NIH Public Access
Author Manuscript
Acad Pediatr. Author manuscript; available in PMC 2010 September 1.

Published in final edited form as:
Acad Pediatr. 2009 ; 9(5): 330–338. doi:10.1016/j.acap.2009.05.028.

Color-coding Improves Parental Understanding of Body Mass Index Charting

Matthew D. Oettinger, BS[1], **Joanne P. Finkle, RN, JD**[2,3], **Denise Esserman, PhD**[4], **Lisa Whitehead, MD**[3], **Thomas K. Spain, BS**[5], **Steven R. Pattishall, BS**[1], **Russell Rothman, MD, MPP**[6], and **Eliana M. Perrin, MD, MPH**[2,3]

[1] University of North Carolina School of Medicine, Chapel Hill, NC

[2] Division of General Pediatrics and Adolescent Medicine, University of North Carolina School of Medicine, Chapel Hill, NC

[3] Department of Pediatrics, University of North Carolina School of Medicine, Chapel Hill, NC

[4] Division of General Medicine and Clinical Epidemiology, University of North Carolina School of Medicine, Chapel Hill, NC

[5] Vanderbilt University School of Medicine, Nashville, TN

[6] Center for Health Services Research, Vanderbilt University Medical Center, Nashville, Tennessee, Nashville, TN

Abstract

Objectives—To assess parental understanding of body mass index (BMI) and BMI percentiles using standard versus color-coded charts and investigate how parental literacy and/or numeracy (quantitative skills) impacts that understanding.

Methods—A convenience sample of 163 parents of children aged 2–8 years at two academic pediatric centers completed a demographics questionnaire, the mathematics portion of the Wide Range Achievement Test (WRAT-3R), the Short Test of Functional Health Literacy in Adults (S-TOFHLA), and an “Understanding BMI” questionnaire, which included parallel BMI charting questions to compare understanding of standard versus color-coded BMI charting. Outcomes included parental-reported versus actual understanding of BMI, the odds (obtained by generalized estimating equations) of answering parallel questions correctly using standard versus color-coded charting, and odds of answering questions correctly based on numeracy and literacy.

Results—Many parents (60%) reported knowing what BMI was, but only 30% could define it even roughly correctly. Parents using color-coded charts had greater odds of answering parallel BMI charting questions correctly than parents using standard charts (mean 88% vs. 65% correct; pooled AOR=4.32, 95% CI: 3.14–5.95; p<.01). Additionally, parents with lower numeracy (K-5 level) benefited more from color-coded charts (increased from 51% to 81% correct) than did higher numeracy parents (≥ high school level), who performed well using both charts (89% vs. 99% correct).

Corresponding Author: Eliana M. Perrin, MD, MPH, University of North Carolina School of Medicine, Department of Pediatrics, Division of General Pediatrics and Adolescent Medicine, 231 MacNider Building, 333 South Columbia Street, CB #7225, Chapel Hill, NC 27599-7225, eliana_perrin@med.unc.edu (e-mail), 919-966-2504 (phone), 919-966-3852 (fax).

Conflicts of Interest: There are no conflicts of interest to report.

Conclusions—Parents consistently performed better using color-coded than standard BMI charts. Color-coding was particularly helpful for lower numeracy parents. Future studies should investigate whether these results translate into offices and whether understanding motivates parents toward important lifestyle change.

Keywords

Body Mass Index; Overweight; Obesity; Literacy; Numeracy

INTRODUCTION

Childhood obesity in the United States is increasing at an alarming rate, creating challenges for healthcare providers. Early treatment can prevent worsening weight status.[1] Although best strategies for preventing and treating obesity continue to evolve, national policy statements urge pediatricians to discuss behavioral changes with parents (e.g., limiting television, limiting sweetened drinks, and increasing physical activity), particularly for children at higher risk.[2] While pediatricians and parents seem well-positioned to help children reverse unhealthy weight patterns,[2, 3] initiating these or other behavioral prescriptions requires parental motivation. One of the barriers to motivation may be that both providers and parents under-recognize the problem for individual children.

Parents often fail to recognize when their children are overweight; this is particularly true for young children.[4–7] Additionally, prior studies have demonstrated that fewer than 20% of pediatric physicians routinely use recommended Centers for Disease Control and Prevention (CDC) age- and gender-specific Body Mass Index (BMI; BMI= kg/m^2) charts, explicitly designed to screen for unhealthy weight trajectories.[8, 9] In one study of health supervision visits, only 6% of visits had BMIs plotted.[10] Pediatrics providers also report low self-efficacy in managing obesity, citing multiple barriers including poor patient and parent motivation.[11–13] One study noted that 65% of pediatricians believed “caregiver does not perceive weight as a problem” to be a frequent barrier to optimal care.[14] Furthermore, according to focus group study, concern about parents not understanding BMI’s complexity deters some pediatricians from discussing it.[15]

Few data exist to indicate whether or not parents do, in fact, understand BMI. Literacy and numeracy skills are likely required to understand and review BMI charting with health professionals. How literacy and numeracy affect understanding of BMI charting, though, has not been previously reported. Assessing whether parents understand BMI and developing effective tools for conveying children’s BMI status to parents in pediatricians’ offices could facilitate improved parental BMI understanding and motivation. Such understanding and motivation would allow pediatricians to partner with parents to implement recommended obesity prevention and treatment strategies.

One potentially helpful communication tool is a color-coded BMI chart. Color-coding assigns “stop light” green, yellow, and red colors to increasingly concerning zones of weight status, analogous to the frequently-used “Asthma Action Plan.”[16, 17] It has been previously described as helpful to primary care pediatricians’ efforts.[18, 19] Whether color-coding the BMI chart facilitates understanding for parents, however, has not been investigated.

The goals of this study were as follows: to assess parental understanding of BMI charting using both currently available, standard BMI charts[20] and color-coded BMI charts; and to determine the relationship between health literacy and numeracy skills and the ability to comprehend standard and color-coded BMI charting. We hypothesized that parents would interpret color-coded BMI charts more accurately than standard charts, and parents with lower health literacy and numeracy skills would be especially helped by color-coding.

Methods

Participants

A convenience sample of parents or caregivers was recruited from the waiting room of the University of North Carolina primary care and subspecialty pediatrics clinic and the Vanderbilt University primary care clinic waiting room at varying times of the day and week for this cross-sectional study. Individuals were approached as they entered the waiting room after checking into clinic and asked if they were interested in participating in the study. Those who agreed to participate received a small ($10.00) monetary honorarium on completion of the study. This study was approved by the UNC IRB (#06-0978) and the Vanderbilt IRB (#071014).

Caregivers were deemed eligible if they had a child aged 2–8, spoke English, had sufficient vision (visual acuity >20/50 using the Rosenbaum Pocket Vision Screener), and did not have a neurologic or mental illness that would interfere with their ability to complete the questionnaire. Parents were considered to speak English if they were planning to communicate with their child's doctor in English during their clinic visit (without the use of an interpreter) so as to simulate a real clinic experience and level of understanding. All caregivers were screened for colorblindness using the Neitz test of color vision; however, colorblindness was not an exclusion criterion.

Data collection

All questionnaires were administered to the caregiver on a one-to-one basis in a confidential manner and took approximately 20–30 minutes to complete. Participants completed a short demographic questionnaire assessing race, ethnicity, educational attainment, and insurance status (Medicaid, TennCare, private insurance, or none). They were then given the previously validated Short Test of Functional Health Literacy in Adults (S-TOFHLA) to assess health literacy,[21] followed by part I of the "Understanding BMI" questionnaire, described below. After Part I, the participants completed the mathematics portion of the Wide Range Achievement Test (WRAT-3R), a previously validated measure,[22] to assess numeracy or quantitative skills (this was placed in between Parts I and II of the Understanding BMI questionnaire to distract participants). Finally, they completed Part II of the Understanding BMI questionnaire.

Understanding BMI questionnaire

Part I of the Understanding BMI questionnaire included: 1) a question asking the ages of all children in the household; 2) a question as follows: "During any of your child(ren)'s last regular check ups, did the doctor talk to you about Body Mass Index (BMI)?"; 3) assessment of parents' baseline understanding of BMI by an open-ended question where parents were asked to provide a definition in open-ended format that was transcribed verbatim; 4) a question asking parents to identify the weight status of a hypothetical child using a reference table but no BMI chart; 5) four closed-ended, multiple choice questions requiring interpretation of standard BMI charts (see Figure 1), and 6) two closed ended, multiple choice "control" questions whose answers were not dependent on color-coding (see Figure 1). Part II of the Understanding BMI questionnaire included the same multiple choice BMI charting questions from Part I (see Figure 1), except color-coded BMI charts were used instead of standard ones for interpretation. Questions in Parts I and II requiring interpretation of BMI charts will be subsequently referred to as "parallel BMI charting questions." To minimize the effect of question order on participant response, the parallel BMI charting questions were randomized to a different order for Part II versus Part I.

On the color-coded charts, areas were shaded green indicating "healthy weight" (5^{th} to < 85^{th} percentile), yellow indicating "at risk for overweight" (85^{th} to < 95^{th} percentile), or red indicating either "overweight" or "underweight" ($\geq 95^{th}$ or $< 5^{th}$ percentiles, respectively) (see Figure 2). Each question using a BMI chart included a key, explaining the significance of each color for color-coded charts (e.g., "on this chart, green indicates healthy weight," etcetera) or the percentile lines for standard charts (e.g., "on this chart, between the 5^{th} percentile and 85^{th} percentile indicates healthy weight," See Figure 1). All BMI questions were worded and read to caregivers by the research assistant in a way intended to simulate how clinicians present information about BMI. On questions requiring BMI chart interpretation, the research assistant also pointed to the "X" on the chart for each question, when applicable, in order to further simulate clinician communication.

Of note, the recommended terminology for obesity changed during the study period, with the previous "at-risk" category now "overweight" and the previous "overweight" category now "obese."[2] For consistency, the initial terminology and BMI categories were used for the "Understanding BMI" questionnaire throughout the project and will be reported as such here.

Data Analysis

Descriptive statistics were calculated for the combined sample and for each of the two sites. Comparisons between the sites were made using Fisher's exact test for categorical variables and the two-sample t-test for continuous variables. Fisher's exact test was also used to compare parents' understanding of BMI using the standard charts among those who had discussed BMI with their physicians at a prior regular check ups and those who had not.

The correctness of parents' open-ended BMI definition was determined using a 2 out of 3 consensus amongst co-authors (EP, MO, and JF) blinded to other parent data. A BMI definition was considered "correct" if the caregiver included the notion that BMI is the way medical personnel determine whether a child is at a healthy weight and/or if the caregiver described that BMI accounts for differences in weight by height. The correct mathematical equation was not necessary. The agreement of "correctness" of the three researchers was assessed using kappa as a measure of inter-rater reliability. Logistic regression was employed to calculate the odds ratio (OR) of understanding BMI (the ability to correctly define BMI in an open-ended short-answer format) based on WRAT-3R, S-TOFHLA scores, education, income, race, and insurance, adjusting for site.

The proportion of parents correctly answering each of the four multiple choice parallel BMI charting questions requiring interpretation of standard and color BMI charts and two control questions was calculated. The individual proportion for each question, in addition to a pooled estimate of the overall percent correct, was obtained for each of the BMI chart types. Generalized estimating equations (GEE) with an exchangeable correlation matrix, logistic link function and individual clusters were used to calculate ORs for answering a question correctly using the color-coded versus standard chart. Models were run for each combined individual question pair of parallel BMI charting questions (standard and color-coded) adjusted for site, and by site, and for the pooled data (excluding control questions), adjusting for question since there was variability in response to the different questions, for both the combined sample (adjusted for site) and by site. The pooled data were used to explore the association between answering a question correctly and each of the following variables independently adjusting for chart type (standard versus color-coded), question, and site (for combined sample): continuous standardized WRAT-3R score or raw S-TOFHLA score, years of education, income, type of insurance (public, including Medicaid, AccessCare, North Carolina's Medicaid managed care, and Tenncare, Tennessee's Medicaid managed care, or private), mean age of youngest child, number of children, and race/ethnicity (black/African American, white, "other", Hispanic). Due to the extremely small number in the "no insurance" group, we excluded those individuals

(2 total) rather than arbitrarily assign them since they could not be in their own group due to model convergence issues.

Individuals were then stratified into three groups based on their WRAT-3R scores: K-5; Middle School; or High School and greater. Due to sample size constraints, only combined data were used to explore the relationship between a parent's numeracy level and the difference in performance using standard versus color-coded charts on the parallel BMI charting questions; analyses were completed for each individual question as well as the pooled sample. Since 94% of the sample classified as "adequate" health literacy based on S-TOFHLA score,[21] conducting a similar stratified analysis for health literacy was not possible. Statistical significance was established at a p<0.05. All analyses were conducted using SAS version 9.1 (SAS Institute Inc., Cary, NC).

Results

The majority of individuals approached for the study participated (66 refused, 54 were ineligible, and 2 did not complete the study). Demographic characteristics of the final sample (N=163) are summarized in Table 1. Differences between sites were noted and accounted for in subsequent analyses. The majority of parents identified as either black/African American (48%) or white (38%). Nearly 40% had an annual income less than $20,000; 66% were publicly insured. A large majority (84%) had WRAT-3R scores at or below middle school numeracy.[22] Most (94%) parents had "adequate" health literacy.[23] None screened as colorblind.

On average, both groups answered 65% of the standard BMI charting questions correctly. Less than a third (27%) said their child's doctor had discussed BMI at a prior regular check-up with their child(ren). However, these parents did not differ from parents who reported not discussing BMI at a prior check-ups in their ability to correctly interpret BMI charts.

Sixty percent of parents responded that they knew what BMI was, but only 30% could correctly define BMI in open-ended format (in 89% of cases where some answer was provided, all reviewers agreed as to its correctness; kappa = 0.85). The odds of providing a correct definition of BMI were 1.06 (95% CI 1.00–1.13; p=0.04) and 1.18 (95% CI 1.02–1.37; p=0.03) times greater for each point higher an individual scored on the WRAT-3R and S-TOFHLA, respectively. The odds of providing a correct definition of BMI were 1.28 (95% CI 1.11–1.47; p=0.0005) times greater for each additional year increase in education, 6.53 (95% CI 1.59–26.73) times greater for those in the $40,000–60,000 income range and 4.83 (95% CI 1.50–15.50) times greater for those earning $60,000 or greater, both compared to those earning < $10,000. Those who were white were 2.71 times (95%CI 1.25–5.87) times greater than those who were black/African American to be correct (Hispanics and "other" were not significantly different than black/African American). Finally, those with public insurance were 0.37 (95% CI 0.18–0.76) times as likely as those with private insurance to provide a correct definition.

On pooled parallel BMI charting questions, parents were correct 65% of the time using standard charting compared to 88% using the color-coded charting. After adjusting for site and question variability, this translates into over four times greater odds of answering a question correctly using the color-coded charting compared to the standard charting (OR 4.32, 95% CI 3.14–5.95) (Table 2). This significant difference was similar for both sites. When individual parallel BMI charting questions were assessed separately, parents from the combined sample scored better using the color-coded than the standard BMI charts on every question (all p values <0.01) (Table 2). In contrast, for two control questions, where interpretation of the questions were independent of the charting's color-coding scheme, the odds of answering a question correctly were not significantly greater using color-coded compared to standard charts (p=0.62 for Control Question 1 and p=0.53 for Control Question 2). This reflects the specificity of the color-coding “intervention” as well as arguing against a learning effect of having the standard chart questions first.

Higher continuous S-TOFHLA and WRAT-3R scores, greater number of years of education, being at the highest compared to lowest income bracket, having private versus public insurance, and being white or of “other race” rather than Black or African American were all associated with greater odds of answering a parallel BMI charting question correctly regardless of whether the question was asked using a standard or color-coded chart. Neither number of children nor age of the youngest child was related to correct answers of parallel BMI charting. All odds ratios are shown in Table 3. Analyses done by site revealed similar results, though data are not shown.

While color-coding was associated with higher scores on the BMI charting questions for all numeracy levels, the greatest benefit was experienced by those with lower numeracy. Parents with K-5 level numeracy increased from an average of 51% correct on the standard charts to 81% on the color-coded charts (30% difference, $p < 0.0001$), those with middle school numeracy went from averages of 70% to 90% (23% difference, $p < 0.0001$), and those with high school or greater numeracy went from 89% to 99%) (10% difference, $p = 0.011$).

DISCUSSION

Our study assessed parental understanding of BMI, investigated demographic factors associated with BMI chart understanding, and tested differentials in parental understanding using standard versus color-coded BMI charts. Previous studies have shown that pediatricians hesitate to show BMI charts to parents, believing that parents will not be able to understand their complexity.[15] With standard BMI charts, parents answered less than two-thirds of the questions correctly, even when they reported their child(ren)’s doctor had previously discussed BMI. However, parents universally demonstrated greater understanding using the color-coded BMI charts. Parents demonstrated more than four times greater odds of answering questions correctly using color-coded charts than standard charts. Furthermore, parents with the lowest numeracy demonstrated the largest increases with color-coded charts, suggesting color-coding could help reduce numeracy disparities in understanding BMI charting.

It makes sense that parental numeracy skills would be highly correlated with understanding of BMI and BMI charts since BMI and graphs in general are numerical entities. Previous studies have also shown a link between numeracy and adult understanding of health information that is reliant on numerical skills, such as understanding of food labels,[24] anticoagulation management,[25] interpretation of glucose meter readings and insulin adjustment in patients with diabetes,[26] and asthma management.[27] Similar to our study, several studies found a stronger relationship between comprehension and numeracy than comprehension and literacy.

There are several important limitations of this study. First, our study population had relatively high health literacy, with almost all participants scoring in the “adequate” range on the S-TOFHLA as in other recent studies.[28] Despite this “ceiling effect,” we did find an association between literacy level and the ability to both provide a correct definition of BMI in open-ended format and interpret BMI charts in general. However, we were unable to assess the impact of color-coded BMI charting on parents with inadequate health literacy, which had been one of our initial goals. Second, although our “Understanding BMI” questionnaire was designed to assess parental understanding of BMI charting, there is, as yet, no validated tool to test this. Therefore, it is unclear whether correctly interpreting BMI charting on this questionnaire translates to understanding of a child’s weight status in a real office setting, or, more importantly, whether the ability to interpret a BMI chart would contribute to parental motivation to make recommended lifestyle changes. Third, our study was completed using a convenience sample derived from two large academic centers' pediatrics clinics. While those participating in this study reflected a diverse sample similar demographics to the clinics from which they were recruited, those demographics may or may not be generalizable to other settings. Similarly, due to the non-random nature of recruitment and lack of prior data regarding our population's children's BMIs, it is not possible to confirm that our participants' responses regarding BMI experience and knowledge are typical for the clinic populations in general. However, given that the demographics of our sample are consistent with our clinic populations, there is no particular reason to expect selection bias. Fourth, in one clinic, patients visiting specialty physicians as well as general pediatricians were included, which may account for differences in demographics between sites. To reduce the impact of these between-site differences, such differences were adjusted for in all analyses. Fifth, surprisingly, our study population included no participants with colorblindness on our screen, so it was not possible to assess the interpretability of color-coded BMI charts for those individuals. If color-coded BMI charting (or other color-coded interventions) were to be implemented in practice, categories should be easily distinguishable, even to those who are so-called "red-green" colorblind. Also, our data only allowed the exploration of potential factors associated with understanding BMI; they did not allow for predictive modeling. Therefore, we were unable to ascertain, for example, whether higher education was a proxy for higher numeracy ability, or if higher education itself was an independent predictor of a parents' ability to understand BMI charting. This leaves remaining questions about which parents are most likely to find which type of BMI charting most helpful in discussions about BMI. Finally, the terminology of BMI categories changed during our study, and it is hard to know how much of a role new terminology of BMI categories would help or hinder BMI charting understanding.

Despite these limitations, our findings have important implications. If color-coding helps improve parents' understanding of BMI, doctors may be able to use the color-coded BMI chart as a tool in their practice to communicate weight status to parents more effectively. In one study, when asked what resources would be most helpful, 90% of pediatricians endorsed better tools to communicate weight problems to patients.[14] We also know that parental readiness to make changes is affected by parents' perceptions of their children's weight. One study noted that if parents perceived their children were overweight, they were twice as likely to fall into the preparation/action stage of change to help their children lose weight.[29] In another study, most (68%) parents of obese children who thought their children's weight was unhealthy were told this by a doctor, and more parents whose doctors explained their children's weight as unhealthy were preparing to make lifestyle changes compared with those whose doctors never stated this (75% vs. 25%, $p<0.05$).[30] In a recent British study of the effects of a structured weight communication program, half the parents of young obese children who were told their children's weight was unhealthy reported positive health behavior change, and most wanted such weight-based communication regularly.[31] Finally, when doctors fail to take obesity seriously at younger ages, parents perceive this as a barrier to change health habits.[32] Color-coded BMI charts could be one way to communicate early problems in the universally-understood stop light motif. Whether better communication of BMI to parents leads to increased recognition of their children's weight status and whether such understanding then leads to improved lifestyle or weight trajectories are projects deserving further research, and we have begun to study these important questions.

To our knowledge, our study is the first to evaluate whether use of color-coded charts aids parental understanding of BMI charting. Our results suggest that color-coded BMI charts increase the number of parents who will understand BMI charting, particularly those with lower numeracy. Color-coded BMI charting may be one element in the growing repertoire of tools to assist pediatricians in effectively communicating with parents and may help start a conversation of therapeutic lifestyle change in an era of a childhood obesity epidemic.

Acknowledgments

Funding was provided by the Short-Term Research Training grant from the NIH-National Institute of Diabetes, Digestive and Kidney Diseases (#5 T35DK007386-29; PI: Sandler). Dr. Perrin is supported by an NICHD Career Development Award (#3 K23 HD051817; PI: Perrin). Dr. Rothman is supported by an NIDDK Career Development Award (#5 K23 DK065294; PI: Rothman). Dr. Esserman is supported by the UNC Clinical Translational Science Award (#1 UL1RR025747-01, PI: Pisano).

We would like to acknowledge medical student, Kate Scott, for help with data collection and Drs. Michael Steiner and Andrew Perrin for manuscript draft review. Dr. Eliana Perrin 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.

Abbreviations

BMI
: Body Mass Index

WRAT-3R
: Wide Range Achievement Test

S-TOFHLA
: Short Test of Functional Health Literacy in Adults

References

1. Yoshinaga M, Sameshima K, Miyata K, Hashiguchi J, Imamura M. Prevention of mildly overweight children from development of more overweight condition. Prev Med 2004;38:172–174. [PubMed: 14715208]
2. Barlow SE. Expert Committee. Expert committee recommendations regarding the prevention, assessment, and treatment of child and adolescent overweight and obesity: Summary report. Pediatrics 2007;120 (Suppl 4):S164–92. [PubMed: 18055651]
3. Himes JH, Dietz WH. Guidelines for overweight in adolescent preventive services: Recommendations from an expert committee. The expert committee on clinical guidelines for overweight in adolescent preventive services. Am J Clin Nutr 1994;59:307–316. [PubMed: 8310979]
4. Baughcum AE, Chamberlin LA, Deeks CM, Powers SW, Whitaker RC. Maternal perceptions of overweight preschool children. Pediatrics 2000;106:1380–1386. [PubMed: 11099592]
5. Etelson D, Brand DA, Patrick PA, Shirali A. Childhood obesity: Do parents recognize this health risk? Obes Res 2003;11:1362–8. [PubMed: 14627757]
6. Jain A, Sherman SN, Chamberlin DL, Carter Y, Powers SW, Whitaker RC. Why don't low-income mothers worry about their preschoolers being overweight? Pediatrics 2001;107:1138–46. [PubMed: 11331699]
7. Maynard LM, Galuska DA, Blanck HM, Serdula MK. Maternal perceptions of weight status of children. Pediatrics 2003;111:1226–31. [PubMed: 12728143]
8. Barlow SE, Dietz WH, Klish WJ, Trowbridge FL. Medical evaluation of overweight children and adolescents: Reports from pediatricians, pediatric nurse practitioners, and registered dietitians. Pediatrics 2002;110:222–228. [PubMed: 12093999]
9. Perrin EM, Flower KB, Ammerman AS. Body mass index charts: Useful yet underused. J Pediatr 2004;144:455–460. [PubMed: 15069392]
10. Barlow SE, Bobra SR, Elliott MB, Brownson RC, Haire-Joshu D. Recognition of childhood overweight during health supervision visits: Does BMI help pediatricians? Obesity (Silver Spring) 2007;15:225–232. [PubMed: 17228051]
11. Story MT, Neumark-Stzainer DR, Sherwood NE, et al. Management of child and adolescent obesity: Attitudes, barriers, skills, and training needs among health care professionals. Pediatrics 2002;110:210–214. [PubMed: 12093997]
12. Kolagotla L, Adams W. Ambulatory management of childhood obesity. Obes Res 2004;12:275–283. [PubMed: 14981220]

13. Jelalian E, Boergers J, Alday CS, Frank R. Survey of physician attitudes and practices related to pediatric obesity. Clin Pediatr (Phila) 2003;42:235–45. [PubMed: 12739922]
14. Perrin EM, Flower KB, Garrett J, Ammerman AS. Preventing and treating obesity: Pediatricians' self-efficacy, barriers, resources, and advocacy. Ambul Pediatr 2005;5:150–156. [PubMed: 15913408]
15. Flower KB, Perrin EM, Viadro CI, Ammerman AS. Using body mass index to identify overweight children: Barriers and facilitators in primary care. Ambul Pediatr 2007;7:38–44. [PubMed: 17261481]
16. National Heart Lung and Blood Institute. National Asthma Education and Prevention Program, Clinical Practice Guidelines. Bethesda, MD: National Heart, Lung, and Blood Institute; 1997. Expert panel report 2: Guidelines for the diagnosis and management of asthma.
17. Plaut, TF.; Brennan, C. Asthma Charts and Forms. Amherst, MA: Pedipress, Inc; 1996.
18. Gilbert MJ, Fleming MF. Use of enhanced body mass index charts during the pediatric health supervision visit increases physician recognition of overweight patients. Clin Pediatr (Phila) 2007;46:689–697. [PubMed: 17579096]
19. Perrin EM, Finkle JP, Benjamin JT. Obesity prevention and the primary care pediatrician's office. Curr Opin Pediatr 2007;19:354–361. [PubMed: 17505200]
20. Department of Health and Human Services, Centers for Disease Control and Prevention. Body Mass Index. [Accessed May 15, 2009]. http://www.cdc.gov/nccdphp/dnpa/healthyweight/assessing/bmi/index.htm
21. Parker RM, Baker DW, Williams MV, Nurss JR. The test of functional health literacy in adults: A new instrument for measuring patients' literacy skills. J Gen Intern Med 1995;10:537–541. [PubMed: 8576769]
22. Wilkinson, GS. Wide Range Acheivement Test: Administration Manual. Wilmington, Delaware: Wide Range Inc; 1993.
23. Baker DW, Williams MV, Parker RM, Gazmararian JA, Nurss J. Development of a brief test to measure functional health literacy. Patient Educ Couns 1999;38:33–42. [PubMed: 14528569]
24. Rothman RL, Housam R, Weiss H, et al. Patient understanding of food labels: The role of literacy and numeracy. Am J Prev Med 2006;31:391–398. [PubMed: 17046410]
25. Estrada CA, Martin-Hryniewicz M, Peek BT, Collins C, Byrd JC. Literacy and numeracy skills and anticoagulation control. Am J Med Sci 2004;328:88–93. [PubMed: 15311167]
26. Cavanaugh K, Huizinga MM, Wallston KA, et al. Association of numeracy and diabetes control. Ann Intern Med 2008;148:737–746. [PubMed: 18490687]
27. Apter AJ, Cheng J, Small D, et al. Asthma numeracy skill and health literacy. J Asthma 2006;43:705–710. [PubMed: 17092853]
28. Lokker N, Sanders L, Perrin EM. Parental misinterpretations of over-the-counter pediatric cough and cold medication labels. Pediatrics . 2008(in press)
29. Rhee KE, De Lago CW, Arscott-Mills T, Mehta SD, Davis RK. Factors associated with parental readiness to make changes for overweight children. Pediatrics 2005;116:e94–101. [PubMed: 15995022]
30. DeLago C, Arscott-Mills T, Rhee K, Chanoine P, Krysko R. Communicating the obesity problem to the parents [abstract]. Pediatr Res 2004;55:224A. [PubMed: 14605245]Abstract 1268
31. Grimmett C, Croker H, Carnell S, Wardle J. Telling parents their child's weight status: Psychological impact of a weight-screening program. Pediatrics 2008;122:e682–8. [PubMed: 18762503]
32. Borra ST, Kelly L, Shirreffs MB, Neville K, Geiger CJ. Developing health messages: Qualitative studies with children, parents, and teachers help identify communications opportunities for healthful lifestyles and the prevention of obesity. J Am Diet Assoc 2003;103:721–8. [PubMed: 12778044]

<table>
<tr><th>Scenario stem read to parent</th><th>Explanation of BMI chart</th><th>Question asked</th><th>Answer choices</th></tr>
<tr><td>1. A pediatrician points to a mark on the BMI chart (researcher points to the X marked on the BMI chart indicating a 7 year old boy with a BMI of 16) and tells you that your 7 year old boy falls at the 65th percentile on the BMI chart.</td><td rowspan="4">During Part I, a standard BMI chart is used and the researcher reads:
"On this chart, below the 5%ile indicates underweight, between the 5%ile and 85%ile indicates healthy weight, between the 85%ile and 95%ile indicates at risk for overweight, and above the 95%ile indicates overweight."
During Part II, a color-coded BMI chart is used and the researcher reads:
"On this chart, green indicates healthy weight, yellow indicates at risk for overweight, and red indicates underweight (below) or overweight (above)."</td><td rowspan="4">"What does the BMI chart tell you about the weight status of your child?" Note: This question was not needed for #4, where it was contained in the stem</td><td rowspan="4">☐ The child is underweight.
☐ The child is a healthy weight.
☐ The child is at risk for overweight.
☐ The child is overweight.</td></tr>
<tr><td>2. A pediatrician points to a mark on the BMI chart (researcher points to the X marked on the standard BMI chart indicating an 8 year old girl with a BMI of 20) and tells you that your 8 year old girl falls at the 94th percentile point on the BMI chart.</td></tr>
<tr><td>3. A pediatrician points to a mark on the BMI chart (researcher points to an X marked on the BMI chart indicating a 6 year old boy with a BMI of 20) and tells you that your 6 year old boy falls above the 95th percentile line on the BMI chart.</td></tr>
<tr><td>4. What would you say about the weight status of a child whose BMI is here on the graph (researcher points to the X marked on the BMI chart indicating a 6 year old girl with a BMI of 18)?</td></tr>
</table>

<table>
<tr><th colspan="3">Control questions (interpretation is independent of color coding)</th></tr>
<tr><th>Question</th><th>Explanation of BMI chart</th><th>Answer choices</th></tr>
<tr><td>1. Using the BMI chart (parent has a BMI chart with points A, B, C, and D indicated), where would a 5 year-old boy with a BMI of 16 fall on the chart?</td><td rowspan="2">During Part I, a standard BMI chart is used.
During Part II, a color-coded BMI chart is used.</td><td rowspan="2">☐ A
☐ B
☐ C
☐ D</td></tr>
<tr><td>2. Using the BMI chart (parent has a BMI chart with points A, B, C, and D indicated), where would a 5 year-old boy with a BMI of 19 fall on the chart?</td></tr>
</table>

Figure 1.

Parallel BMI charting questions asked using standard and color-coded BMI charting.

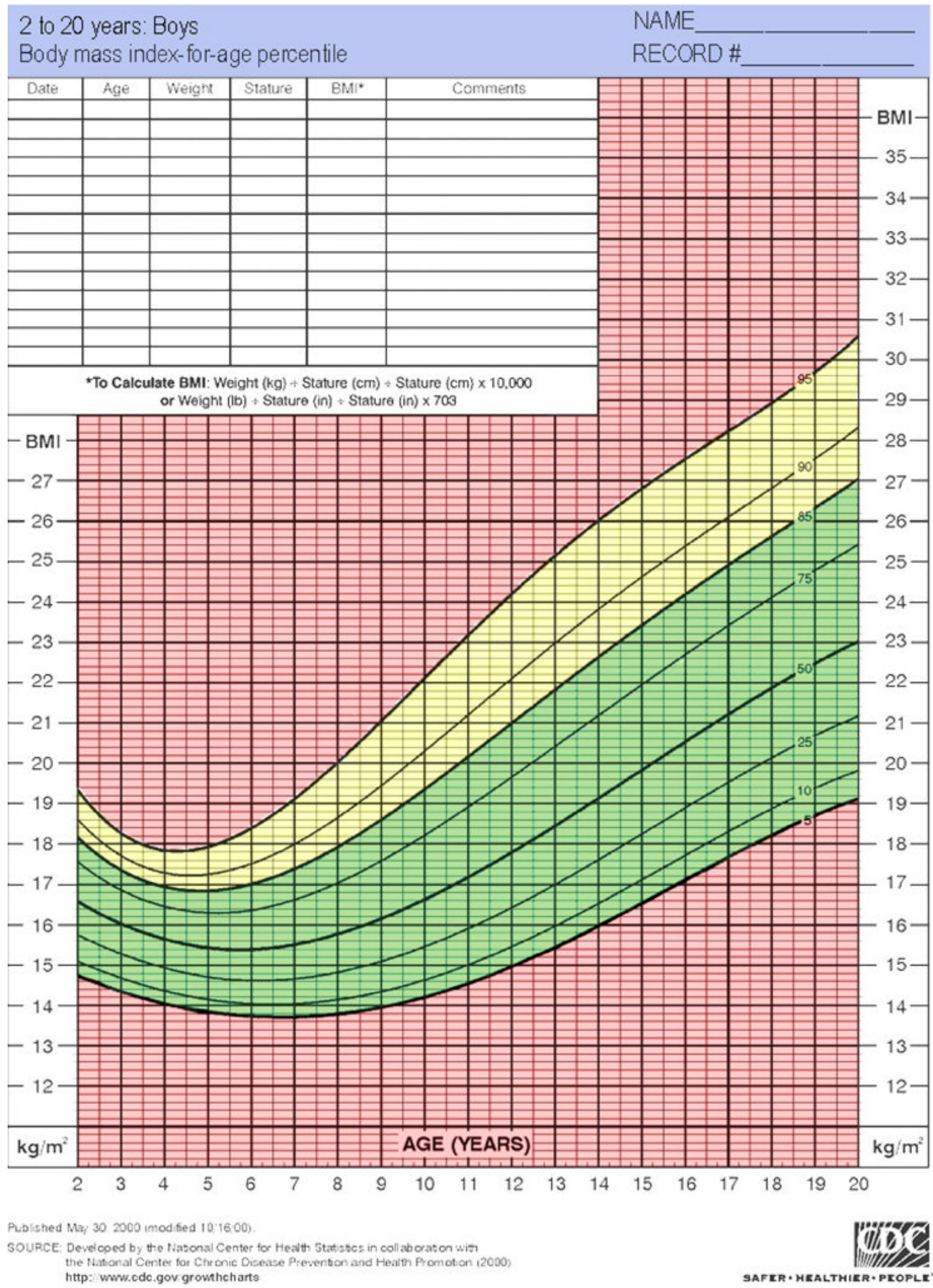

Figure 2.

Example of color-coded BMI chart. Green indicates healthy weight (BMI 5th–<85th percentile), yellow indicates at risk for overweight (now called overweight; BMI 85th to <95th percentile), and red indicates underweight (<5th percentile) or overweight (now called obese; ≥95th percentile).

Table 1

Demographic characteristic

Variable	Combined (n=163)	Vanderbilt (n=69)	UNC (n=94)	p-value‡
Race*, n (%)				0.07
American Indian or Alaskan Native	2 (1)	0 (0)	2 (2)	
Asian	5 (3)	1 (2)	4 (4)	
Black or African American	77(48)	32 (46)	45 (49)	
Native Hawaiian or other Pacific Islander	1 (1)	1 (1)	0 (0)	
White	61 (38)	32 (46)	29 (32)	
Hispanic or Latino	15 (9)	3 (4)	12 (13)	
Insurance, n (%)				<0.01
Public	107 (66)	56 (81)	51 (54)	
Private	54 (33)	13 (19)	41 (44)	
None	2 (1)	0 (0)	2 (2)	
Income				0.02
< $10,000	42 (26)	27 (39)	15 (16)	
$10,000 – $19,999	21 (13)	8 (12)	13 (14)	
$20,000 – $39,999	52 (32)	19 (28)	33 (35)	
$40,000 – $59,999	13 (8)	4 (6)	9 (10)	
$60,000+	28 (17)	8 (12)	20 (21)	
Missing	7 (4)	3 (4)	4 (4)	
Years of Education†, Mean (SD)	13.5 (2.9)	12.8 (3.0)	14.0 (2.7)	0.01
S-TOFHLA Score†, Mean (SD)	33.1 (5.4)	32.6 (6.3)	33.5 (4.6)	0.31
WRAT-3R Score, Mean (SD)	34.6 (5.9)	33.5 (6.1)	35.5 (5.7)	0.04
Mean number of children	2.5 (1.3)	2.6 (1.3)	2.5 (1.4)	0.67
Mean age of youngest	3.3 (2.1)	3.4 (2.1)	3.3 (2.1)	0.8
Knowledge of BMI				
Doctor discussed BMI at last visit, n (%)	44 (27)	14 (20)	30 (32)	0.11
Reports understanding of BMI, n (%)	98 (60)	36 (52)	62 (66)	0.11
Correctly defines BMI, n (%)	49 (30)	16 (23)	33 (35)	0.12

S-TOFHLA = Short Test of Functional Health Literacy in Adults, WRAT-3R = Wide Range Achievement Test – mathematics portion, BMI = body mass index

*Overall Sample size is 161; Sample size at UNC is 92

†Overall Sample size is 162; Sample size at UNC is 93

‡Calculated using Fisher’s exact test or two-sample t-test. P-value reflects comparison between sites.

Table 2

Parent performance on parallel BMI charting questions using standard versus color-coded charts

	Site	Standard % correct	Color-coded % correct	OR (95% CI)[‖]	p-value
Parallel question #1	Vanderbilt[†]	71	88		
	UNC[‡]	66	97		
	Combined[§]	68	93	6.47 (3.32–12.62)	<.0001
Parallel question #2	Vanderbilt	62	80		
	UNC	63	89		
	Combined	63	85	3.47 (2.18–5.53)	<.0001
Parallel question #3	Vanderbilt	78	82		
	UNC	73	88		
	Combined	75	86	1.98 (1.25–3.14)	0.0038
Parallel question #4	Vanderbilt	41	80		
	UNC	61	97		
	Combined	52	90	8.79 (5.03–15.36)	<.0001
Pooled parallel questions[*]	Vanderbilt	63	83		
	UNC	66	93		
	Overall	65	88	4.32 (3.14–5.95)	<.0001
Control Question 1	Vanderbilt	86	88		
	UNC	91	91		
	Overall	89	90	1.14 (0.68–1.91)	0.616
Control Question 2	Vanderbilt	80	90		
	UNC	94	89		
	Overall	88	90	1.20 (0.67–2.15)	0.532

Standard %= % correct using standard chart; Color % = % correct using color-coded chart

[*] Adjusted for question

[†] n=69 for Vanderbilt data

[‡] n=94 for UNC data

[§] N= 163 for combined data

[‖] Odds ratio, confidence interval, and p-value calculated for combined data, adjusted for site

Table 3

Association between covariates and parent performance on four parallel BMI charting questions

Variable	Combined OR of answering a BMI charting question correctly (95% CI)*
WRAT-3R†	1.18 ‡ (1.14, 1.22)
S-TOFHLA†	1.12 ‡ (1.08, 1.16)
Education§	1.24 ‡ (1.15, 1.34)
Income ‡,‖	
$10,000–$19,999	2.11¶ (1.08, 4.14)
$20,000–$39,999	2.60‡ (1.57, 4.31)
$40,000–$59,999	1.94 (0.78, 4.86)
$60,000+	10.20‡ (4.65, 22.35)
Private insurance\\	2.58 ‡ (1.54, 4.31)
Mean age of youngest child	1.0** (0.91–1.1)
Number of children	0.91†† (0.76–1.08)
Race/ethnicity§§	
White	3.13 (1.87–5.26)
Hispanic	0.99 (0.49–2.02)
Other	4.13 (1.24–16.71)

WRAT-3R = Wide Range Achievement Test – mathematics portion, S-TOFHLA = Short Test of Functional Health Literacy in Adults

*Adjusted for Question, Chart-type, and Site

†Odds ratio is for every single-point increase in WRAT-3R or S-TOFHLA score

‡p<.01

§Odds ratio is for each additional year of education

‖Reference group < $10,000

¶p <.05

\\Reference group is public insurance (“no insurance” group was dropped due to model convergence issues with only two in that category).

**Odds ratio is for each additional year of age

††Odds ratio is for each additional child

§§Reference group for all listed is Black