (4)	7 (6)	8 (3)	0.17
$25,000–29,999	17 (4)	7 (6)	10 (4)	0.34
$30,000–34,999	18 (4)	3 (2)	15 (5)	0.19

Demographics	Total (N = 409)	Numeracy Level		p-value[1]
		Low (0–1) (N = 126)	Adequate (2–3) (N = 283)	
\$35,000–39,999	18 (4)	12 (10)	6 (2)	0.001
\$40,000–49,999	29 (7)	12 (10)	17 (6)	0.19
\$50,000–79,999	94 (23)	38 (30)	56 (20)	0.019
\$80,000–99,999	51 (13)	13 (10)	38 (13)	0.39
≥\$100,000	132 (32)	13 (10)	119 (42)	<0.001
Literacy Score, mean (SD)	6.87 (0.46)	6.76 (0.68)	6.92 (0.32)	0.001
Clinic Blood Pressure in mmHg, mean (SD)	128/80 (28.5/25.9)	125/78 (34.1/31.7)	129/81 (25.5/22.8)	0.2 0.3

[1] p-value calculated using Chi-squared test for categorical variables and t-test for continuous variables.

Table 2

Reported Home Blood Pressures by Numeracy Level

Demographics	Total (N = 409)	Numeracy Level		p-value[1] (SBP/DBP)
		Low (0–1) (N = 126)	Adequate (2–3) (N = 283)	
<u>**Overall**</u>				
Morning BPs in mmHg, mean (SD)	128/80 (11/9)	129/80 (11/11)	128/80 (10/7)	0.5/0.6
Evening BPs in mmHg, mean (SD)	130/80 (11/8)	131/81 (11/8)	130/80 (10/8)	0.7/0.1
<u>**Week 1**</u>				
Morning BPs in mmHg, mean (SD)	129/80 (11/8)	129/81 (12/8)	128/80 (11/7)	0.5/0.2
Evening BPs in mmHg, mean (SD)	130/80 (11/8)	131/81 (12/8)	130/79 (11/8)	0.4/0.1
<u>**Week 2**</u>				
Morning BPs in mmHg, mean (SD)	128/80 (11/12)	129/80 (12/18)	128/80 (11/8)	0.6/0.9
Evening BPs in mmHg, mean (SD)	130/80 (11/8)	130/81 (11/8)	130/80 (11/8)	0.9/0.1

[1] p-value calculated using t-test; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Table 3

Home BP Completeness by Numeracy Level

	Numeracy Level		p-value
	Low (0–1) (N=126)	**Adequate (2–3) (N=283)**	
Mean HBPM, % (SE)[1]	93.7 (0.008)	96.2 (0.005)	0.009
Mean HBPM, % (SE)[2]	93.6 (0.009)	96.2 (0.005)	0.020

[1]Unadjusted using t-test

[2]Adjusted for gender, race, marital status, health status, income level, and literacy level using linear regression

Table 4

85% or Greater Home BP reporting by Numeracy Level

	Numeracy Level		p-value
	Low (0–1) (N=126)	**Adequate (2–3) (N=283)**	
≥85% Reporting, %[1]	88.1	94.7	0.018

[1] p-value calculated using Chi-Squared test