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PSYCHOSOCIAL CORRELATES OF DIETARY INTAKE: Advancing Dietary Intervention

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ABSTRACT

Psychosocial variables that predict dietary behavior become important targets for change in nutrition education programs. Psychosocial variables in models with higher predictability provide more effective levers to promote healthy dietary change. A review of the literature on models with psychosocial variables predicting dietary fat and fruit and vegetable consumption revealed generally low predictiveness, $R^2 < 0.3$ (where R^2 is the squared multiple correlation of the statistical model). No single theory provided models that regularly out-predicted others. When models predicted narrower categories of behavior (e.g. milk or salad consumption), predictiveness tended to be higher. Substantial problems were revealed in the psychometrics of both the independent and dependent variables. Little theory-based research has been conducted with adolescents, and the few studies done with children had low predictiveness. In order to increase the predictiveness of models, future research should combine variables from several theories, attend to the psychometrics of all variables, and incorporate variables that moderate the relationship of psychosocial to dietary behavior (e.g. genetics of taste, stage in the life course). Refinements on current research would include longitudinal designs and use of non–self-report methods of dietary behavior to supplement the self-report methods. Improved understanding of dietary behavior should lead to more effective dietary behavior change interventions.

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BACKGROUND

Research in the field of behavioral nutrition employs behavioral science theory and methods to understand dietary behavior (e.g. what food people eat) and to design and evaluate dietary change programs (3). Interventions recently have been analyzed in terms of mediating variables (variables that explain why or how one variable is related to or causes another) (4, 7). From this perspective, interventions effect change in variables (called mediators) that in turn result in behavior change. Similarly, a recent method for the design of nutrition education programs has proposed that educators must first assess the key variables that influence the behavior of interest, which in turn become intervention targets (11). Applying the mediating variable framework reveals that the effectiveness of interventions is limited by two factors: the ability of mediating variables to predict behavior, and the ability of the interventions to effect change in the mediating variables. This paper reviews the behavioral nutrition literature that assesses the relationships between various psychosocial variables (potential mediating variables) and dietary behaviors. Implications are drawn for dietary change interventions.

Early behavioral nutrition research used basic learning theory to address the issues of how much and when a person chose to eat (22). Because nutrients predispose to chronic disease, nutrition epidemiology focuses on the nutrients in foods a person consumes (79). Primarily because people eat and think in terms of foods, behavioral nutrition focuses on the foods people eat (79). This paper focuses on behavioral science issues in the selection of foods high in the nutrients of health interest. To limit the scope, we focus on predictors for selection of fruit, juice, and vegetables (FJV), a food group people appreciate

less but should consume more of, and on food sources of dietary fat, a food group people generally like but should consume less of, as well as lower-fat alternatives. The factors influencing consumption of these food groups may be different as well. Some behavioral nutrition research has focused on "increasing healthy eating." Because people differ in what they mean by "healthy eating," this paper does not review these articles.

A substantial literature has been generated on how food preferences and sensory characteristics of foods influence consumption (38). Because studies of adults were recently reviewed by Drewnowski (38) and studies of children are reviewed in this volume by Birch & Fisher (14), they are not reviewed further here.

A variety of behavior theories have been employed to understand or predict dietary behavior. The theories most commonly employed include the Theory of Reasoned Action (TRA) (71) or, its latest modification, the Theory of Planned Behavior (TPB) (71); the Social Cognitive Theory (SCT) (8), also sometimes called the Self Efficacy Theory and previously called the Social Learning Theory and its Self Control procedures; the Health Belief Model (HBM) (92); and the Transtheoretical Model (TTM), also sometimes called the Stages of Change (80). Simple schematic representations of the component concepts and how they are interrelated appear in Figure 1 for each of these theories.

Recent literature demonstrates that human food consumption varies substantially by age (CL Warneke, KW Cullen, C de Moor, T Baranowski & M Davis, submitted for publication). The influences on eating patterns of children (who may be dependent on parents) are likely different from influences on eating patterns of adolescents (who often are attempting to break their dependence on parents) (77), which in turn are likely different from influences on food choices of adults. Finer age breakdowns might be enlightening, but insufficient literature exists to assess influences within narrower categories.

A key consideration is how to evaluate whether theoretical models are doing an adequate job of accounting for the phenomenon of concern. Typically, this has been done with an indicator of model fit: R^2, the squared multiple correlation of the statistical model with the phenomenon of interest. Low R^2 values (e.g. <0.3) suggest that the models are not predicting substantial variance in behavior and thus interventions based on these models will not have a substantial impact on behavior (4, 7). This indicator has not always been reported in the literature, but it is the most appropriate indicator available at this time. Sometimes investigators report the R^2 of intentions or expectations with psychosocial mediators. This review focuses on prediction of FJV- and fat-consumption behaviors, the most clearly relevant dietary public health outcome. Summary and evaluative comments are presented after the summary of key findings within age and food group sections.

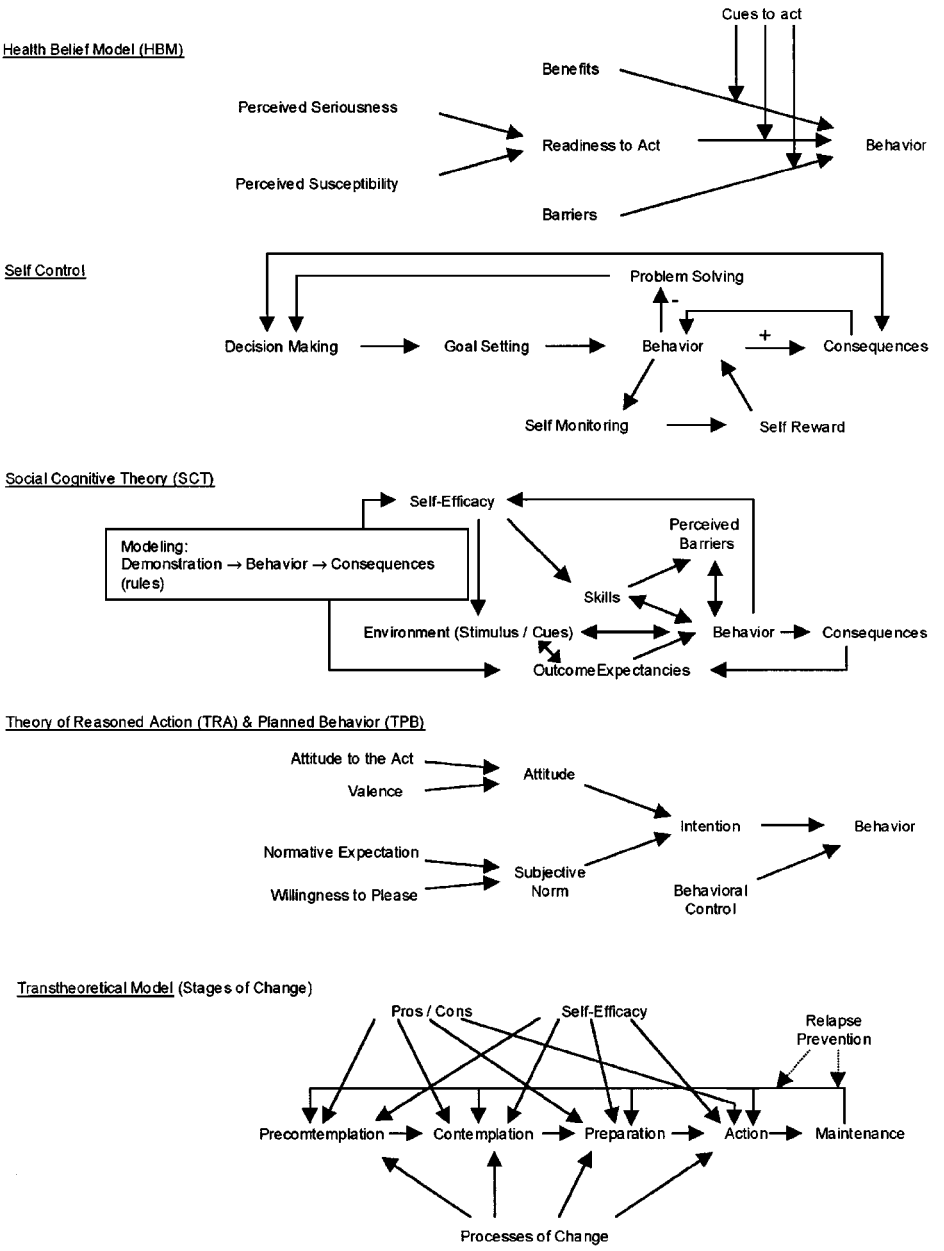

Figure 1 Schematic representations of major psychosocial theories.

KEY FINDINGS

Adult Fat Consumption

High-fat consumption practices varied by meal and by day of the week. It was highest for dinner (2.75 practices per day), consistently low for snacks and weekday breakfasts (1.25 practices per day each), and moderate for lunch and weekend breakfasts (2 practices per day each) (10). This variability in consumption practices suggests that influences also varied by meal and day of the week.

NONTHEORETICAL STUDIES Some studies employed no theory and used mostly demographic characteristics (73) and more intuitive predictors of dietary behavior (e.g. knowledge, body mass index) (40, 74, 78, 82). In general, these studies obtained some statistically significant relationships, but they accounted either for none of the variability in milk consumed (40) or for only small percentages of the variability [e.g. 0.03 (82), 0.06 (74), 0.08 (73)]. Four factors were determined from 21 eating-attitude items: helpless and unhealthy, food exploration, meat preference, and health consciousness (58). Nonsignificant to moderate (-0.47) correlations were detected between these factors and meat consumption (a high-fat behavior) but not with fat and dairy consumption (58).

THEORY OF REASONED ACTION OR PLANNED BEHAVIOR In several cases the TRA-TPB model R^2 values were not reported (19, 81). Most reported R^2 values were below 0.3 (or accounted for less than 30% of the variability in behavior). Thus, TRA and TPB models had a higher, though still modest, predictiveness than those using demographic characteristics. The predictiveness of the models exceeded 0.3 when the dependent variable was intention, not behavior (76); however, behavior is the outcome of greatest interest. Predictiveness of specific behaviors (e.g. low-fat milk consumption) (81, 95) may have been high because people think and act in terms of these specific behaviors rather than in terms of categories of foods (baked grain products) (89) or nutrients (e.g. fat in my diet) (89). Higher predictiveness was obtained when the TRA constructs from six models predicting six high-fat foods were aggregated into a single model by averaging construct values (88); this was likely achieved because the dependent and independent variables increased in reliability from the combinations.

When behavior was the dependent variable, attitude had a greater predictiveness than the component termed subjective norm, a person's perception of how significant others expect that person to behave and the person's desire to meet those expectations (19, 88, 95); however, when intention or expectation was the dependent variable, either subjective norm had greater predictiveness (76) or attitude and subjective norm had comparable influence (81). Predictiveness

of subjectively estimated fat intake was higher than that of objectively estimated fat intake (19), which suggests that people were not aware of actual fat intake or were not aware of all the sources of fat intake. Younger adults had unrealistically low expectations about the likelihood that they will develop a chronic disease and whether certain dietary practices lead to chronic disease (89). When grouped into categories of usual milk consumption, consumers of different levels of fat clearly had different beliefs (95).

TRANSTHEORETICAL MODEL (TTM) A problem in comparing results from investigations using TTM with those using other models is that an R^2 was not reported. Instead, investigators reported differences in the variables of interest across stages. A key issue in this literature is whether the algorithms for staging respondents work as would be predicted: that no differences occur in dietary fat across the first three stages, when cognitive changes are occurring; that there is somewhat lower dietary fat in the action stage, when people are first trying to lower fat; and that the least fat is among those in the maintenance stage, when the attempts to change diet have ended. One algorithm was unable to stage more than a third of respondents (1); dietary intake did not vary across stages as would be predicted in two others (28, 70). Substantially different distributions of cases were obtained when people were staged using subjective estimates of fat consumption versus those using more objective estimates (66), providing evidence that people generally were not aware of the fat in their diet.

LIFE STAGES Using qualitative methods, the influences on food consumption on women varied substantially depending on their stage in life (especially in regard to whether children were in the home and, if so, what the ages those children were) (30). A quantitative follow-up revealed that the role a woman played (parent, partner, worker) accounted for little of the variability in fat avoidance ($R^2 = 0.02$), that the role-related beliefs (in regard to caretaking, barriers, and perceived social norms) accounted for substantially more of the variability ($R^2 = 0.22$), and that influences varied by stage in life course (31).

HEALTH BELIEF MODEL The predictiveness of the HBM models was also modest [0.17 (64), 0.26 and 0.27 (87)]. Key correlates for husbands was (*a*) having the self-efficacy (the belief or confidence a person has in his or her ability to perform a specific behavior, including overcoming the barriers to performing that behavior) to eat a low-fat diet, (*b*) the threat of chronic disease, and (*c*) the benefits of a low-fat diet (87); for wives, cost as a barrier and a benefit was important (63). Single indicators of HBM constructs were aggregated into general categories (predisposing and enabling variables), making it difficult to draw implications for HBM in predicting dietary behavior (64).

SOCIAL COGNITIVE THEORY (SCT) Both qualitative (13) and more quantitative (83) studies demonstrated that important correlates of food consumption were cost, taste (preference, pleasure), convenience, and concern for health. Concerns for nutrition, convenience, and weight control predicted frequency of fast food consumption (a high-fat behavior), but only concerns for weight control predicted cheese consumption and taste; cost predicted neither (46). Among participants who reported low preference for high-fat foods, consumption was associated with higher availability in their environment of such foods (20), but no relationship was detected among those reporting a high preference for fat. This suggests that those who enjoy high-fat foods will find ways of consuming them, even if not available in their immediate environment (20). Thus, nonlinear relationships may exist among these constructs.

THEORETICALLY ECLECTIC Several investigators combined concepts and measures from several theories. Knowledge, attitudes, and norms predicted percentage of calories from fat and low-fat dietary behaviors in expected patterns, but at less than 30% of the variability (63). Acculturation (a likely bidirectional and multidimensional process wherein a person from one culture enters another and changes to reflect or incorporate aspects of the new culture) was a significant predictor of fat avoidance among Mexican-Americans (98). The preventive health behaviors practiced by members of a social network, their subjective norm, and their motivation to comply predicted preventive nutrition behavior, but the pattern of predictiveness varied by level of locus of control [a Social Learning Theory construct that proposes that people learn from their lifelong experiences whether what happens in their life is due to their own efforts (internal control), to the behaviors of others (external control), or to chance (external control)] (44). The subjective norm was higher among those who were not chance oriented and those who did not shift responsibility to others; actual preventive health behavior was higher among those with a perceived low-degree of personal responsibility, those who were not chance oriented, and those who did not shift the responsibility to others. No indicator of comparative model fit was provided.

Adult Fruit, Juice, and Vegetable Consumption

On the average, adults consumed most fruit, juice, and vegetables (FJV) at dinner (about 1.5 servings per day) and almost as many during weekday lunch (about 1.4 servings per day) (10). During weekend lunch, consumption of fruit, juice, and vegetables was substantially lower (about 1.0 servings per day) but higher than during breakfast or snacks (about 0.5 servings per day each) (10). These patterns of consumption suggest different influences by meal and day of the week.

Three dimensions were identified in a perceptual analysis of similarities among 20 vegetables: calories, color/nutrition, and convenience (78). Sensory characteristics (e.g. taste), more than perceived health and fattening characteristics, were associated with consumption of FJV (60).

KNOWLEDGE ATTITUDE BEHAVIOR MODELS Knowledge of number of servings specified in the Food Guide Pyramid was associated with FJV consumption in one study (62) but only with vegetable consumption in another (50). Knowledge of the prescribed number of servings, of a diet-disease relationship, and of the fat and fiber content of foods were correlated with FJV consumption, but at low levels (51).

Qualitative research revealed that primary determinants of FJV consumption were cost, taste, texture, appearance, convenience, and safety (84). The taste of fruit and vegetables was an important predictor of consumption, as were habit of consumption since childhood and the knowledge of prescribed servings, but these accounted for 23% of the variability, at best. Taste and convenience were weak correlates in another survey (51) and accounted for a small percentage of the variance in another (46).

A helpless and unhealthy attitude factor was related to fruit and beans, but not vegetable, consumption among women, but not among men (58). Meat preference attitude was related to fruit and beans, but not vegetable consumption, among men and women (58). Health consciousness was related to fruit consumption in men, but not women, and did not predict vegetable or bean consumption among either (58).

HEALTH BELIEF MODEL (HBM) Qualitative research revealed a number of barriers to FJV consumption, including the cost and quality of fresh FJV, storage difficulties, spoilage, lack of availability in local stores, and difficulties in changing existing behavior (84). General barriers were significantly negatively correlated with FJV consumption, but work barriers and cost were not (24). Several HBM components (benefits, barriers, susceptibility to cancer, nutritional concerns) were related to consumption, with barriers accounting for the most variability and the model accounting for only 16% of the variability (32). A model including several HBM variables—but using one-item indicators for each, which were then aggregated into predisposing and enabling variables—accounted for 13% of the variability in consumption (64).

THEORY OF PLANNED BEHAVIOR (TPB) AND ATTITUDE-SOCIAL INFLUENCE SELF-EFFICACY MODEL The single article using TPB with FJV only reported regressing intentions on TPB model components and achieved moderate levels of R^2 (0.33–0.47), with most of the predictiveness contributed by attitudes, some by social norms, and little by perceived control (27).

The attitude–social influence self-efficacy (ASE) model combines TPB with SCT constructs but does not employ TPB formalisms (e.g. multiplication of normative expectations by desire to please). Focus groups revealed that the relative importance of influences on consumption differed for boiled vegetables, salads, and fruit (15). The influences identified were similar to those from other focus groups (84). The ensuing quantitative study revealed that self-efficacy was the dominant predictor after intention for vegetables, salads, and fruit consumption; outcome beliefs contributed to predictiveness for boiled vegetables and salads but not fruit; and social influence contributed to salads alone (18). The predictiveness of three models varied from 0.12 to 0.37, but each included intention, which was the dominant predictor (18). A subsequent reanalysis using more objective measures revealed that people overestimated their consumption of FJV; the correspondence of the objective and subjective estimates were low; and the ASE models showed substantially higher predictiveness with the subjective estimates of consumption compared with the objective estimates (65). However, the patterns of predictiveness of the ASE model components were similar between the objective and subjective estimates (65).

TRANSTHEORETICAL MODEL Differences in consumption across stages were obtained that would not be predicted, i.e. average vegetable and fruit intakes were substantially lower in the maintenance than the action stages (16). The same was true for attitudes, self-efficacy, and comparison with others in regard to vegetables and fruit (16). Most respondents were placed in different stages based on whether staging was conducted using subjectively or objectively assessed consumption (66). Most respondents were in action or maintenance when using the subjective (the usual) method, but most were in precontemplation when using more objective measures (66). Although consumption of fruit and vegetables varied in a pattern that would be expected (increases only at action) for a subjectively estimated stage, odd patterns occurred with objectively estimated stages (e.g. higher levels of consumption among precontemplators than all other groups except action/maintenance) (66).

In one sample, patterns of consumption across stages were as expected (21), as was self-efficacy; weak expected patterns were obtained for barriers and social support and there were no differences for perceived benefits (21).

MARKET SEGMENTATION Cluster analysis identified market segments based on multiple indicators of behavioral (smoking, alcohol, nutrition, exercise, and weight control), personal, and environmental variables (69). Seven market segments (physical fantastics, active attractives, tense but trying, decent dolittles, passively healthy, hard-living hedonists, and non-interested nihilists) predicted FJV consumption beyond variance accounted for by demographics, taste,

nutrition, cost, convenience, and weight control, but overall predictiveness was relatively low (sum of $\varepsilon^2 = 0.175$) (47). Thus, what foods a person consumed were not independent of other health-related habits.

Adolescent Fat Consumption

Reports on fat consumption among adolescents included studies of high school and college students. For 22 different foods, including several high-fat foods, "liking" the food was the primary predictor; perception of how much a parent ate of that food was a secondary predictor; perceived consumption of the food by peers was less frequently a predictor; and perceived healthfulness of the food was not a predictor (99). Concern about weight was a primary predictor, and enjoyment of high-fat foods a secondary predictor both of intake of fat and percentage of kilocalories as fat (55). Gender differences were detected in consumption of 24 of 96 foods assessed. The differences between genders in consumption of high-fat foods ("treats" and meats) were explained by the fact that boys saw higher health value in the treats and were less concerned about body image (45).

THEORY OF REASONED ACTION Substantial R^2 values were obtained for predictors of several high-fat foods, but intention was the primary component and habit the secondary predictor in each model (95). Subjective norm accounted for only 1% of the variability in fat intake, and attitude accounted for approximately 16% (42).

SOCIAL COGNITIVE THEORY Modeling accounted for about 6% of the variability in fat consumption, more than the 1% for subjective norm (42). The result of a complicated series of analyses revealed that whether an adolescent was dieting was a more important predictor of fat intake than weight status, accounting for 16% of the variability (26). Children who experienced restrictions on what they were allowed to eat at age 10 were more likely to eat a lower-fat diet in adolescence (29). Self-efficacy, perceived influence over food at home, and amount of television on the weekend predicted fat intake but not knowledge (48). Self-efficacy and eating more foods from the school cafeteria were associated with fat consumption among boys, but eating more fast foods and more foods from the school cafeteria (not self-efficacy) were associated with fat consumption among girls (42).

SOCIAL NETWORKS Adolescents ate meals with peers relatively infrequently, and when they did it was mostly lunches and snacks (42). Correspondence in consumption between child and peer was substantially lower than for child and parent, which suggests low influence of peers on adolescent food choices.

Adolescent Fruit, Juice, and Vegetable Consumption

An early study revealed that nutrition knowledge was negatively correlated with an index of diet quality that emphasized FJV consumption (93). The greater likelihood that girls would eat FJV was explained by girls' higher levels of belief in the health value and higher preference and greater concern for body image (45). Qualitative research revealed that FJV consumption was influenced by availability of FJV, by peers, and by involvement in food preparation at home (56). Teens also influenced family food purchases (56).

When predicting the consumption of specific FJV (apples, orange juice, potato, tomato), somewhat higher than usual R^2 values were obtained for limited models (0.21–0.33). Liking the food was the dominant predictor and perception of parent's consumption the secondary predictor for apples and tomatoes, but perceptions of parent's consumption was the primary predictor and liking the secondary predictor for orange juice and potatoes. The perception of a friend's consumption was a weak predictor only for orange juice and potatoes (99).

The issues faced by adolescents are developmentally different than those faced by other people. With the adolescent separating from the family and relying on peers for resources formerly obtained from the family (77), the role of peers has drawn much attention. With the development of a peer culture, other lifestyle issues arise (e.g. eating disorders, substance abuse, and school performance). A large statewide sample of middle and high school students revealed that inadequate FJV consumption was part of a larger set of adolescent health issues, including dieting, weight dissatisfaction, binge eating, substance abuse, suicide attempts, and poor family connectedness (75). Similar patterns were detected in a large Native American sample (91).

Children's Fat Consumption

Preadolescent children are usually dependent on their family for foods available in the home and for selecting where they go out to eat. As a result, psychosocial variables may be less predictive of children's consumption, whereas environmental factors, e.g. availability and accessibility of foods at home and elsewhere, might be more influential.

THEORY OF PLANNED BEHAVIOR For individual food categories (i.e. milk, spreads, yogurt, cultured milk) likely to be high in fat, the components of the TPB model predicted intentions at high levels (0.81, 0.71, 0.50, 0.84), but intentions were weakly related to behavior; perceived control made no additional contribution to predicting behavior; perceived difficulty added a little to predictiveness for each food except spreads; and overall model predictiveness of behavior was low (0.12, 0.02, 0.21) except for cultured milk (0.38) (49). Children had only partial knowledge of the fat content of different foods (86).

Children's Fruit, Juice, and Vegetable (FJV) Consumption

Children's FJV consumption varied by meal and day of the week. Children consumed just over 1.0 serving of FJV at weekday lunch but under 0.4 servings on weekend lunch. Children consumed almost 1.0 servings of FJV at Sunday dinner, which linearly declined to Saturday dinner. About 0.4 servings or less were consumed at breakfast and about 0.3 servings for snacks (9). These patterns suggest that influences on FJV consumption vary by meal and day of the week.

COGNITIVE THEORY Three dimensions were identified in eight vegetables among a group of eight-year-olds (12). The authors labeled these factors sensory properties (especially texture), situational usages (e.g. eaten at Sunday dinner), and perceived need for cooking (12). Children who ate vegetables only once a week (i.e. at Sunday dinner) appeared to have different perceptions than those who ate vegetables every day, but the sample was small to reliably make this inference (12).

SOCIAL COGNITIVE THEORY Qualitative research in one Southern community revealed that many factors influenced the low FJV consumption by children, but the three most important appeared to be that there was low availability of FJV in the children's homes, they did not like vegetables, and they lacked skills for making FJV dishes when they were responsible for making their own meals (6). These findings were confirmed in three other cities in the Southeast and Midwest (61). In addition, the factors influencing FJV consumption were shown to vary by social class (e.g. low FJV availability existed in lower class, not middle class, homes; canned and frozen FJV were more likely available in lower class homes and fresh FJV more likely available in middle class homes, etc) (61).

A paper and pencil measure of FJV preferences correlated with consumption, and preferences were higher among those exposed to the specific FJV (33). Two factors in a measure of FJV outcome expectancies were detected: social, and health and physical activity (34). Correlations with consumption were higher, though weak, with health and physical activity than with the social outcome expectancies (34).

Two factors were detected in a measure of FJV self-efficacy: environmental resistance and persuasion by others (53). Both were significant factors in discriminating between children who ate a varied diet and those who did not, with environmental resistance the more important (53). Four different factors were detected in a separate measure of FJV self-efficacy: eating FJV for after-school snacks, breakfast and lunch FJV, independent shopping for FJV, and assisted shopping for FJV (36). Only breakfast and lunch FJV self-efficacy was related to consumption (36).

A full model predicting FJV consumption revealed that preferences were the primary predictor, with a predictiveness of 0.03 for fruit, 0.09 for vegetables, and 0.12 for FJV combined (36). In a follow-up study with a much larger sample, preferences were the primary predictor of FJV consumption, positive outcome expectancies accounted for a little predictiveness, and both combined accounted for about 10% of the variance in FJV consumption (85). Availability and accessibility of FJV at home, alone, accounted for 11% of the variability in FJV consumption. After adjusting for socioeconomic status, availability of FJV at school lunch correlated with children's consumption (52).

TRANSTHEORETICAL MODEL One set of authors used a simple staging algorithm and interpreted their findings to indicate that their staging protocol revealed stage-related differences consistent with TTM predictions (28). A more complicated staging protocol resulted in an inability to replicate the stages, which was likely due to measurement problems (35). A simple staging algorithm obtained results on consumption by stage that were not consistent with predictions from TTM (T Baranowski, D Hebert, C de Moor, DM Hearn & J Baranowski, submitted for publication).

ASSESSMENT

These studies have made important contributions to understanding how existing psychosocial models predict dietary selection or food choices. A recent review reported the patterns of predictiveness of specific psychosocial constructs of dietary fat consumption (90). The current review compares models and addresses how the field can move beyond the existing literature. For the most part, this review ignored differences in the country of origin or region within country. As future replications occur, the cross-national and cross-regional generalizeability of these findings can be examined.

In general, the predictiveness of the models was low (i.e. $R^2 < 0.3$). This was true of research with adults and adolescents, although there was little theory as a foundation for the work with adolescents. Predictiveness was even lower with children, but few model-testing studies have been conducted with children.

The R^2 values appeared to be higher when the models predicted narrow-category foods [e.g. milk (95), salads (18)]. This suggests that influences vary by foods, but developing models for each individual food would be an overwhelming task. A more efficient approach would be to more intensively explore how people think about foods in order to identify groups of foods that are maximally homogeneous in regard to influences on consumption. Some have investigated composites of foods in a meal (83) whereas others have investigated dimensions and clusters among individual foods (37). One analysis revealed

that sweet corn, peas, and cooked carrots clustered together across three dimensions among children (12), which suggests this cluster could be used for analysis as a dependent variable for influences on consumption. This work needs to be replicated with larger numbers of foods and diverse groups of participants.

The patterns of findings were often contradictory across studies, making it difficult to interpret the results. The lack of consistency in results could be due to issues in conceptualization, research design, measurement, and analysis.

Conceptualization

The relatively low predictiveness of these varied models suggests conceptual limitations. The TRA-TPB models varied in their predictiveness. A problem with these models is the focus on attitudes and norms in predicting intentions, not the behavior. The perceived control variable increased the predictiveness of behavior in some studies but not others. The relationship of intention to behavior needs to be tested prospectively, rather than cross-sectionally, because intention refers to future behavior. Tests need to be made of the added predictiveness of the formalisms in TRA-TPB (i.e. the multiplicative relationships in attitude to the act and subjective norm). Triandis (94a) suggested that habit should be included as a variable, but habit simply indicates that past behavior predicts future behavior and provides little leverage on change: One changes habit by changing behavior.

A broad variety of variables were included within tests of SCT models, which suggests a lack of consensus on the key SCT constructs. SCT models did not substantially predict FJV consumption among elementary school children. Environmental influences (e.g. availability and accessibility of foods) (52) may be more important than psychosocial factors among a group with little control over purchase.

Use of TTM produced mixed results. In some cases substantial questions were raised about the ability of the algorithms to stage participants in theoretically appropriate ways. Although subjective staging resulted in patterns of other variables across stages more likely to be consistent with theoretical predictions, the mean values at the action and maintenance stages often differed from what would be expected. It is possible that people cannot adequately stage themselves because many sources of fat are hidden and sources of FJV are not always memorable. More success was obtained with the simple selection from among statements than with the algorithm approach involving time estimates (28).

Although one group interpreted their pattern of findings by stage as consistent with theory, the differences in behavior were very small and thus the variability in the dependent variable across stages overlapped (28). Although overlapping distributions would be expected among the first three stages, where people are only engaging in cognitive change, there should be little or no overlap

between those in maintenance (who have already completed change) and those in planning (who have not started yet).

Insufficient research was conducted with the HBM in regard to FJV or fat consumption to draw firm conclusions.

No research tested the comparative fit among models in predicting the desired behavior. No research tested the differing assumptions on which these models are predicated and, thereby, the theoretical appropriateness of the models. There is substantial overlap among constructs, e.g. similar constructs are specified by SCT outcome expectancies, HBM benefits, TTM pros and cons, and TRA-TPB attitude to the act; the SCT construct of self-efficacy in large part addresses the confidence a person has in being able to overcome HBM barriers to performing a behavior. This suggests that some advantage may be obtained by combining the distinct constructs from each theory into a more comprehensive model, as proposed by several authors (2, 41, 96). Incorporating new theoretical ideas from more basic behavioral and social science also holds promise. Perhaps grounded theory approaches will generate new concepts particularly appropriate to dietary behavior (13).

Much of this research has emphasized cognitive (rational) factors in food consumption. Fear of chronic disease in adult years is an emotional construct within HBM, but it demonstrated little predictiveness (32, 87). Alternatively, the primary dietary attitude factor "helpless and unhealthy" significantly correlated with emotional indicators (e.g. obsessive-compulsion, depression, anxiety, hostility, etc) (58), which suggests that emotions were a component of the eating experience and would benefit from more intensive investigation.

Perhaps many (if not all) of the key independent variables are known, but not when they are most applicable, i.e. moderators of their relationships to consumption (44). The amount of food (kilocalories) and macronutrients (e.g. fat) consumed is in part determined by biological factors (25). People who usually consume a high-fat diet rated their pre-meal hunger at higher levels than those who commonly consumed a lower-fat, high-carbohydrate diet, and they were more likely to select higher-fat foods to satisfy their hunger (25). Those who habitually ate higher-fat food did not prefer higher- or lower-fat foods, but those who habitually ate lower-fat foods preferred higher-carbohydrate foods (25). Usual macronutrient consumption should become a variable in future psychosocial research.

Genetics also likely moderates the influence of psychosocial variables on dietary behavior. Psychosocial factors (preferences, self-efficacy, outcome expectations) in part are developed by experience with foods. Sensitivity to a specific bitter taste, particularly among cruciferous vegetables, has been demonstrated to be genetically determined (39). It appears likely that those who find this bitter taste aversive will develop lower preference, lower self-efficacy, and

more negative outcome expectancies for selecting and eating these foods. Preferences for and consumption of fats among young children has been related to the body mass index of parents, which suggests a genetic link (43). The extent to which genetic factors relate to consumption, and psychosocial factors account for this relationship, are important areas for research.

Although the market segmentation procedures (69) hold promise, differences in dietary behaviors across subgroups may simply be a linear function of one or two of the several psychosocial variables used to define the clusters. Future research will need to determine whether clustering by psychosocial characteristics provides information that is more valuable than that provided by the component variables separately or by stratification by variables empirically determined to be related to behavior, e.g. regular consumption of fat (25).

Research Design

Most of the designs were quantitative (i.e. they used statistical procedures to detect relationships) and cross-sectional. Although quantitative research provides the most objective test of specific hypotheses and enables assessment of comparative fit across models, it assumes a level of understanding of the phenomenon and measurement of the key variables that often do not currently exist. Although quantitative research must continue, the field would also benefit from more qualitative analyses of key issues that hold the promise of enhancing the depth of understanding of relationships (32) and improving measurement of predictor variables. Because the broad-scoped qualitative work has been done, (6, 13, 15, 61, 84), future qualitative research needs to more intensively focus on specific critical issues.

Although cross-sectional research is relatively easy to conduct, and thereby cost effective, it is subject to various errors. Simultaneous assessment of dependent and independent variables could be influenced by a variety of factors that could affect the answers to all questions posed and thereby induce correlations (positive or negative) in the data that do not reflect the true underlying relationships (96). This literature would be stronger if investigators supplemented self-reported data with non–self-report measures of dietary behavior (e.g. visual observations at work-site cafeterias), employed more checks on self-reported diet, or collected independent and dependent variables on different days separated by enough time that single emotion-laden events would not affect both reports and the respondent would not likely remember the responses to the first questionnaire. At a minimum, longitudinal research should be initiated that assesses the relatively enduring psychosocial characteristics at one time and the dependent behavioral variable over the ensuing two weeks to a month.

Little attention has been given to the comparative study of groups of people who might be expected to differ on both targeted behaviors and the correlates

of those behaviors (e.g. groups that differ in food-related religious beliefs, or cultural groups) (97).

Measurement-Dependent Variables

Even within a relatively narrow scope, such as fat-eating patterns, enormous variability existed in the dependent variables selected for investigation, e.g. fat grams, fat as a percentage of total calories ingested, changes in fat grams consumed, usual fat consumption (high fat vs low fat), fat avoidance, or specific narrow categories of foods (e.g. milk, meat) or practices (e.g. frequency of eating at a fast food restaurant) likely to be high in fat. Methodological studies must be conducted on the correspondence among those measures and consensus developed among investigators on the most useful ways to think about and to measure the relevant dependant behavior.

There was a lack of attention to the validity and reliability of the dependent measures employed. In a few cases, the method of assessing the dependent dietary variable(s) was not reported. In other cases, the dependent dietary variable was measured with one self-reported item with no attention to the validity or reliability of self-report. In other cases, self-report methods were employed and reliability or validity reported for other samples but not for the reported sample. In relatively few cases were dietary assessment methods employed that had previously demonstrated validity and reliability, and reliability reported for the reported sample. In no case were the correlations between predictor and dependent variables corrected for the reliability in the dependent variables (94). Because 24-h dietary recalls and multiple-day food records are particularly susceptible to intraindividual (day to day) variability [sometimes requiring 9 days (5) to 2 weeks (WO Thompson, T Baranowski, M Smith, LS Lin & M Davis Hearn, submitted for publication) of data collection to achieve a reliability of 0.8] and collecting for 9–14 days may not be feasible, correction for unreliability in the dependent measure is important. Corrections for social approval bias among men and social desirability bias among women also may hold promise of increasing accuracy of report (54).

Some situations provide opportunities for more objective assessment of behavior, e.g. school lunch receipts, observations of school or work-site consumption. Because the research on patterns of consumption suggests that influences vary by meal and day of the week (10), studies of correlates of consumption at lunch (over multiple lunches) appears appropriate.

Measurement-Independent Variables

There also was a lack of attention to the measurement qualities of the independent variables. On several occasions, a variable with the same label (e.g. self-efficacy) was conceptualized in different ways. In some studies, self-efficacy

was appropriately conceptualized as self-confidence in being able to perform a particular behavior and to overcome the likely barriers in doing that behavior (19), whereas in others self-efficacy was reported to be an attitude to the behavior (87), and in still others no conceptualization was identified (98). When measures were operationalized from different conceptualizations, they likely measured different things. As a result, the relationships detected (even if they were at the same quantitative level across studies) were not comparable. Self-efficacy is not accurately or reliably measured by single-item indicators of confidence (67), nor is it related to health (57), but it is behavior specific (57). By theory, self-efficacy measures should tap three dimensions: level, strength, and generality (68). Level is measured by yes/no responses concerning one's ability to perform a set of successively more difficult behaviors; strength is assessed by a rating of probability that one can perform each of the behaviors with a yes response; and generality is measured by applying the same procedures to multiple behaviors within a domain (68). The concept of successively more difficult behaviors is often operationalized by measuring confidence in ability to perform the same behavior in the presence of various barriers to performance. Because diet presents so many behaviors and possible barriers, investigators have often jettisoned the level component. Although this may appear to be a reasonable compromise from the practitioner's perspective, little work has been done to validate the resulting measures, with unknown implications for tests of model predictiveness. Although the field may benefit from different methods of operationalizing the same construct to assess the comparative validity of methods, the field cannot advance if different underlying concepts are used for the same term.

A substantial number of articles did not report the reliabilities (internal consistency, interobserver, or test-retest) of the predictor variables employed. Although reasonable reliability in the initial samples of the developer of a measure may have been obtained, the same reliability may not be attainable in later samples because the characteristics of the sample and/or the circumstances of assessment may differ, the appropriateness of the measure may have been time limited (e.g. the meaning of words may change over decades), or the presentation in the popular press of the issues related to the concept may have affected how people related to it. Thus, some form of reliability (e.g. internal consistency) should be presented in each new sample analyzed, even at multiple times in longitudinal studies.

The field has tolerated reliability as low as 0.3 in a measure. Some authors have employed single-item indicators of underlying constructs, for which reliability cannot be estimated and which violates the complex nature of most psychosocial constructs. Many in the field of psychometrics attempt to attain a reliability of 0.8 or higher. This level has been accepted because if a correlation is corrected for attenuation by a variable with this level of reliability or higher [e.g. divided by the (reliability)$^{1/2}$, which in this case would be $0.80^{1/2}$ or roughly

0.9], the change in the detected relationship is minimal. Because statistically correcting for attenuation is never as good as using a variable with high reliability in the first place, the field must insist on reliability of assessment close to or higher than 0.8, especially for variables commonly used. Measurement method studies on smaller samples should be initiated before main studies to ensure that the measures attain desired levels of reliability.

Virtually all of the psychosocial predictor variables have been obtained by self-report. Although self-report is virtually the only way to assess the beliefs, feelings, and experiences of people, using only one method limits the inferences that can be made. The field would benefit from the following: (*a*) simultaneously employing complementary methods of assessing the same variables (e.g. proxy report by knowledgeable others, diaries of feelings or beliefs that can be converted to variables, or momentary time sampling of beliefs or feelings); (*b*) assessing related aspects of the same variable (e.g. a social network report of performance of supportive behavior in relation to the target person's perception of the social support received within a network); and (*c*) using multiple methods for the self-report of the same construct (e.g. a rating scale assessment of preferences for particular foods and responses to the preferences of the same foods presented for tasting).

Data Analysis

Statisticians have demonstrated that values of variables tend to cluster within existing social units (e.g. schools, work sites) (72). Inferences could be drawn about relationships that are due primarily to clustering. Statistical packages exist that correct for this clustering (59) and that have only begun to be used in psychosocial correlate research.

Investigators employing TTM have not reported R^2 values for their models, thereby precluding the comparison of predictiveness with those from other theories. Although it would be interesting to know what percentage of variability in consumption is accounted for by stage, if the stage algorithm works properly it is in part a proxy for consumption, not an explanatory variable. It would, however, be helpful to know how much of the variability in dietary behavior is accounted for by the usual TTM psychosocial constructs (pros/cons, self-efficacy, processes of change). It appears that significant interaction terms between stage and psychosocial correlates would be primary evidence for the predictiveness of TTM.

APPLICATION

This literature will benefit from greater consistency in use of validated measures and reassessment of reliability in each new sample to assist comparability across studies. Models will be most predictive of behavior when they focus

on small groups of foods perceived to be homogeneous, include variables from several models, and take into account moderating variables, e.g. developmentally or behaviorally homogeneous subgroups of people. Comparative tests of models should more clearly identify which provide the best understanding of dietary behavior.

Mediating Variable Scheme

The relationship of mediating (psychosocial) variables to outcomes has been identified as one of the limits on the effectiveness of interventions (4, 7). Most current models at best account for less than 30% of the variability in dietary behavior, except in unusual circumstances, and most predict at lower levels. Theories that regularly predict behavior at higher levels (e.g. 50%) would provide a firmer understanding of behavior and thereby likely provide stronger levers for promoting change. A substantial amount of work remains to be done to increase that predictiveness. We hope this review has yielded some useful ways to begin.

What if implementing these procedures does not improve predictiveness appreciably above 0.3? If our theories can not substantially improve predictiveness, then there is probably a severe limit to how effective our interventions can be. Philosophically, we might be pleased that there is a limit to how much we might be influenced by any undesired behavioral interventions, e.g. advertising. Alternatively, when is predictiveness sufficient to facilitate reasonable efficacy of behavioral interventions? The answer to this question is not clear, but it suggests that interventions based on models that account for more of the variability in behavior will likely be more effective. Interventions should be developed only when predicated on models with substantial predictiveness (given the contemporary state of the art) of the target behavior. With lower predictiveness of theory, there is a premium on designing manipulations that more effectively induce change in the psychosocial variables and thereby maximize the possible effect from the predictiveness of these mediating variables. The ability of interventions to induce change in mediating variables is the subject for another review.

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