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Identifying meaningful dietary intake and physical activity questions for individual and population health

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Abstract

We aimed to identify valid screening questions for adults regarding physical activity and dietary behaviours that (a) were correlated with BMI, (b) were deemed by patients and providers to be relevant to clinical care, and (c) have utility for longitudinal understanding of health behaviours in populations. The goal was to identify screening questions that could be implemented at annual health care visits. First, we identified dietary behaviour questions and solicited patient input. Next, we tested both physical activity and dietary behaviour questions in a large sample to test their potential utility. Finally, we used cognitive interviews with patients and physicians to narrow our assessment for clinical settings. We present a parsimonious and reliable six-question scale of physical activity and dietary behaviours for research settings, as well as a three-question scale for clinical settings. We demonstrate a robust relationship between these measures and obesity. Additionally, we present evidence that these measures may serve as a useful red flag for patients before they develop obesity. We provide a concise and useful tool for assessing patients' physical activity and dietary behaviours in a variety of research settings. We also highlight the importance of incorporating this tool into the clinical intake flow for inclusion in patients' Electronic Health Record.

Keywords

dietary intake; electronic health record; obesity; physical activity

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AUTHORS CONTRIBUTIONS

Haws is the lead author of Study 1, Shinall is the lead author of Study 2, and Schlundt is the lead author of Study 3. Shinall and Haws were the primary authors of the manuscript. Barkin serves as the multiproject team leader. All other authors assisted with project development and analysis.

CONFLICT OF INTEREST

The authors have no conflict of interest to disclose.

1 | INTRODUCTION

Since 1980, obesity rates have doubled in more than 70 countries.¹ In the United States alone, obesity is associated with at least 111,000 excess deaths per year,² and multiple data sources show steady increases in population levels of obesity.^{3,4} Because obesity is a risk factor for many health problems, including heart disease, diabetes, and cancer,⁵ the U.S. Preventative Services Task Force recommends that physicians screen for obesity and promote weight loss among adults classified as overweight or obese.^{6,7} A comprehensive weight loss approach should include reduced energy intake, moderate-to-vigorous physical activity, and self-management strategies for changing eating behaviours.⁸ Although body weight and other vital signs (such as blood pressure) are standard health screenings, assessing dietary and physical activity behaviours is not. As such, the National Academy of Medicine has recommended routinely assessing physical activity and dietary behaviours as part of a patient's psychosocial and behavioural vital signs.⁹

Screening patients for diet and physical activity behaviours as part of the vital signs' assessment offers several important advantages, such as providing an opportunity for clinicians to discuss behaviour change, tracking individual change in behaviours over time, and aggregating the data to better understand population health trends. Yet, given the time constraints of a typical medical visit, any time spent collecting additional vital signs must be carefully scrutinized to provide maximum benefit while having minimal impact on workflow. To accomplish these objectives, screening measures must fit easily into the normal workflow and assist the provider in initiating behavioural interventions. Given the important role of healthcare providers in motivating patient behavioural change,¹⁰ including a well-crafted dietary and physical activity assessment within the regular intake flow of physician-patient interactions has great potential for assessing longitudinal outcomes and for improving individual and population health.

The electronic health record (EHR), which is increasingly becoming a standard of care in medicine,¹¹ poses an opportunity to incorporate behavioural screenings for diet and physical activity. Before 2013, few studies had examined whether EHR-based tools could help clinicians address obesity.¹² Of the tools identified, most focused on increasing identification of overweight and obesity, rather than assisting in its prevention and management.¹² Thus, our key objective in the present research was to facilitate obesity prevention and management by developing a succinct measure of dietary and physical activity behaviours.

A thorough review of the literature revealed several potential measures of physical activity, with some convergence around an existing parsimonious measurement tool in the area of physical activity, Kaiser Permanente's *Exercise as a Vital Sign*.^{13–16} Therefore, we focused on further testing its reliability and usefulness. Assessment of eating behaviours is more complex since many existing methodologies—including dietary recalls, food diaries, food frequency questionnaires, and eating patterns questionnaires—are too time-consuming for use as a screening tool.^{17,18} We reviewed numerous tools—including the 26-item National Health and Nutrition Examination Survey dietary screener questionnaire,¹⁹ the 18-item Three-Factor Eating Questionnaire,^{20,21} and the 7-item WAVE questionnaire^{10,22}—

but concluded that a sufficiently succinct measure to capture dietary behaviour in a manner useful for tracking and improving population health was lacking. Consequently, we aimed to develop such a measure.

Here, we present our process for selecting and testing screening questions designed to (a) tailor obesity counselling in the context of routine annual well-check visits, and (b) conduct longitudinal research on population health outcomes. The comprehensive version of our dietary-behaviour measure, the Adult Dietary Intake and Activity Plus (ADIA+) scale, broadly covers core aspects of dietary and physical activity behaviours in an easy-to-administer six-item scale. The concise version of our ADIA scale, narrowed through a cognitive interview process, focuses on a single indicator of eating behaviour and two indicators of physical activity, which can be more seamlessly implemented into the intake flow of a healthcare system in order to provide valuable information for the prevention and treatment of obesity and other chronic illnesses.

2 | EMPIRICAL APPROACH

We began by reviewing prior literature from clinical and population health settings for measures to assess physical activity and dietary behaviours. Using PubMed/Medline, a team member performed searches with the following inclusion criteria: English-language, published from 2000 to the present, survey questions for nutrition and/or physical activity, and for ages 18 and over.

For physical activity, we found that two questions from Kaiser Permanente's *Exercise as a Vital Sign* had demonstrated usefulness in clinical ambulatory settings and had validated relationships with both weight loss among overweight patients and reduction in glycosylated haemoglobin among diabetic patients.^{15,16}¹ In a sample of over 1.5 million people, these questions demonstrated face and discriminant validity and were correlated with improved population health outcomes.

A review of measures related to dietary behaviours yielded many results,^{19,20,23,24} but did not reveal a parsimonious, yet meaningful measure to capture this important indicator within a routine clinical setting. Because our goal was to identify questions to assist in obesity prevention and management, we decided to cover a broad scope of relevant dietary behaviour questions. After starting with a larger set, we focused on 75 questions from various measurement instruments, which, after discussion regarding critical themes and redundancies, we ultimately narrowed to 13 for further testing.² Space constraints do not allow for a thorough discussion of all relevant measures; still, our review identified three key areas of dietary behaviours that merited representation within the 13 measures retained: (a) what people eat, (b) how much they eat, and (c) when, where, and why they eat.

Following our identification and narrowing of questions, we conducted three studies—each with a distinct purpose—as outlined below. Our objective was to propose a useful and reliable measure for assessing physical activity and dietary behaviours that would both

¹Table 2 provides the text of the Kaiser Permanente questions (labelled as Activity 1 and Activity 2).

²The seventy-five dietary questions identified in our literature review are detailed in Appendix Table A1.

promote dialogue and intervention in a clinical setting and provide longitudinal research insights related to obesity.

In Study 1, we collected exploratory data from a small online sample to ensure patients' voices were considered in developing the ADIA + scale. Next, Study 2 collected data from a large online sample to test proposed ADIA+ scale questions for their usefulness and relationship with proposed correlates. Finally, in Study 3, we conducted cognitive interviews with both providers and patients to evaluate the ADIA+ scale further and to provide recommendations regarding (a) how to reduce the scale to a smaller set of questions (the ADIA scale), which could be incorporated more seamlessly into a clinical setting, and (b) how to use the scale initially and over time to facilitate patient wellbeing and the prevention and treatment of obesity.

2.1 | Study 1: Item generation and selection

The purpose of our first data collection was to ensure that the prior measures of dietary intake we compiled fully captured the patients' point of view in order to inform our decisions about what screening measures would be most useful.

2.1.1 | Methods—We conducted a survey using an online sample ($n = 120$, see Table A2 for baseline sample characteristics) to identify potential screening questions and help refine our focus. Amazon's Mechanical Turk (MTurk) is an online participant-recruitment service widely utilized for social science research²⁵ and previously validated by researchers for reliability and better resemblance to the U.S. population than many other available subject pools.^{26–28} Consent was obtained at the beginning of each survey, and all protocols were approved by Vanderbilt University Institutional Review Board (IRB No. 181135). Participants who completed the survey were paid \$1.50.

Study participants were asked to provide their ideas for “simple and meaningful” questions that their primary care physician could ask them to better understand their nutrition, which included (a) the different kinds of foods you eat, (b) the portions or amounts of food you eat, and (c) when, where, and why you eat. Participants were encouraged to provide up to eight questions for each category (see Appendix A for instructions).

We then provided participants with the series of 13 dietary behaviour questions identified from prior literature (see Table 1) and asked participants to evaluate the usefulness of each question on the following scale: 1 (“This is a very poor question”) to 7 (“This is a very good question”). Participants were next presented with the questions they themselves had generated and asked to evaluate these questions on the same scale. Finally, participants provided basic demographic information, including age, gender, ethnicity, education, and household income.

2.1.2 | Results—We reviewed the questions provided by participants for each of the three categories. The median number of questions provided for all three categories was four. Participants evaluated their questions (unsurprisingly) as meaningful. We also assessed the perceived usefulness of each of the 13 questions identified in the literature (see Table 1). All means were significantly above the midpoint (4) of the scale; we therefore focused on

the seven questions with the highest means. From these questions, we noted two strong themes: control over eating behaviours and consumption of positive/negative food types. To narrow the questions as much as possible—while continuing to capture these two themes—we selected item two (Dietary 2 in Table 2), concerning portion control, and item 12 (Dietary 3 in Table 2), concerning emotional eating. Further, to capture the importance of healthy and unhealthy food types—emphasized within the 13 existing measures and the participant-generated measures—while acknowledging the need for parsimony consistent with the demands of the clinical setting, we generated a simplified dietary healthiness question as a global representation of the recognized importance of one’s overall eating tendencies, labelled as Dietary 1 in Table 2.

2.2 | Study 2: Large-scale survey

After narrowing our dietary behaviour assessment to three questions through our pilot study, we turned to our principal contribution in Study 2, which used a much larger MTurk survey (N = 8070) to evaluate our proposed activity and eating behaviour measures with respect to both population metrics and correlation with BMI (as an indicator of predictive power). In Study 2, we added a fourth dietary behaviour question (Dietary 4 in Table 2), intended to capture patient priorities regarding key underlying issues relevant to dietary consumption, which could be helpful for initiating discussions in research and clinical settings.

2.2.1 | Methods—The MTurk survey was conducted with inclusion criteria of age of 18 years or older and English-speaking. The 8070 participants were compensated \$1.50 for their participation. Similar to participants in other MTurk studies, Study 2 participants were younger, more educated, and more likely to be employed than the average person in the United States (see Table A2 for a comparison to Census data).²⁹ Nonetheless, both the median income and the race/ethnicity distribution of participants largely mirrored that of the U.S. population, and over one quarter of participants self-identified as having class I, II, or III obesity.^{30 3}

The relevant questions in the survey included the two Kaiser Permanente physical activity questions (which we used to compute the average minutes of physical activity each week), the four dietary intake questions shown in Table 2, and a series of demographic questions (including gender, race, ethnicity, age, educational attainment, height, and weight).

2.2.2 | Results—Tables 3 and 4 report the relationships between our ADIA+ scale questions, participants’ BMI, and demographic variables. Below we highlight key findings from this analysis.

³Here, we use the standard definitions of class I (30 < BMI < 35), class II (35 < BMI < 40), and class III (BMI ≥ 40) obesity. Because Study Two relies on participants’ self-reported BMI, concerns may arise regarding the reliability of this data. As shown by Cawley (2004),³⁰ which develops a correction for participant misreporting of BMI, participant misreporting is not typically severe enough to shift a participant into a different BMI category. (For example, even if participant with obesity overestimates his height or underestimates his weight, the participant is unlikely to do so in a way that would shift him into the overweight BMI category. Thus, our main specifications from study two use BMI categories (underweight, normal weight, overweight, class I/II obese, and class III obese) instead of a continuous BMI measure. As a robustness check, however, we reestimate the results from Table 4 using continuous BMI (as well as BMI₂), which we present in Appendix Tables A5 and A6, and find substantially similar results.

As seen in Table 3, our participants reported an average of 165.8 minutes of exercise per week, with 9.3% of our participants reporting that they never exercised, and 0.4% of our participants reporting the maximum amount permissible in the survey (17.5 hours of exercise per week). Table 3 also reveals an inverse relationship between BMI and weekly exercise—participants in higher BMI classifications engaged in far fewer minutes of exercise per week. As a result, participants with class III obesity averaged over an hour less exercise per week than those of normal weight, and they were almost four times as likely to report never exercising.

A similar relationship emerges between participant BMI and current dietary behaviours in Table 3. Although only a small percentage of our participants report often eating after feeling full, often eating to cope with emotions, or eating a generally unhealthy diet (7.4%, 10.8%, and 13.2%, respectively), reports of poor dietary behaviours were concentrated among participants with class I/II obesity and class III obesity. In contrast, such behaviours were most infrequent among participants of normal weight.

Other notable results from Table 3 include gender differences—women were far more likely than men to report eating to cope with emotions (13.1% of women engage in this behaviour often, vs 8.0% of men), and men exercised for substantially more minutes per week (190.2 minutes, vs 146.1 minutes for women). As participants' education level and income increased, so did the healthiness of their diet. Additionally, unemployed individuals reported the fewest minutes of weekly exercise (137.0 minutes, vs 174.3 minutes for full-time workers and 165.1 minutes for part-time workers).

Table 3 also reports the relationship between desired changes in dietary behaviours, participants' BMI, and demographics. Participants in higher BMI classifications were more likely to report a desire to improve their portion control (monotonically increasing from 13.2% of individuals classified as underweight to 45.1% of individuals with class III obesity). They were also more likely to report a desire to decrease their emotional eating (monotonically increasing from 5.9% of individuals classified as underweight to 18.7% of individuals with class III obesity). Individuals classified as underweight and normal weight were more likely to express no desire for changes in dietary behaviour. Finally, women were more likely than men to report a desire to decrease emotional eating (13.3%, vs 8.0% for men).

Given the expected correlation between participants' BMIs and their demographic characteristics, Table 4 takes an additional step towards parsing the relationships observed in the previous summary statistics tables. Table 4 regresses responses to the six questions of interest on participants' BMI classification and demographic characteristics using ordinary least squares.⁴ As this table demonstrates, the relationships observed between BMI and participant responses in the prior tables hold and remain quite strong in the regression estimates. Looking at columns (1) through (7) of Table 4, every aspect of reported dietary behaviour declines as a participants' BMI category increases. For instance, even after controlling for other demographic characteristics, column 2 reveals that participants

⁴Full regression results are presented in Appendix Tables A3 and A4.

classified as overweight were 1.8 percentage points more likely to eat after feeling full often than were participants of normal weight; that number increases to 11.2 percentage points for participants with class III obesity. Along these lines, column 4 demonstrates that participants classified as overweight were 3.5 percentage points more likely to eat to cope with emotions often than were participants of normal weight; participants with class III obesity were 17.0 percentage points more likely to eat to cope. Similar relationships are seen between BMI category and minutes of exercise (column 8). Participants who were overweight exercised approximately 11.0 percent less each week than participants who were normal weight. Participants who had class I/II obesity exercised about 40.7% less, and participants who had class III obese exercised about 69.6% less.³¹ ⁵

Table 4 also reveals some interesting relationships between participant BMI category and answers to the desired dietary behaviour changes. Across the board, participants classified as overweight and as having obesity were more likely to identify portion control and emotional eating as their principal dietary issues in need of modification (columns 11 and 13). In contrast, participants classified as underweight and normal-weight were likely to select eating more healthy food or improving the timing of their eating as their principal dietary issues (columns 10 and 12).⁶

In order to test the usefulness of our ADIA+ scale in clinical and research settings further, Table 5 considers how efficiently the scale may identify individuals for targeted intervention. Specifically, this Table examines the relationship between participants' BMI classification and the number of ADIA+ scale questions answered in a clinically problematic manner. Here, a problematic answer is defined as an admission that the participant never exercises, eats an unhealthy diet, eats after feeling full often, or eats to cope often. (Participant responses to Dietary 4 are not considered in Table 5 since the design of the question makes it difficult to label responses as problematic.) Given the formative nature of the ADIA+ scale, we suggest this approach as the best way to provide an overall activity and dietary assessment, rather than as a measure of internal reliability.³² Table 5 indicates that answering even one of the ADIA+ scale questions problematically may be a cause for concern. 40.1% of participants who answered at least one ADIA+ scale question problematically were classified as having obesity; 52.6% of participants who answered at least two ADIA+ scale questions problematically were classified as having obesity. Moreover, 57.0% of all participants with Class III obesity answered at least one ADIA+ scale question in a problematic manner.

Table 5 suggests that ADIA+ scale questions may serve as a useful red flag for intervention *before* a patient develops obesity. In particular, answering at least one ADIA+ scale question problematically is more closely associated with obesity in participants 40 and older.

⁵These percentages were calculated based on the coefficients in column 8 of Table 4 and the method outlined by Halvorsen and Palmquist (1980).³¹

⁶In addition to evaluating the relationship between demographics and ADIA+ scale question responses, we also examined the correlation between participant responses to each of the six questions. These correlations, presented in Appendix Table A7, reveal that none of the responses are highly correlated, suggesting that each of the six questions measures a distinct dietary or physical activity behaviour. (Unsurprisingly, the highest response correlations stem from participants who identified a problematic dietary behaviour, such as eating to cope, then later selecting that behaviour as one of the things they would to change about their diet.) Additionally, participant responses to physical activity questions are not highly correlated with responses to dietary intake questions.

Only 36.6% of participants under 40 who answered at least one ADIA + scale question problematically were classified as having obesity, compared to 51.1% of participants 40 and older. This finding is supported by previous studies suggesting that problematic dietary and exercise behaviours may catch up with individuals as they age.^{33,34} Additionally, answering one or more ADIA+ scale questions problematically may serve as a particularly useful marker for patients of lower socioeconomic status. Table 5 indicates that individuals with low education, with low household income, and without a job may be particularly susceptible to obesity if problematic dietary or exercise behaviours are present, which is also supported by prior studies.^{35,36}⁷

Based on the above results, we conclude that our full six-item ADIA+ scale is a useful method of assessing patient physical activity and dietary behaviours. All six questions have persistent relationships with participant BMI in the expected directions. The two physical activity questions and the first three dietary behaviour questions appear particularly adept at targeting participants with class I, II, and III obesity for further intervention. We believe our ADIA+ scale could be used in research settings, and where appropriate, in clinical settings. Yet, given the realities of the clinical setting, and our desire to integrate the questions into patients' EHR, we sought to reduce the number of items further in an effort to capture the important behaviours as succinctly as possible. We describe this process of creating the reduced-form ADIA scale in Study 3 below.

2.3 | Study 3: Cognitive interviews

Cognitive interviews were conducted with patients and providers to gather insights on the usability of the questions and impact on annual well-check visits. Research staff conducted the interviews with a script that asked participants 1) to read each question aloud, then 2) to talk about how they would answer the question. The staff additionally used probes to identify potential issues in the context of well-check visits.

2.3.1 | Method—Patient participants (N = 20) were recruited in person by research staff from waiting rooms of adult primary care providers at Vanderbilt University Medical Center and compensated with a \$20 gift card. Patients had to be at least 18 years old and English-speaking to participate. All participants signed an informed consent document before participating.

Vanderbilt University Medical Center primary care providers (N = 9) were interviewed in person or over the phone. Cognitive interview questions were designed to identify provider opinion, perceived importance, problems with item wording, and relevance of the ADIA+ scale in the context of an annual well-check visits. Each interview was audio recorded, transcribed, and coded using a hierarchical system to capture four themes: (a) clarity, (b) sensitivity, (c) difficulty, (d) usefulness. The number of interviews was determined by available resources and data saturation.

⁷Appendix Table A8 provides comparison summary statistics for individuals with higher educational attainment, in higher-income households, and part- and full-time employment statuses. Generally, answering one or more ADIA+ scale questions in a problematic manner appears less associated with obesity for individuals of higher socioeconomic statuses.

2.3.2 | Results—We performed a qualitative analysis of the coded cognitive interviews with patients and providers. As seen in Table 6, patients found the physical activity questions easy to answer, and providers found value in the questions. The only minor issues identified concerned item clarity. Both patients and providers suggested giving further examples in order to better frame the questions about moderate-to-strenuous physical activity. Still, providers appreciated quantifying physical activity level to serve as a systematic reference during annual well-check visits.

Reactions to the measures for dietary behaviours were more mixed. The questions about overeating and emotional eating (Dietary 2 and 3) were viewed as somewhat embarrassing, as more psychological in nature, and as likely to lead to socially desirable responding. Patients expressed concerns regarding lack of self-awareness of eating behaviours and the need for a strong patient-provider relationship prior to being asked these questions. Providers expressed concern over the questions' practicality.

The other dietary behaviour questions (Dietary 1 and 4), which asked about healthy eating, were not as sensitive. Providers reacted most positively to Dietary 1; they believed the response could be used to start a conversation and encourage behaviour change within the context of an annual well-check visit. Dietary 4 received less favourable reviews—although less sensitive, patients characterized the prompt to pick up to two choices as too complex. Providers also noted it might be difficult for patients who are satisfied with their diet to answer because “[i]t implies that [they] already don't feel good about [their] weight.”

Based on this provider and patient feedback, we selected the two physical activity questions and the question on healthiness of diet (Dietary 1) as the final components of our reduced, three-question ADIA scale, intended for use in routine clinical screening. As seen in Table 5, problematic responses to ADIA scale questions continue to have a strong relationship with higher BMI. 43.6% of participants who identified as eating an unhealthy diet or engaging in no exercise were classified as having obesity; 54.9% of participants who admitted to both behaviours were classified as having obesity. Moreover, as with the full scale, problematic responses to ADIA questions were particularly associated with obesity in older participants and participants of lower socioeconomic status. Thus, answering one or more ADIA scale questions may similarly serve as a useful red flag for intervention before a patient develops obesity. The persistence of a strong relationship between problematic answers to ADIA scale questions and higher BMI make the reduced-form version particularly palatable for incorporation into annual well-check visits.

In settings where time pressure and sensitivity are less acute, including longitudinal health research, the full six-question ADIA+ scale has greater advantages. The addition of the Dietary 2 and 3 questions allow for greater identification of individuals at higher risk of developing obesity in the future. The addition of the Dietary 4 question is useful to help initiate conversation, particularly when there is an established relationship between provider and patient to facilitate positive interventions. Given the more robust relationships with BMI demonstrated in Tables 3, 4, and 5, use of the full ADIA+ scale is preferable whenever possible. Nonetheless, when time constraints or sensitivity concerns render use of the full ADIA+ scale impractical, the shorter ADIA scale remains useful.

3 | DISCUSSION

In this research, we utilized a three-pronged data collection methodology to identify and test dietary and physical activity screening questions that can help tailor health counselling and improve population health outcomes. Through literature review, crowdsourcing surveys, and cognitive interviews, we finalized two brief measures for introduction into a variety of health-related settings. The three-question ADIA scale is intended for integration into the EHR as a vital sign to stimulate clinical discussions about diet and physical activity. Currently, these two critical behaviours are not systematically assessed, despite their importance for prevention and chronic disease management, so we suggest the brief ADIA scale as a simple way to integrate a baseline assessment of these behaviours. In turn, clinicians and researchers can use this assessment for immediate patient-physician interaction and for tracking changes in health outcomes over time. The full, six-question ADIA+ scale is intended for integration in other clinical and research settings wherein additional time is available and concerns about question sensitivity are less acute.^{37,38} Both scales, we suggest, may be utilized in two different ways—first, by examining responses to individual items, and second, by summing the total numbers of problematic responses to form an overall assessment—for both present-time assessment and longitudinal trend analysis.

By way of developing these two scales, we achieved other important insights. We lent further validation to *Exercise as a Vital Sign*'s physical activity questions, and more broadly, we confirmed that patient perceptions of their own health-related behaviours are reliable tools for measuring obesity risk factors, namely BMI. Finally, the cognitive interviews served as a useful reminder that context matters. Before the cognitive interviews, our team favoured incorporating questions on overeating and emotional eating into the EHR. Patient and provider interviews raised concerns that such emotionally sensitive questions might hinder, rather than help, patient-provider interactions.

This study does have several limitations, yet we believe the strengths collectively outweigh these limitations. First, our three-part study relies on self-reporting of activity and dietary measures, as well as BMI. However, our results suggest that these self-reported measures are in fact meaningfully associated with BMI. To mitigate any self-reporting bias, we rely on BMI classifications (in ranges) instead of a continuous BMI measure.³⁰ For data collection in the clinical setting, BMI and other health-related outcomes will be measured objectively; therefore, relating these outcomes to our ADIA measures will further validate their usefulness in the future. Second, MTurk's crowdsourcing platform is a convenience sample; consequently, Study 2 sought to overcome resulting unrepresentativeness concerns by using a very large sample. To the extent our large-scale MTurk sample may be unrepresentative of the U.S. population,³⁹ we have shown through regression analysis that the relationships between BMI classification and ADIA scale responses hold—even after race, ethnicity, educational level, and other demographic characteristics are taken into account. Third, because we recruited the cognitive interview participants from clinic waiting rooms, we may have underrepresented opinions of those less connected to healthcare systems.

Since being finalized, the ADIA scale has been incorporated into the EHR at Vanderbilt University Medical Center and connected with clinical decision support tools to improve point-of-service care during annual well-check visits, including deeper probing into problematic areas of behaviour. In future research, our team expects to collect the resulting data and assess implications for population and individual health. Specifically, we expect to examine the ADIA scale's intervention effect on all patients' health outcomes, including changes in BMI, haemoglobin A1c, physical activity, and dietary behaviours; importantly, we plan to examine these trends over time, as the longitudinal data become available. Because we have integrated similar questions into the EHR of patients as young as 12 at Vanderbilt, our approach also holds the potential to track longitudinal behaviour changes from childhood to adulthood, a novel tactic for obesity prevention and treatment. (In a separate publication, we detail the parallel process to develop similar measures for children.⁴⁰) Implementation of interventions over the life cycle will shed light on the most effective strategies and timing for behavioural health changes.

In closing, we have described our process of vetting dietary and physical activity screening questions and have created a pragmatic tool for individualized counselling, providing appropriate referrals, developing interdisciplinary teams, and improving population health outcomes (the ADIA scale). We have vetted additional questions for research studies with a greater focus on dietary behaviours (the ADIA + scale). Both versions of the scale will allow for the capture of longitudinal assessment of foundational behaviours for health promotion, disease prevention, and chronic disease management to improve individual and population health. As vital signs, the ADIA scale questions are easily administered and incorporated into the workflow of many clinical settings. Combined with clinical decision support tools, the ADIA scale holds the potential to change the way providers manage obesity for all adult patients, and, more broadly, combat the obesity epidemic.

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APPENDIX A: Instructions used in Study 1

Please imagine that your primary care physician wanted to address his or her patient's eating behaviours as a part of your yearly physical checkup. In other words, in addition to typical questions such as "What medications are you currently taking?", they wanted to get a general sense of what your eating habits and preferences are like in order to potentially make some recommendations to improve your health.

Please take a moment to think about how your physician might be able to phrase these types of questions in a simple and meaningful way.

- "Simple" means easy to understand and answer
- "Meaningful" means that your answers would help your doctor give you useful advice

We are particularly interested in three different types of questions:

1. Questions focusing on the different kinds of foods you eat.
2. Questions focusing on your portions or amount of food you eat.
3. Questions focusing on your when, where, and why you eat.

On the screens that follow, we will ask you to provide examples for each type of question. We will provide a sample question, but please do not feel restricted to similar questions.

Please click to the next screen to continue.

TABLE A1

Existing dietary measures reviewed

Measure	Items	Scoring	Total Items
PCORI ^a	For each of the following groups of food, tell us how often you eat each one: <ol style="list-style-type: none"> 1. Fast food or pizza 2. Desserts, candy, cookies, sweets, or salty snacks 3. Vegetables and/or vegetable juices 4. Fruits and/or fruit juices 5. A glass, can, or bottle of soft drinks, kool-aid, sweet tea, or othersweetened drinks Which of the following behaviours describes when you eat? <ol style="list-style-type: none"> 1. Breakfast 2. Lunch 3. Dinner 4. Snacks 	Never; Rarely (less than once a week); Sometimes (once a week or more but not everyday); Often (once a day or more) Never, A few times a week, Daily	9
Personal Diabetes Questionnaire (PDQ) ^b	During the past 3 months, how often did you...? <ol style="list-style-type: none"> 1. Overeat until you felt stuffed or too full? 2. Eat unplanned snacks that you wish you had not? 3. Make poor food choices that you wish you had not? 4. Eat as a way to cope with negative feelings like anger, unhappiness, stress, or depression? 	Never; Rarely (less than once a week); Sometimes (once a week or more but not everyday); Often (once a day or more)	4
Patient-Reported Outcomes Measurement Information System (PROMIS) Global Health Measures ^c	<ol style="list-style-type: none"> 1. In general, would you say your health is: 2. In general, would you say your quality of life is: 3. In general, how would you rate your physical health?* 4. In general, how would you rate your mental health including your mood and your ability to think? 5. In general, how would you rate your satisfaction with your social activities and relationships? 6. In general, please rate how well you carry out your usual social activities and roles.* 	Excellent (5), Very Good, Good, Fair, Poor (1)	10

Measure	Items	Scoring	Total Items
	7. To what extent are you able to carry out your every physical activities such as walking, climbing stairs, carrying groceries, or moving a chair?*	Completely, Mostly, Moderately, A little, Not at all	
	8. How often have you been bothered by emotional problems such as feeling anxious, depressed or irritable?*	Never, Rarely, Sometimes, Often, Always	
	9. How would you rate your fatigue on average?	None, Mild, Moderate, Severe, Very Severe	
	10. How would you rate your pain on average?	Scale 0 (No pain) to 10 (Worst Imaginable Pain)	
Kaiser Permanente: Medicare Total Health Assessment Questionnaire ^d	1. How many servings of fruits and vegetables do you eat in a typical day? (A serving is 1 piece of fruit, 1/2 cup of fruit or vegetables, 1 cup of raw leafy vegetables, or 3/4 cup of juice.)	0,1,2,3,4,5 or more	3
	2. Do you eat fewer than 2 meals a day?	Yes/No	
	3. How many days a week do you have a drink containing alcohol?	0–7	
WAVE questionnaire ^e	1. Yesterday, how many times did you eat vegetables (excluding corn and potatoes)?	0,1,2,3,4, More than 4	7
	2. Yesterday, how many times did you eat fruits (excluding fruit juice)?		
	3. Yesterday, how many times did you eat bran cereals or beans(excluding green/string beans)?		
	4. Yesterday, how many times did you have milk, soy milk, yogurt, cheese,or other dairy products?		
	5. How often do you use lowfat dairy products?	Never; Sometimes; Always; Do not know	
	6. Yesterday, how many sugared drinks like soda (excluding diet soda), fruit drinks/juice, lemonade, or sports drinks (eg, Gatorade) did you drink?	0,1,2,3,4, More than 4	
	7. Yesterday, how many times did you eat candy bars, french fries, potato chips, or other “junk food” (eg, cookies)?		
NHANES Dietary Screener Questionnaire (DSQ) ^f	26 items, available at: https://epi.grants.cancer.gov/diet/shortreg/instruments/dsq-in-nhanes-09-10-self-administered-english-version.pdf		26
TFEQ-18 ^g	Cognitive Restraint		18
	1. I deliberately take small helpings as a means of controlling my weight.	Definitely true; mostly true, mostly false, definitely false	
	2. I consciously hold back at meals in order not to gain weight.		
	3. I do not eat some foods because they make me fat.		
	4. How frequently do you avoid ‘stocking up’ on tempting foods?	Almost never; seldom; usually; almost always	
	5. How likely are you to consciously eat less than you want?	Unlikely; slightly likely; moderately likely; very likely	
	6. On a scale of 1 to 8, where 1 means no restraint in eating (eating whatever you want, whenever you want it) and 8 means total restraint (constantly limiting food intake and never ‘giving in’), what number would you give yourself?	See question, 1–8	

Measure	Items	Scoring	Total Items
	Uncontrolled Eating		
	7. When I smell a sizzling steak or a juicy piece of meat, I find it very difficult to keep from eating, even if I have just finished a meal.	Definitely true; mostly true, mostly false, definitely false	
	8. Sometimes when I start eating, I just cannot seem to stop.		
	9. Being with someone who is eating often makes me hungry enough to eat also.		
	10. When I see a real delicacy, I often get so hungry that I have to eat right away		
	11. I get so hungry that my stomach often seems like a bottomless pit.		
	12. I am always hungry so it is hard for me to stop eating before I finish the food on my plate.		
	13. I am always hungry enough to eat at any time.		
	14. How often do you feel hungry?	Only at mealtimes; sometimes between meals; often between meals; almost always	
	15. Do you go on eating binges though you are not hungry?	Never; rarely; sometimes; at least once a week	
	Emotional Eating		
	16. When I feel anxious, I find myself eating.	Definitely true; mostly true, mostly false, definitely false	
	17. When I feel blue, I often overeat.		
	18. When I feel lonely, I console myself by eating.		
Total Measures			75

^aThe PCORI scale is found in Heerman, W. J., et al., Clusters of healthy and unhealthy eating behaviours are associated with body mass index among adults. *J Nutr Educ Behav*, 2017. 49(5): p. 415–21.

^bThe original PDQ scale is found in Stetson, B., et al., Development and validation of The Personal Diabetes Questionnaire (PDQ): a measure of diabetes self-care behaviours, perceptions and barriers. *Diabetes Res Clin Pract*, 2011. 91(3): p. 321–332. A short form of the PDQ scale is tested in Akohoue, S. A., et al., Psychometric evaluation of the short version of the Personal Diabetes Questionnaire to assess dietary behaviours and exercise in patients with type 2 diabetes. *Eat Behav*, 2017. 26: p. 182–88. The items listed above are Items 1–4 of the shortened PDQ-11 shortened form.

^cHealth Measures. (2017, March 6). A brief guide to PROMIS Global Health instruments. http://www.healthmeasures.net/images/PROMIS/manuals/PROMIS_Global_Scoring_Manual.pdf.

^dThese questions are numbers 23, 25, and 28. Kaiser Permanente. (2012). Medicare Total Health Assessment Questionnaire. https://mydoctor.kaiserpermanente.org/ncal/Images/Medicare%20Total%20Health%20Assessment%20Questionnaire_tcm75-487922.pdf.

^eThis WAVE Questionnaire was adapted by Berry, L. L., et al. Physician counselling of overweight patients about preventive health behaviours. *Am J Prev Med*, 2014. 46(3): p. 297–302. The original WAVE questionnaire is found in Tsai, A.G. and T.A. Wadden, Treatment of obesity in primary care practices in the U.S.: a systematic review. *J Gen Intern Med*, 2009. 24(9): p. 1073–79.

^fNational Cancer Institute: Division of Cancer Control & Population Sciences. (2009). Dietary Screener Questionnaire. <https://epi.grants.cancer.gov/diet/shortreg/instruments/dsq-in-nhanes-09-10-self-administered-english-version.pdf>.

^gThe 18-item version of the TFEQ is available in Karlsson, J, et al., Psychometric properties and factor structure of the Three-Factor Eating Questionnaire (TFEQ) in obese men and women: results from the Swedish Obese Subjects (SOS) study. *Int J Obes Relat Metab Disord*, 2000, 24(12): p. 1715–1725. The original 51-item version of the TFEQ is available at Stunkard, A. J., and S. Messick, S., The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. *J Psychosom Res*, 29(1): p. 71–83.

TABLE A2

Baseline characteristics of samples

Characteristic	Study 1 (N = 120)	Study 2 (N = 8070)	U.S. Population (2018 Census Benchmark)
Female (%)	52.23	55.29	51.82
Median Age	33.00	33.00	42.00
Married (%)	–	41.08	51.36
Hispanic/Latino (%)	7.34	8.06	16.30
White (%)	78.90	81.47	74.05
Black/African-American (%)	10.09	9.93	12.07
Asian (%)	1.83	7.20	6.08
B.A. or Higher if 25 + (%)	63.37	55.35	33.06
Employed (%)	–	81.47	62.77
Median Household Income (\$2018)	–	\$51,049	\$60,293

Note: U.S. population estimates are derived from the 2018 American Community Survey Public Use Microdata using the sample weight (members of the armed forces and residents of group quarters are excluded). U.S. population median age calculated for employed persons. U.S. population percentages are calculated for individuals who report a single race.

TABLE A3

Study two OLS regressions of nutrition and physical activity question responses on participant demographics

	Dependent Variable							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Never/ Rarely Eats after Feeling Full	Often/ Very Often Eats after Feeling Full	Never/ Rarely Eats to Cope	Often/ Very Often Eats to Cope	Generally/ Fairly Unhealthy Diet	Generally/ Fairly Healthy Diet	Never Exercises	ln(Minutes of Exercise per Week +1)
Female	-0.024 ^b (0.011)	-0.002 (0.006)	-0.162 ^c (0.011)	0.054 ^c (0.007)	-0.040 ^c (0.008)	0.013 (0.011)	0.029 ^c (0.007)	-0.300 ^c (0.038)
Hispanic	0.032 (0.020)	0.028 ^b (0.013)	0.032 (0.020)	-0.002 (0.013)	0.011 (0.015)	-0.012 (0.019)	-0.016 (0.011)	0.105 ^a (0.063)
Black	0.093 ^c (0.019)	-0.021 ^b (0.009)	0.055 ^c (0.019)	-0.001 (0.013)	0.004 (0.014)	-0.000 (0.019)	0.015 (0.013)	-0.062 (0.069)
Asian	-0.029 (0.024)	0.004 (0.012)	-0.004 (0.023)	-0.001 (0.014)	-0.015 (0.014)	-0.033 (0.023)	-0.009 (0.011)	-0.030 (0.068)
Married	-0.004 (0.012)	-0.004 (0.006)	0.039 ^c (0.012)	-0.024 ^c (0.008)	-0.029 ^c (0.008)	0.061 ^c (0.012)	-0.003 (0.007)	-0.088 ^b (0.040)
Has Children	0.018 (0.012)	-0.002 (0.007)	0.030 ^b (0.012)	-0.020 ^b (0.008)	-0.007 (0.008)	-0.019 (0.012)	-0.008 (0.007)	0.015 (0.041)
40 or Older	0.084 ^c (0.012)	-0.030 ^c (0.006)	0.093 ^c (0.012)	-0.047 ^c (0.007)	-0.055 ^c (0.008)	0.118 ^c (0.012)	0.018 ^b (0.008)	-0.127 ^c (0.042)
Some College	-0.017	-0.006	-0.024	-0.004	-0.043 ^c	0.018	-0.042 ^c	0.175 ^b

	Dependent Variable							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Never/ Rarely Eats after Feeling Full	Often/ Very Often Eats after Feeling Full	Never/ Rarely Eats to Cope	Often/ Very Often Eats to Cope	Generally/ Fairly Unhealthy Diet	Generally/ Fairly Healthy Diet	Never Exercises	ln(Minutes of Exercise per Week +1)
	(0.021)	(0.012)	(0.020)	(0.014)	(0.016)	(0.020)	(0.015)	(0.081)
B.A. or Higher	-0.056 ^c	-0.007	-0.033 ^a	-0.008	-0.067 ^c	0.114 ^c	-0.063 ^c	0.279 ^c
	(0.020)	(0.011)	(0.020)	(0.013)	(0.016)	(0.020)	(0.014)	(0.079)
Employed Part-Time	-0.043 ^b	0.005	-0.028	0.005	-0.011	0.011	-0.057 ^c	0.363 ^c
	(0.018)	(0.010)	(0.018)	(0.012)	(0.013)	(0.017)	(0.012)	(0.064)
Employed Full-Time	-0.005	-0.004	0.040 ^c	-0.023 ^b	-0.026 ^b	0.026 ^a	-0.057 ^c	0.401 ^c
	(0.015)	(0.008)	(0.015)	(0.010)	(0.011)	(0.015)	(0.011)	(0.056)
Underweight (BMI < 18.5)	0.080 ^b	0.012	0.042	0.002	0.026	-0.013	0.048 ^b	-0.357 ^c
	(0.033)	(0.018)	(0.034)	(0.020)	(0.023)	(0.035)	(0.023)	(0.127)
Overweight (25 BMI < 30)	-0.122 ^c	0.018 ^c	-0.113 ^c	0.035 ^c	0.042 ^c	-0.125 ^c	0.011	-0.116 ^c
	(0.014)	(0.007)	(0.013)	(0.008)	(0.009)	(0.014)	(0.007)	(0.042)
Class I/II Obese (30 BMI < 40)	-0.208 ^c	0.057 ^c	-0.218 ^c	0.094 ^c	0.114 ^c	-0.288 ^c	0.055 ^c	-0.522 ^c
	(0.015)	(0.008)	(0.015)	(0.010)	(0.011)	(0.014)	(0.009)	(0.050)
Class III Obese (BMI ≥ 40)	-0.278 ^c	0.112 ^c	-0.303 ^c	0.170 ^c	0.232 ^c	-0.398 ^c	0.163 ^c	-1.190 ^c
	(0.024)	(0.018)	(0.024)	(0.021)	(0.022)	(0.020)	(0.020)	(0.100)
R ²	0.04	0.02	0.08	0.04	0.05	0.10	0.04	0.07
N	7839	7839	7839	7839	7839	7839	7839	7839

Note: Regressions (1)-(7) are estimated using a linear probability model. Regression (8) is estimated using ordinary least squares; a value of 1 minute of weekly exercise is added to all observations of the dependent variable in regression (8). Regression sample excludes 231 respondents who refused to report their race or ethnicity. Heteroskedasticity-robust standard errors in parentheses below estimated coefficient.

^a p < 0.1.

^b p < 0.05.

^c p < 0.01.

TABLE A4

Study two OLS regressions of desired dietary changes on participant demographics

	Dependent Variable					
	(1)	(2)	(3)	(4)	(5)	(6)
	Eat Less Unhealthy Food	Eat More Healthy Food	Better Portion Control	Better Frequency/ Timing of Eating	Less Emotional Eating	No Desired Dietary Changes
Female	-0.003	-0.053 ^c	-0.007	-0.018 ^b	0.059 ^c	-0.004 ^a
	(0.012)	(0.012)	(0.011)	(0.009)	(0.007)	(0.002)
Hispanic	-0.006	-0.028	-0.030	0.036 ^b	0.006	-0.002
	(0.021)	(0.021)	(0.018)	(0.017)	(0.013)	(0.003)
Black	-0.054 ^c	-0.004	-0.043 ^b	0.041 ^b	-0.027 ^b	-0.004

	Dependent Variable					
	(1)	(2)	(3)	(4)	(5)	(6)
	Eat Less Unhealthy Food	Eat More Healthy Food	Better Portion Control	Better Frequency/ Timing of Eating	Less Emotional Eating	No Desired Dietary Changes
	(0.020)	(0.020)	(0.017)	(0.016)	(0.012)	(0.002)
Asian	0.040 ^a	-0.015	0.033	0.015	-0.022 ^a	-0.005
	(0.024)	(0.024)	(0.022)	(0.019)	(0.013)	(0.004)
Married	0.022 ^a	-0.020	0.029 ^b	-0.036 ^c	-0.014 ^a	0.000
	(0.013)	(0.013)	(0.011)	(0.009)	(0.008)	(0.002)
Has Children	0.002	0.026 ^b	-0.004	0.003	-0.020 ^c	-0.006 ^c
	(0.013)	(0.013)	(0.011)	(0.010)	(0.008)	(0.002)
40 or Older	-0.025 ^a	0.030 ^b	-0.039 ^c	-0.025 ^c	-0.031 ^c	0.003
	(0.013)	(0.013)	(0.011)	(0.009)	(0.008)	(0.002)
Some College	0.000	-0.016	0.013	0.040 ^b	-0.010	0.000
	(0.021)	(0.021)	(0.018)	(0.016)	(0.014)	(0.003)
B.A. or Higher	-0.010	-0.017	0.051 ^c	0.002	0.002	0.004
	(0.021)	(0.021)	(0.018)	(0.015)	(0.014)	(0.003)
Employed Part-Time	0.003	0.010	0.012	-0.002	-0.009	-0.004
	(0.018)	(0.018)	(0.016)	(0.014)	(0.012)	(0.004)
Employed Full-Time	0.025	-0.018	0.031 ^b	-0.028 ^b	-0.018 ^a	-0.009 ^c
	(0.015)	(0.016)	(0.014)	(0.012)	(0.010)	(0.003)
Underweight (BMI < 18.5)	-0.122 ^c	0.071 ^b	-0.055 ^b	0.129 ^c	-0.026	0.014
	(0.034)	(0.035)	(0.025)	(0.034)	(0.018)	(0.011)
Overweight (25 < BMI < 30)	0.013	-0.086 ^c	0.135 ^c	-0.038 ^c	0.033 ^c	-0.006 ^c
	(0.014)	(0.014)	(0.012)	(0.010)	(0.008)	(0.002)
Class I/II Obese (30 < BMI < 40)	0.008	-0.131 ^c	0.215 ^c	-0.055 ^c	0.083 ^c	-0.006 ^b
	(0.015)	(0.015)	(0.014)	(0.011)	(0.010)	(0.002)
Class III Obese (BMI ≥ 40)	-0.035	-0.115 ^c	0.275 ^c	-0.075 ^c	0.102 ^c	-0.008 ^c
	(0.025)	(0.025)	(0.024)	(0.017)	(0.019)	(0.003)
R ²	0.01	0.02	0.05	0.02	0.03	0.01
N	7839	7839	7839	7839	7839	7839

Note: All regressions are estimated using a linear probability model. Regression sample excludes 231 respondents who refused to report their race or ethnicity. Heteroskedasticity-robust standard errors in parentheses below estimated coefficient.

^a $p < 0.1$.

^b $p < 0.05$.

^c $p < 0.01$.

TABLE A5

Study two OLS regressions of nutrition and physical activity question responses on participant demographics (using continuous BMI)

	Dependent variable							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Never/ Rarely Eats after Feeling Full	Often/ Very Often Eats after Feeling Full	Never/ Rarely Eats to Cope	Often/ Very Often Eats to Cope	Generally/ Fairly Unhealthy Diet	Generally/ Fairly Healthy Diet	Never Exercises	ln(Minutes of Exercise per Week +1)
Female	-0.025 ^b (0.011)	-0.001 (0.006)	-0.162 ^c (0.011)	0.055 ^c (0.007)	-0.038 ^c (0.008)	0.009 (0.011)	0.032 ^c (0.007)	-0.318 ^c (0.038)
Hispanic	0.027 (0.021)	0.029 ^b (0.013)	0.026 (0.020)	0.000 (0.013)	0.014 (0.015)	-0.020 (0.020)	-0.014 (0.011)	0.087 (0.063)
Black	0.095 ^c (0.019)	-0.022 ^b (0.009)	0.057 ^c (0.019)	-0.002 (0.013)	0.003 (0.014)	0.002 (0.019)	0.015 (0.013)	-0.055 (0.069)
Asian	-0.030 (0.024)	0.005 (0.012)	-0.005 (0.023)	0.000 (0.014)	-0.014 (0.014)	-0.033 (0.023)	-0.008 (0.011)	-0.036 (0.069)
Married	-0.003 (0.012)	-0.004 (0.006)	0.040 ^c (0.012)	-0.025 ^c (0.007)	-0.030 ^c (0.008)	0.063 ^c (0.012)	-0.004 (0.007)	-0.079 ^b (0.040)
Has Children	0.018 (0.012)	-0.002 (0.007)	0.028 ^b (0.012)	-0.019 ^b (0.008)	-0.007 (0.008)	-0.021 ^a (0.012)	-0.008 (0.007)	0.015 (0.041)
40 or Older	0.086 ^c (0.012)	-0.031 ^c (0.006)	0.094 ^c (0.012)	-0.047 ^c (0.007)	-0.055 ^c (0.008)	0.119 ^c (0.012)	0.017 ^b (0.008)	-0.121 ^c (0.042)
Some College	-0.016 (0.021)	-0.006 (0.012)	-0.023 (0.020)	-0.004 (0.014)	-0.043 ^c (0.016)	0.019 (0.020)	-0.042 ^c (0.015)	0.175 ^b (0.081)
B.A. or Higher	-0.057 ^c (0.020)	-0.007 (0.011)	-0.035 ^a (0.020)	-0.007 (0.013)	-0.067 ^c (0.016)	0.115 ^c (0.020)	-0.064 ^c (0.014)	0.285 ^c (0.079)
Employed Part-Time	-0.043 ^b (0.018)	0.005 (0.010)	-0.029 ^a (0.018)	0.006 (0.012)	-0.010 (0.013)	0.011 (0.017)	-0.057 ^c (0.012)	0.358 ^c (0.064)
Employed Full-Time	-0.003 (0.015)	-0.005 (0.008)	0.040 ^c (0.015)	-0.023 ^b (0.010)	-0.027 ^b (0.011)	0.028 ^a (0.015)	-0.058 ^c (0.011)	0.407 ^c (0.056)
BMI	-0.039 ^c (0.004)	0.005 ^a (0.003)	-0.030 ^c (0.004)	0.007 ^b (0.003)	0.007 ^b (0.004)	-0.038 ^c (0.004)	0.001 (0.003)	-0.019 (0.016)
BMI ²	0.0004 ^c (0.000)	-0.000003 (0.000)	0.0002 ^c (0.000)	-0.000003 (0.000)	0.00004 (0.000)	0.0003 ^c (0.000)	0.0001 (0.000)	-0.0003 (0.000)
R ²	0.04	0.02	0.08	0.04	0.05	0.10	0.04	0.07
N	7839	7839	7839	7839	7839	7839	7839	7839

Note: Regressions (1)–(7) are estimated using a linear probability model. Regression (8) is estimated using ordinary least squares; a value of 1 minute of weekly exercise is added to all observations of the dependent variable in regression

(8). Regression sample excludes 231 respondents who refused to report their race or ethnicity. Heteroskedasticity-robust standard errors in parentheses below estimated coefficient.

^a $p < 0.1$.

^b $p < 0.05$.

^c $p < 0.01$.

TABLE A6

Study two OLS regressions of desired dietary changes on participant demographics (using continuous BMI)

	Dependent Variable					
	(1)	(2)	(3)	(4)	(5)	(6)
	Eat less unhealthy food	Eat more healthy food	Better portion control	Better frequency/timing of eating	Less emotional eating	No desired dietary changes
Female	-0.003 (0.012)	-0.053 ^c (0.012)	-0.007 (0.010)	-0.017 ^a (0.009)	0.061 ^c (0.007)	-0.003 ^a (0.002)
Hispanic	-0.007 (0.021)	-0.031 (0.021)	-0.024 (0.018)	0.035 ^b (0.017)	0.009 (0.013)	-0.002 (0.003)
Black	-0.054 ^c (0.020)	-0.003 (0.020)	-0.045 ^c (0.017)	0.042 ^b (0.016)	-0.027 ^b (0.012)	-0.004 (0.002)
Asian	0.041 ^a (0.024)	-0.015 (0.024)	0.034 (0.022)	0.013 (0.019)	-0.021 ^a (0.013)	-0.005 (0.004)
Married	0.023 ^a (0.013)	-0.021 (0.013)	0.028 ^b (0.011)	-0.037 ^c (0.009)	-0.015 ^a (0.008)	0.000 (0.002)
Has Children	0.001 (0.013)	0.025 ^b (0.013)	-0.003 (0.011)	0.004 (0.010)	-0.020 ^c (0.008)	-0.006 ^c (0.002)
40 or Older	-0.025 ^b (0.013)	0.030 ^b (0.013)	-0.040 ^c (0.011)	-0.024 ^c (0.009)	-0.031 ^c (0.008)	0.003 (0.002)
Some College	0.000 (0.021)	-0.015 (0.021)	0.013 (0.018)	0.039 ^b (0.016)	-0.011 (0.014)	0.000 (0.003)
B.A. or Higher	-0.009 (0.021)	-0.017 (0.021)	0.052 ^c (0.018)	-0.000 (0.015)	0.001 (0.014)	0.004 (0.003)
Employed Part-Time	0.002 (0.018)	0.011 (0.018)	0.012 (0.016)	-0.003 (0.014)	-0.009 (0.012)	-0.004 (0.004)
Employed Full-Time	0.025 (0.015)	-0.017 (0.016)	0.030 ^b (0.014)	-0.028 ^b (0.012)	-0.019 ^a (0.010)	-0.009 ^c (0.003)
BMI	0.013 ^c (0.004)	-0.028 ^c (0.004)	0.038 ^c (0.004)	-0.015 ^c (0.003)	0.014 ^c (0.003)	-0.002 ^c (0.001)
BMI ²	-0.0002 ^c (0.000)	0.0003 ^c (0.000)	-0.0004 ^c (0.000)	0.0002 ^c (0.000)	-0.0001 ^c (0.000)	0.00002 ^b (0.000)
R ²	0.01	0.02	0.05	0.02	0.03	0.01
N	7839	7839	7839	7839	7839	7839

Note: All regressions are estimated using a linear probability model. Regression sample excludes 231 respondents who refused to report their race or ethnicity. Heteroskedasticity-robust standard errors in parentheses below estimated coefficient.

^a $p < 0.1$.

^b $p < 0.05$.

^c $p < 0.01$.

TABLE A7

Study two correlation of participant responses to nutrition and physical activity questions

	Minutes of Weekly Exercise	Frequency of Eating when Full	Frequency of Eating to Cope	Healthiness of Diet	Wants to Eat Less Unhealthy Food	Wants to Eat More Healthy Food	Wants Better Portion Control	Wants Better Timing of Eating	Wants Less Emotional Eating
Minutes of Weekly Exercise	1.00	-0.04	-0.09	0.22	-0.03	-0.03	-0.04	0.05	0.004
Frequency of Eating when Full	-0.04	1.00	0.44	-0.26	0.02	-0.13	0.22	-0.08	0.13
Frequency of Eating to Cope	-0.09	0.44	1.00	-0.28	-0.02	-0.12	0.13	-0.07	0.30
Healthiness of Diet	0.22	-0.26	-0.28	1.00	-0.09	-0.06	-0.06	0.10	-0.04
Wants to Eat Less Unhealthy Food	-0.03	0.02	-0.02	-0.09	1.00	-0.18	-0.19	-0.26	-0.14
Wants to Eat More Healthy Food	-0.03	-0.13	-0.12	-0.06	-0.18	1.00	-0.32	-0.19	-0.21
Wants Better Portion Control	-0.04	0.22	0.13	-0.06	-0.19	-0.32	1.00	-0.13	-0.05
Wants Better Timing of Eating	0.05	-0.08	-0.07	0.10	-0.26	-0.19	-0.13	1.00	-0.09
Wants Less Emotional Eating	0.004	0.13	0.30	-0.04	-0.14	-0.21	-0.05	-0.09	1.00

TABLE A8

Class I/II/III obesity rates among respondents who answered “Yes” to At Least One ADIA+ or ADIA scale question on problematic dietary and exercise behaviour

Answer “Yes” to	All Participants	Age < 40	Age > 40	Educations High School	Education= Some College	Education > Bachelor's Degree
ADIA+ Scale: >0 Questions	40.16%	36.58%	51.13%	46.10%	44.94%	34.76%
ADIA+ Scale: >1 Question	52.62%	49.82%	62.58%	58.24%	57.19%	46.69%
ADIA Scale: >0 Questions	43.59%	40.50%	52.46%	43.27%	47.58%	39.91%

Answer “Yes” to	All Participants	Age < 40	Age > 40	Educations High School	Education= Some College	Education > Bachelor’s Degree
ADIA Scale: >1 Question	54.88%	53.63%	58.21%	55.26%	62.37%	47.66%
N	8070	5748	2322	697	2906	4467
Answer “Yes” to	Income < \$30,000	\$30,000 < Income < \$75,000	Income > \$75,000	Unemployed	Employed Part-Time	Employed Full-Time
ADIA+ Scale: >0 Questions	44.33%	41.49%	32.93%	43.60%	39.52%	39.06%
ADIA+ Scale: >1 Question	57.79%	53.22%	45.18%	57.89%	43.13%	54.26%
ADIA Scale: >0 Questions	46.88%	44.11%	37.94%	45.62%	41.43%	43.51%
ADIA Scale: >1 Question	63.51%	54.40%	42.55%	58.33%	45.28%	57.02%
N	1847	3802	2421	1428	1646	4996

Note: Reported income is total household income. Reported N is the number of participants of all BMI classifications who identified with the category of interest (eg, low income, middle income, high income).

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What is already known about this subject?

- Dietary behaviours and physical activity are important to long-term health outcomes but are rarely assessed by healthcare providers in a systematic manner.
- Existing studies show that measures of physical activity can be successfully integrated into Electronic Health Records (EHRs).

What does this study add?

- We develop a simple assessment of dietary intake and physical activity (ADIA scale) for well-visit medical appointments for all adult patients.
- We develop an extended assessment of dietary intake and physical activity (ADIA+ scale) for use in research contexts.
- Use of these measures will inform and facilitate meaningful physician-patient interaction around the topics of dietary and physical activity behaviours. Longitudinal data collection through incorporation of the ADIA scale into EHRs can help researchers better understand relationships between dietary patterns, physical activity, and other health outcomes both for prevention and treatment.

TABLE 1

Dietary intake measures assessed in Study 1

	Mean	SD
1 How many servings of vegetables do you eat on a typical day?	5.89	1.36
2 How often do you continue to eat after you feel full?	5.73	1.53
3 How often do you experience eating problems such as overeating, binge eating, impulsive eating, or emotional eating?	5.74	1.54
4 How often do you deliberately make choices about how much to eat in order to lose weight or to keep from gaining weight?	5.23	1.60
5 When choosing what to eat for your meals and snacks, how often do you feel like you make healthy food choices?	5.47	1.43
6 On a typical day, how often do you eat fried or processed foods?	5.63	1.56
7 On a typical day, how often do you drink juice, soda, or sugary beverages?	5.87	1.53
8 How many servings of fruit do you eat per day?	5.85	1.48
9 How often do you deliberately make choices about what to eat in order to lose weight or to keep from gaining weight?	5.39	1.55
10 How often do you eat unhealthy foods to reward yourself for eating healthier foods?	5.17	1.59
11 What is the relative quantity of healthier versus less healthy foods in your diet?	4.50	1.78
12 How often do you eat as a way to cope with negative feelings like unhappiness, stress, or depression?	5.92	1.36
13 How often do you eat away from home at restaurants or fast food establishments?	5.56	1.55
Participant-provided questions about Food Types	5.94	0.89
Participant-provided questions about Food Amounts	5.81	0.99
Participant-provided questions about When, Where, Why	5.70	1.00

Note: Participants assessed how good each question was on the following scale: 1 “This is a very poor question” to 7 “This is a very good question” scale. All measures were significantly higher than the mean scale score of 4.0.

Final ADIA+ screening questions

TABLE 2

Short-form for clinical use (the Adult Dietary Intake and Activity [ADIA] scale):

- Activity 1 Think about your physical activity over the past month and include exercise, sports, walking to get places, and strenuous work (eg, pushing a lawnmower). How many days per week do you usually do moderate (eg, walking briskly) to strenuous (eg, running, biking) physical activity? [0–7 days]
- Activity 2 On the days that you do physical activity, how long are you active (in minutes)?
 - [Number 0–150]
- Dietary 1 Based on your understanding of healthy eating, how would you describe your diet?
 - Almost always healthy
 - Healthy more often than unhealthy
 - Healthy about half the time
 - Unhealthy more often than healthy
 - Almost always unhealthy

Longer form for (potential) clinical use and research studies (the ADIA+ scale):

Includes three measures above, plus the following:

- Dietary 2 How often do you continue to eat after you feel full?
 - [Never, rarely, sometimes, often, very often]
- Dietary 3 How often do you eat to cope with feelings of sadness, depression, or stress?
 - [Never, rarely, sometimes, often, very often]
- Dietary 4 What do you wish you could change about your diet? Select up to two.
 - Increasing consumption of healthy foods
 - Decreasing consumption of unhealthy foods
 - Improving my portion control
 - Improving the frequency/timing of my eating
 - Improving my eating-related responses to negative emotions

Note: Activity measures combined to form a single measure of estimated weekly activity minutes.

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	Never/ Rarely Eats after Feeling Full	Often/ Very Often Eats after Feeling Full	Never/ Rarely Eats to Cope	Often/ Very Often Eats to Cope	Generally/ Fairly Unhealthy Diet	Generally/ Fairly Healthy Diet	Never Exercises	Average Minutes of Exercise per Week	Average BMI	N	Eat Less Unhealthy Food	Eat More Healthy Food	Better Portion Control	Better Frequency/ Timing of Eating	Less Emotional Eating	No Desired Dietary Changes
\$30,000 < Income < \$75,000	55.18%	7.31%	58.42%	10.47%	14.05%	44.58%	9.34%	161.49	27.63	3802	43.98%	46.63%	29.17%	17.28%	10.92%	0.71%
Income > \$75,000	52.71%	7.72%	61.67%	9.29%	9.42%	53.57%	6.57%	176.21	26.67	2421	44.44%	46.26%	30.86%	15.86%	10.12%	0.74%
Underweight (BMI < 18.5)	69.86%	6.85%	68.04%	8.68%	12.33%	54.34%	11.87%	165.56	16.86	219	30.14%	57.99%	13.24%	33.79%	5.94%	3.20%
Normal Weight (18.5 < BMI < 25)	63.09%	5.11%	66.16%	7.39%	8.09%	58.35%	6.48%	184.00	22.32	3289	43.45%	52.90%	19.15%	19.82%	8.21%	1.09%
Overweight (25 < BMI < 30)	52.75%	6.68%	58.71%	9.41%	12.30%	46.70%	7.45%	175.61	27.20	2349	44.57%	45.51%	32.18%	16.05%	10.09%	0.43%
Class I/II Obese (30 < BMI < 40)	44.75%	10.44%	46.87%	15.78%	19.28%	30.12%	12.74%	135.88	33.76	1743	43.95%	40.79%	39.36%	14.11%	15.66%	0.40%
Class III Obese (BMI > 40)	37.44%	16.17%	35.96%	24.68%	31.70%	18.09%	23.83%	100.64	46.47	470	39.15%	41.28%	45.11%	12.98%	18.72%	0.21%

Note: Participants could select up to two desired dietary changes. Reported income is total household income. Note that 231 respondents refused to report their race or ethnicity.

TABLE 4
Study two OLS regressions of nutrition and physical activity question responses on participant demographics

	Dependent variable													
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Never/ Rarely eats after full	Often/ Very often eats full	Never/ Rarely eats to cope	Often/ Very often eats to cope	Generally/ Fairly unhealthy diet	Generally/ Fairly healthy diet	Never exercises	ln(Minutes of exercise per week +1)	Eat less unhealthy food	Eat more healthy food	Better portion control	Better frequency/ timing of eating	Less emotional eating	(14) No desired dietary changes
Underweight (BMI < 18.5)	0.080 ^b (0.033)	0.012 (0.018)	0.042 (0.034)	0.002 (0.020)	0.026 (0.023)	-0.013 (0.035)	0.048 ^b (0.023)	-0.357 ^c (0.127)	-0.122 ^c (0.034)	0.071 ^b (0.035)	-0.055 ^b (0.025)	0.129 ^c (0.034)	-0.026 (0.018)	0.014 (0.011)
Overweight (25 < BMI < 30)	-0.122 ^c (0.014)	0.018 ^c (0.007)	-0.113 ^c (0.013)	0.035 ^c (0.008)	0.042 ^c (0.009)	-0.125 ^c (0.014)	0.011 (0.007)	-0.116 ^c (0.042)	0.013 (0.014)	-0.086 ^c (0.014)	0.135 ^c (0.012)	-0.038 ^c (0.010)	0.033 ^c (0.008)	-0.006 ^c (0.002)
Class I/II Obese (30 < BMI < 40)	-0.208 ^c (0.015)	0.057 ^c (0.008)	-0.218 ^c (0.015)	0.094 ^c (0.010)	0.114 ^c (0.011)	-0.288 ^c (0.014)	0.055 ^c (0.009)	-0.522 ^c (0.050)	0.008 (0.015)	-0.131 ^c (0.015)	0.215 ^c (0.014)	-0.055 ^c (0.011)	0.083 ^c (0.010)	-0.006 ^b (0.002)
Class III Obese (BMI > 40)	-0.278 ^c (0.024)	0.112 ^c (0.018)	-0.303 ^c (0.024)	0.170 ^c (0.021)	0.232 ^c (0.022)	-0.398 ^c (0.020)	0.163 ^c (0.020)	-1.190 ^c (0.100)	-0.035 (0.025)	-0.115 ^b (0.025)	0.275 ^c (0.024)	-0.075 ^c (0.017)	0.102 ^c (0.019)	-0.008 ^c (0.003)
R ²	0.04	0.02	0.08	0.04	0.05	0.10	0.04	0.07 ^a	0.01	0.02	0.05	0.02	0.03	0.01

Note: Regressions (1)–(7) and (9)–(14) are estimated using a linear probability model. All regression samples exclude 231 respondents who refused to report their race or ethnicity (N = 7839). All regressions include controls for sex, race, ethnicity, marital status, parental status, age 40 or older, highest level of education, and employment status (see Tables A3, A4 for full results). Heteroskedasticity-robust standard errors in parentheses below estimated coefficient.

^a P < 0.1.

^b P < 0.05.

^c P < 0.01.

TABLE 5

Relationship between participants' BMI classification and problematic dietary and exercise behaviour

ADIA+ Scale: Percent of Respondents Who Answered "Yes" to Eating After Full Often, Eating to Cope Often, Eating an Unhealthy Diet, and/or No Exercise, by BMI Classification									
Answered "Yes" to	All Participants	Underweight Participants (BMI < 18.5)	Normal Weight Participants (< 25)	18.5 < BMI	Overweight Participants (25 < BMI < 30)	Class I/II Obese Participants (30 < BMI < 40)	Class III Obese Participants (BMI >40)		
0 questions	71.09%	68.95%	73.73%	78.38%	73.73%	61.62%	42.98%		
1 question	20.15%	23.74%	18.90%	17.18%	18.90%	24.10%	30.85%		
2 questions	6.13%	5.94%	5.49%	3.56%	5.49%	9.58%	14.68%		
3 questions	2.19%	1.37%	1.53%	0.76%	1.53%	3.84%	9.79%		
4 questions	0.43%	0.00%	0.34%	0.12%	0.34%	0.86%	1.70%		
>0 questions	28.91%	31.05%	26.27%	21.62%	26.27%	38.38%	57.02%		
>1 questions	8.76%	7.31%	7.36%	4.44%	7.36%	14.29%	26.17%		
ADIA Scale: Percent of Respondents Who Answered "Yes" to Eating an Unhealthy Diet and/or No Exercise, by BMI Classification									
Answered "Yes" to	All Participants	Underweight Participants (BMI < 18.5)	Normal Weight Participants (< 25)	18.5 < BMI	Overweight Participants (25 < BMI < 30)	Class I/II Obese Participants (30 < BMI < 40)	Class III Obese Participants (BMI >40)		
0 questions	80.56%	79.91%	82.63%	86.83%	82.63%	72.75%	55.53%		
1 question	16.39%	15.98%	14.99%	11.77%	14.99%	22.49%	33.40%		
2 questions	3.05%	4.11%	2.38%	1.40%	2.38%	4.76%	11.06%		
>0 questions	19.44%	20.09%	17.37%	13.17%	17.37%	27.25%	44.47%		
Class I/II/III Obesity Rates Among Respondents Who Answered "Yes" to At Least One ADIA+ or ADIA Scale Question on Problematic Dietary and Exercise Behaviour									
	All Participants	Age < 40	Age > 40	High School	Income < \$30,000	Unemployed			
ADIA+ Scale: >0 Questions	40.16%	36.58%	51.13%	46.10%	44.33%	43.60%			
ADIA+ Scale: >1 Question	52.62%	49.82%	62.58%	58.24%	57.79%	57.89%			
ADIA Scale: >0 Questions	43.59%	40.50%	52.46%	43.27%	46.88%	45.62%			
ADIA Scale: 1 Question	54.88%	53.63%	58.21%	55.26%	63.51%	58.33%			

Note: Reported income is total household income. Estimates include N = 8070 participants. Full comparison results for education, income, and employment comparisons are presented in Table A8.

TABLE 6

Qualitative themes and quotes regarding reactions to ADIA+ screening questions

Theme	Sample Quote (referenced question, if applicable)	Source
Clarity	"Moderate to strenuous for me is different that moderate to strenuous for someone that is 20 years younger." (Activity 1)	Patient
	"Certainly, you may lose some clarity or definition by just asking for one specific average." (Activity 2)	Provider
	"Using 'generally, fairly, and sometimes' is confusing." (Dietary 2 and 3)	Patient
Sensitivity	"But I think it is also something that people tend to say happens less often than it actually does because it is somewhat, not embarrassing, but something that is looked at negatively" (Dietary 2)	Patient
	"Some people are more in tune to that than others... they are really psychological questions." (Dietary 2 and 3)	Provider
	"I do not know that they are going to tell somebody that, that they do not know or do not trust." (Dietary 2 and 3)	Provider
	"It implies that [they] already do not feel good about [their] weight." (Dietary 4)	Provider
Difficulty	"People really do not pay attention to how much they eat." (Dietary 2)	Patient
	"All the [other] questions were very simple and quick. [Here] you had to stop and actually read every [answer]." (Dietary 4)	Patient
Usefulness	"I see the ability of people to sort of low ball their answers, but I tend to trust my physician." (Dietary 2 and 3)	Patient
	"It would prompt me to explore [the reason] they are wanting to eat healthy." (Dietary 3)	Provider
	"I would use the information to decide who I need to talk more about activity with and set goals." (Dietary 4)	Provider