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Best practices in nutrition science to earn and keep the public's trust

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ABSTRACT
Public trust in nutrition science is the foundation on which nutrition and health progress is based, including sound public health. An ASN-commissioned, independent Advisory Committee comprehensively reviewed the literature and available public surveys about the public's trust in nutrition science and the factors that influence it and conducted stakeholder outreach regarding publicly available information. The Committee selected 7 overlapping domains projected to significantly influence public trust: *1*) conflict of interest and objectivity; *2*) public benefit; *3*) standards of scientific rigor and reproducibility; *4*) transparency; *5*) equity; *6*) information dissemination (education, communication, and marketing); and *7*) accountability. The literature review comprehensively explored current practices and threats to public trust in nutrition science, including gaps that erode trust. Unfortunately, there is a paucity of peer-reviewed material specifically focused on nutrition science. Available material was examined, and its analysis informed the development of priority best practices. The Committee proposed best practices to support public trust, appropriate to ASN and other food and nutrition organizations motivated by the conviction that public trust remains key to the realization of the benefits of past, present, and future scientific advances. The adoption of the best practices by food and nutrition organizations, such as ASN, other stakeholder organizations, researchers, food and nutrition professionals, companies, government officials, and individuals working in the food and nutrition space would strengthen and help ensure earning and keeping the public's continued trust in nutrition science. *Am J Clin Nutr* 2019;109:225–243.

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Introduction

Is public trust in nutrition science eroding?

The perception among many researchers is that public trust in nutrition science is eroding. This insight contrasts with the view that public trust in science as a broad activity has remained seemingly stable for almost 50 y and remains strong today (1, 2). Such apparent disparities are not unique to nutrition. Decline in trust is often most salient when discrete segments of science are considered. When it occurs, loss of public confidence is likely a consequence of multiple factors: the growing complexity of modern science; its inherently tentative, continuous, and iterative nature; the perception that "experts" are continuously changing assessments of available evidence; repeated failures to uphold professional standards; and the growing polarization of social and policy sectors in which science plays a prominent role and in which there is strong stakeholder engagement (e.g., genetic modification of organisms, climate change, and vaccination). Furthermore, a steady erosion of public trust in expertise in general, rather than in science specifically, is likely at play (3). The negative impacts of the latter dynamic likely are magnified when the traditional "information gatekeeper" roles of

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Supplemental Appendix A and Supplemental Appendix B are available from the "supplementary data" link in the online posting of the article and from the same link in the online table of contents at https://academic.oup.com/ajcn.

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Abbreviations used: COI, conflict of interest; GMO, genetically modified organism; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; PPP, public–private partnership; RCT, randomized controlled trial; SRF, Sugar Research Foundation.

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experts are diminished by an increasingly rapid dissemination of information regardless of quality. This, in turn, makes distinguishing substance from noise much more difficult for the public and perversely further diminishes public trust in expertise. These forces are amplified in the nutritional sciences because of food's intimate connection and interest to all individuals and the size of the food and agriculture economy.

In nutrition, the erosion of trust is most evident when new, unexpected results undermine previously "established" links between intakes of foods (or the specific nutrients or bioactive compounds they contain) and expected or "welcomed" outcomes (6, 7). Examples include changes in the putative health effects of drinking coffee (8) or eating eggs (9), disparities over time regarding the risk of cardiovascular disease associated with specific dietary lipids (10), and failures to confirm expected anticarcinogenic effects of antioxidant supplements in randomized controlled trials (RCTs) (11, 12). Distrust is exacerbated further when practices supporting the generation of knowledge fall short of scientific and ethical standards. Examples include inadequate scientific rigor in research (13–16); failures by researchers, universities, or scientific journals to disclose current and/or historical conflicts of interest (COIs) (financial and other types) or to constructively engage and redress circumstances that enabled real and potential conflicted relations; scientists and/or institutions abetting hyperbole about research findings that are subsequently discredited; and researchers engaging in fraudulent practices.

Text Box 1.

Here is an example that may have led to the erosion of public trust in the field of nutrition science. It is meant to illustrate the potentially long-lasting impact of a lack of transparency in eroding trust, in this case many years after the sponsored activity's conclusion. The example focuses on the roles of saturated fat and cholesterol compared with sucrose as primary dietary causes and/or risk factors for coronary artery disease. A 2016 *Journal of the American Medical Association Internal Medicine* special communication exposed Sugar Research Foundation (SRF) influences on Harvard nutrition faculty in the 1960s to emphasize fat instead of sugar as a contributor to heart disease (4). The SRF sponsored a literature review written by Harvard University nutrition professors and published in *New England Journal of Medicine*, which singled out fat and cholesterol as the dietary causes of coronary artery disease and downplayed evidence that sucrose consumption was also a risk factor. However, a recent article in *Science* (5) notes that available historical evidence is not uniformly supportive of conclusions reached in the referenced *Journal of the American Medical Association* article. The *Science* article posits that when viewed through the lens of what was happening in nutrition science during the 1960s (e.g., declaration of financial support of published reports was not required at the time by most journals), concluding that SRF's sponsorship of a literature review and/or the lack of transparency in its conduct was key in shaping nutrition policy is not warranted. Either way, even when this example is viewed through a historical lens, it is still possible to appreciate the potentially negative impact of inadequate transparency on the public's trust in nutrition, especially when complicated by a sponsor's financial interests.

The media and their use by researchers, their institutions, and other stakeholders can also play a role in promoting and undermining trust. The explosion and immediacy of information sources are both a boon and a barrier to the public's understanding of science. The ease with which viewpoints can be shared facilitates the dissemination of well-informed voices, of voices that advocate opinions with indifference to the totality of scientific evidence as well as conclusions from putatively unbiased authoritative expert panels, and of voices that intentionally misrepresent facts or present opinions or beliefs as facts (2). This dynamic is most salient when science is applied to issues of economic, religious, or personal importance (17). Of increasing visibility is the proliferation of professional bloggers, many of whom have hundreds or thousands (or more) of followers and some of whom earn income through product placement and generate stories that are picked up by the traditional media (18). In short, the volume, multiplicity of sources, and frequency and disparities in "messaging" make discerning objective, accurate information from information that is intentionally biased or overtly misrepresentative overly demanding for nearly all audiences.

These scenarios are unfolding in the context of unprecedented good health globally. Life spans have never been longer, birth outcomes are the best ever, and in much of the world most nutrient deficiencies are no longer the highest-priority public health concern. The importance of nutrition has never been better appreciated, and the evidence has never been more robust that sound nutrition is a prerequisite for the development of human capital and therefore for sustaining, and ideally accelerating, progress (19). For the first time in human history, enough food energy is produced globally to feed the planet's population, and steadily improving technological abilities and remarkable global food distribution systems enable the world to optimize the composition of diets to unprecedented degrees (20). Much of this progress reflects a desirable symbiosis among the public, government funding and regulatory agencies, the science community, and the private sector.

Growing prevalence of diet-related noncommunicable diseases

Yet, not all outcomes related to nutrition science are advancing in desirable directions or rates. The growing prevalence of diet-related noncommunicable diseases, especially those exacerbated by rising rates of obesity and improvements in survival, too often detracts from hard-won advances in other areas related to nutritional well-being. With the continued decline in infectious diseases and the growing prevalence of diet-related noncommunicable diseases, the fraction of the world's total mortality attributable to diet-related noncommunicable diseases is expected to increase from 59% in 2002 to 69% in 2030 (21). Diet-related noncommunicable diseases account for nearly 80% of total health spending in the United States (22), and the total cost of diet-related chronic disease has been estimated to be $1 trillion annually (23). Studies by the World Economic Forum (24) project that the worldwide cost of diet-related noncommunicable diseases will reach $31 trillion by 2030, excluding the costs of mental illness. Both in the United States and worldwide, these changes reflect, in part, a high prevalence of unhealthy diets, steadily increasing proportions of older individuals, continued population growth, and uneven economic development. The persistent epidemic of obesity and overweight adds to the prevalence and severity of these conditions (25), and their complex etiologies present daunting scientific challenges whose resolution will likely require technological and political approaches working in unison with knowledge discovery. This burden is not shared equally among populations, with poverty contributing to higher incidences of chronic disease and food insecurity (26).

This report is the response of the ad hoc Committee charged by ASN to comprehensively explore current practices and threats to public trust in nutrition science, including gaps that erode trust, and to develop priority best practices to support public trust, appropriate to ASN and other food and nutrition organizations.

Core Areas Key to Public Trust in Science and Nutrition

Integrity is fundamental to the conduct of research, including the validity, utility, and acceptance of its results. The Office of Research Integrity of the US Department of Health and Human Services (https://ori.hhs.gov/) defines the core domains of the responsible conduct of research to include mentoring, collaboration, peer review, data management and ownership, publication practices and authorship, COIs and commitment, and research misconduct. These are defined and reviewed elsewhere (27–29). Attention to each of these domains helps to ensure the integrity of the conduct of research and its outcomes. But engendering public confidence in the research enterprise and in the application of new knowledge, especially in fields that directly impact public health, depends on additional factors. These include scrupulous attention to:

- COI and objectivity;
- public benefit;
- achieving highest standards of rigor and reproducibility;
- transparency;
- equity;
- information dissemination: education, communication, and marketing; and
- accountability.

These domains are the primary focus of this report and are considered in greater detail with an eye to the identification of best practices most suitable for professional scientific societies within the field of food science and nutrition, such as the ASN, as well as a wide array of stakeholder groups. The report also recognizes other factors that influence public trust and are of direct relevance to research societies: the breadth and depth of the economic stakes involved and consumer scientific literacy, personal beliefs (30), ethnicity/culture (31), and socio-economic status (32). Best practices are needed to bolster efforts to promote, support, and sustain the best science for individual and/or public action and assist in meeting respective responsibilities to earn and keep the public's trust. The identification of best practices is motivated by the conviction that public trust remains key to the realization of the benefits of past, present, and future scientific advances.

Optimally, public trust in nutrition research should extend equally to all actors and stakeholders who participate in the food system. More information on the various stakeholders in nutrition and the food system and the need for multisectoral engagement in nutrition research can be found in **Supplemental Appendix A.**

Details on the methods used to perform the literature search that formed the basis of this report can be found in **Supplemental Appendix B.**

Scientific literacy and public trust

Scientific literacy is fundamental to both the functioning of modern civilization and its advancement. It influences societal values and preferences, provides opportunity, and is essential for evaluating the credibility of information sources and understanding the evidence underpinning policies and risk management (33). Scientific literacy also cultivates an appreciation for the evolving nature of science and hence the evolution of evidence-based recommendations, including dietary guidance. However, scientific literacy is not a reliable indicator of trust (34). Also, overall consumer awareness of the scientific evidence that underpins many contemporary issues of societal concern often is low, as indicated by studies of the public's approach to understanding the safety of consuming genetically modified organisms (GMOs). Consumers rely on various sources of information to form their opinions, and university-based scientists and government regulators are more trusted sources of information compared with readily accessible media (35) and watchdogs (36).

Views regarding food safety illustrate the often complex nature of consumer perceptions related to nutrition. A recent metainterpretation concluded that there is a widespread lack of confidence by the public in the current safety of the food system (including a lack of confidence in the relevant and responsible state agencies), especially after a food safety breach, whereas trust in medical professionals and university-based researchers is strong (37). Public confidence in the research and medical communities should increase public trust in nutrition as the field increasingly adopts evidence-based recommendations and policies (38).

Unfortunately, few sources of data on the public's perception of nutrition research or pertinent to issues directly related to nutrition (e.g., consumer behavior) are publicly available. Examples of exceptions are a few specific survey questions available in the General Social Survey Data Explorer of the NORC at the University of Chicago (https://gssdataexplorer.norc.org) that yield insight into the public's perceptions. These generally probe issues whose relevance may be extrapolated to nutrition (e.g., the safety of genetically modified foods; possibly the most nutrition-relevant topic) or the safety of nuclear energy and the origins and appropriate responses (if any) to climate change that relate more generally to how the public evaluates scientific information. Across these diverse, complex scientific issues, the public consistently expresses confidence in scientists as the most credible and trusted sources of information. However, it is not all about science. Personal beliefs and politics can be sources of disagreement among the public and scientists (39) and, in turn, erode or bolster trust in scientists by the public (40). This situation amplifies the need for evidence-based, transparent decision-making among scientists and for increasing scientific literacy among the public while respecting other factors that inform an individual's decision-making and policy positions.

COI and objectivity

Legal definitions of COI describe “a situation in which a person has a duty to more than 1 person or organization, but cannot do justice to the actual or potentially adverse interests of both parties” (41). A COI is typically described in terms of “fiduciaries,” where a *fiduciary* is an individual in whom another has placed the utmost trust and confidence to manage and protect property, money, or other valuables, including reputations (27, 42).

Emanuel and Thompson (43) provide a more focused definition of COI in the context of biomedicine as a “set of circumstances or conditions in which professional judgment of a primary interest, such as the integrity and quality of research, tends to be unduly influenced by a secondary interest, such as personal financial gain.” Likewise, the National Academy of Medicine (then the Institute of Medicine) defined COI with respect to medical research as “a set of circumstances that creates a risk that professional judgment or actions regarding a primary interest will be unduly influenced by a secondary interest” (44).

A recent comprehensive review of COI policies of guideline development organizations yielded the following complementary descriptions of COI (45):

> A divergence between an individual’s private interests and his or her professional obligations such that an independent observer might reasonably question whether the individual’s professional actions or decisions are motivated by personal gain, such as financial, academic advancement, clinical revenue streams, or community standing.
>
> and
>
> A financial or intellectual relationship that may impact an individual’s ability to approach a scientific question with an open mind.

In reference to clinical practice guidelines, intellectual COIs are defined as “academic activities that create the potential for an attachment to a specific point of view that could unduly affect an individual’s judgment about a specific recommendation” (46). Hence, COIs not only result from tangible personal gain, but also include inherent personal biases that can compromise objectivity.

Objectivity is a key consideration when assessing COI and one that is not always easily identified or quantified. Scientific objectivity “expresses the idea that the claims, methods and results of science are not, or should not be influenced by perspectives, value commitments, community bias or personal interests, to name a few relevant factors” (47).

Sources of inherent interest and conflict of the research enterprise.

Identifying the competing “interests” inherent to the research enterprise is fundamental to identifying, managing, and avoiding COI at the level of individual researchers, organizations, and institutions. The primary interest of the research enterprise is to generate new reliable knowledge that withstands experimental and/or other means of verification, as well as downstream applications of this knowledge, both of which demand the highest standards of integrity (43). Individual researchers, journal editors, and institutions have numerous secondary interests inherent to the research enterprise because the mere act of acquiring new knowledge has tangible benefits, as does its translation into intellectual property, including commercial goods, practices, and policies. For the researcher, acquiring new knowledge can enhance recognition, funding, mentoring, service, and administrative standings and advance personal, home, and community responsibilities; ownership of intellectual property has the potential for significant additional financial gain. Similarly, for research institutions and organizations, research influences reputation, and research applications may be a principal determinant of a revenue stream or endowment. Conflict arises when secondary interests have the potential to compromise the primary interest (43).

Financial gain is the primary focus of most COI policies because it is easily quantified (43), and public trust is sensitive to it (48). The public are more trusting of scientists when they believe scientists are acting independently of financial interests (49). Horner and Minifie conducted a survey of 5478 individuals regarding the role of COI disclosure in public trust. They reported that 64% of respondents felt that knowing about investigators’ COIs was extremely or very important, and 87% felt that conflicts should be disclosed as part of informed consent (27–29). McComas considered the role of research funding in the objectivity of researchers in nanobiotechnology. A survey of the nanobiotechnology research community indicated that funding sources influenced research directions, including the survey respondents’ own work and the sharing of results (50).

Conflicts arise not only from financial ties of scientists with funders, but also as a result of strongly held personal beliefs, institutional relations, and personal relations (51). These conflicts, however, are more difficult to quantify and manage, and are generally not monitored. One analysis of 94 research articles on the health risks or nutritional value of GMO foods did not find any correlation between a financial COI and research results, whereas professional COIs related to industry affiliations were strongly associated with research outcomes (52). Nutrition and food system research is funded increasingly by philanthropic and other private foundations that often have defined agendas and seek to affect public policy (53, 54). The scope of potential COIs increases with research that has direct and immediate impacts on the public, even in the absence of direct commercialization of intellectual property. Intellectual COIs occur when guidelines or recommendations are authored/approved by a person or persons who stand to lose or gain financially, or otherwise, by their endorsements (55). Expanding COI policies and their management to encompass all secondary interests that can compromise objectivity in research would require a level of transparency and disclosure normally expected of elected officials and justices.

Authoritative guidance for managing COIs.

Emanuel and Thompson (43) described COIs as tendencies, as opposed to occurrences, and described processes to help individuals and organizations avoid tendencies and the occurrence of conflict. One such process is to establish COI policies and allow them to evolve continuously to control secondary interests that can distort professional judgments and thereby instill increased confidence in professional conduct (43). Institutions can establish COI policies that include disclosures of risks related to biasing scientific judgments, independent evaluations and management of risks, and, if necessary, prohibition of activities when effective management is not deemed achievable (43). Scientists and government oversight agencies can continue to work collaboratively to further refine COI expectations and policies to protect the integrity of the scientific enterprise while trying to minimize administrative burden (27, 43).

The National Academy of Medicine (then the Institute of Medicine) established standards for clinical guideline development that include best practices related to transparency, COI management, composition of groups assembled to develop guidelines, uses of systematic reviews, grading evidence, communication of recommendations, conduct of external reviews, and continuous updating (51, 55). Increasingly, clinical practice guideline developers—including the American Heart Association, American Thoracic Society, American College of Chest Physicians, American College of Physicians, and the WHO—all have COI policies encompassing both financial and intellectual conflicts (45, 46), noting that the majority of guideline group chairs and cochairs have financial COIs (56).

The fundamental principles and firewalls considered by medical societies to mitigate COI in their development of guidelines go far beyond robust financial disclosures (57). The proposed multipronged approach included establishing optimal distances between researchers and their financial and institutional supporters, guidance for recusal, third-party performance of evaluations, monitoring adherence to codes of ethics (e.g., those in the *AMA Manual of Style*), approaches for increasing awareness of COI, and commitments to ongoing regulatory reform (e.g., including more transparency in sunshine laws). Yet, despite intensive efforts to achieve full transparency and minimize COI, freedom-of-information requests continue to reveal unacceptable COIs among academic researchers (58). Nonetheless, the reporting, monitoring, and managing of conflicts can be seen as overly burdensome to investigators and costly to institutions. This view arises in large part because attendant processes are not standardized across institutions, as evidenced by the number of COI disclosures commonly required by diverse granting mechanisms (59). Among institutions, Cochrane has some of the most restrictive COI policies with respect to funding source and authorship (http://community.cochrane.org/news/cochrane-and-conflict-interest). For example, Cochrane reviews cannot be funded by a private-sector entity that has a financial interest in the outcomes. With respect to authorship, the majority of authors must be without personal COIs, the first author must be free of any COI, and employees of a company with a COI are prohibited from authorship.

The need to manage COIs and objectivity in nutrition.

Factors that generate COI and influence objectivity are not unique to food and nutrition research; they are common to all research communities where public, private, and governmental sectors interact but are especially acute in nutrition science (60). Effective translation of nutrition research into policies, practices, and products necessitates the involvement of all stakeholders across the food system, including consumers. Advancements in nutrition research have the potential to enhance well-being and benefit consumers, scientists, for-profit companies, nonprofit organizations, and philanthropic institutions through financial and/or reputational gain (60).

Public benefit

The standard for public benefit is best defined for charitable organizations whose primary stated purpose is to serve in the public interest. Such organizations are required to articulate clearly the benefits that accrue to the public without purposeful restriction to any individual, or they may intentionally focus on addressing identifiable subgroups without restriction.

Public benefit has been an expectation of publicly funded education, most notably through the Morrill Act of 1862, which directed public funding of higher education in the agricultural and mechanical arts. Public universities in the United States were created to be accessible and affordable to students and the knowledge generated through research widely disseminated to address societal needs. Some academic societies are registered charitable organizations with a legal requirement to demonstrate public benefit, such as The Physiological Society in the United Kingdom (http://www.physoc.org/public-benefit).

Anticipated public benefits of publicly funded research are a common consideration in justifications of research expenditures. The public benefits of research include contributions to the common good (61), assessments of the proposed research's relevance to society (14), evaluations of the "tolerability" of risks associated with proposed research (62), implementation or use of novel research findings and technologies (63), and unhindered accessibility of research resources among scientists (64). The development of explicit strategies for earning public trust (61) necessitates achieving consistency with more general intellectual property principles (65). The realization of anticipated benefits (or documented avoidance of risk), especially if perceived at the individual level, presumably is correspondingly important in keeping the public's trust (66).

The benefits of research for those individuals within society who ultimately fund university research, mainly taxpayers, are under increased scrutiny (63). Scientific discovery, including the Human Genome Project, transformed human medicine yet at times attained goals that arguably increased the wealth gap (e.g., by creating pharmaceuticals that many cannot afford). Some universities have recognized the need for greater involvement with local communities by prioritizing research questions identified by the local community that address real-life community needs (67) or inequities.

Unfortunately, the literature offers limited evidence-based guidance related to best practices intended to enhance the documentation of public benefits. For example, best practices are lacking for determining the appropriate level of specificity in defining "who" benefits, the time frames and required infrastructure for the realization of benefits, and the resources required to ensure their desired accessibility.

This state of affairs appears to hold throughout the research/knowledge generation process: from the point of otherwise robust priority-setting efforts (68) to trials designed to assess the effectiveness of putatively effective interventions when implemented at scale (69).

Unlike discovery-based research or basic research that primarily seeks to generate knowledge, clinical and public health research can explicitly delineate anticipated benefits. For example, areas that lend themselves to robust RCTs targeting specified health effects (70) have rigorous methodologies for identifying the anticipated health benefit(s) or qualified surrogate markers [e.g., the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) Handbook http://gdt.guidelinedevelopment.org/app/handbook/handbook.html] and for documenting responses to proposed interventions or exposures (70). Among the better examples in the field of nutrition are trials of nutrient supplements when conducted appropriately (71). There are also analyses of distributive benefits and risks (e.g., those associated with the GMO debate) that document and quantify benefits/risks and their respective recipients (72). New web-based approaches for accessing specified public benefits have been described, as have the efficacy and effectiveness of their uses (73).

Unfortunately, this degree of clarity is often beyond the reach of many well-designed nutrition investigations [e.g., interventions undertaken in early life with the expectation of benefits in adulthood (74) or the lack of effect for patient-important outcomes when considering health effects of single nutrients for most chronic disease (14)]. Perhaps the most daunting challenge related to ascertaining public benefits in nutritional science research is the documentation of benefits that relate to multifactorial health outcomes and those that transcend life stages or develop over many years at a particular life stage (16).

Achieving highest standards of rigor and reproducibility

In 2014, the *New York Times* publicized the concern of research reproducibility, emphasizing the roles of publication bias, use of statistics, fraud, and questionable research practices, and the intensification of these concerns due to increased competition for research funding (75). Many of these concerns came to light in Ioannidis's provocative 2005 study, "Why Most Published Research Findings Are False" (76). Key commentaries and articles over the past 5 y have highlighted *1)* a lack of reproducibility in research and *2)* a lack of clinical relevance. More than half of preclinical research is estimated to be irreproducible, at a cost of $28 billion/y in the United States (77).

Scientific *rigor* was recently defined in a publication of the American Society for Microbiology as "theoretical or experimental approaches undertaken in a way that enhances confidence in the veracity of their findings, with veracity defined as truth or accuracy" (78). The authors proposed 5 key elements of rigor: redundancy in experimental design, sound statistical analyses, error recognition, avoidance of logic traps, and intellectual honesty (78). Sources of irreproducibility include lack of consideration of sex as a biological variable (79); unexpected, ambiguous outcomes based on unaccounted for contextual differences that potentially could contribute to discovery (80); pressure for publication in high-impact journals (81); and an unsustainable hypercompetitive system (82).

Efforts to address concerns of rigor and reproducibility in research should not be conflated with misconduct and fraud, which always occur with malevolent intentionality, real or apparent. Serious misconduct in clinical trials, which includes data fabrication and falsification, is rare compared with numerous other questionable research practices. As defined and described by George (83), such questionable research practices include faulty, inappropriate, or incomplete study designs or analyses; absence of reporting of gifts; lack of statements of study limitations; and data "dredging" especially when data identification and analyses are described inadequately and the possibility of false positive findings that may occur by chance is not considered with sufficient rigor. These questionable research practices are likely more common, but little is known about their prevalence. Understanding and judging malevolent intent, or lack thereof, and adequately measuring the prevalence or incidence of malevolent intent remain very challenging. A review of 399 high-impact medical journals revealed great variations in defining misconduct and its handling and called for harmonization of definitions, policies, and procedures (84). Such efforts to enhance the quality of scientific publications are undermined by the proliferation of predatory publishers with minimal or absent standards for assessing the quality of science (85). In developing procedures and practices that promote integrity, Aubert Bonn et al. noted that universities either define integrity on the basis of institutional values or focus on specific behaviors of misconduct. The authors proposed a hybrid approach (86). Several academic societies have developed codes of conduct for member scientists related to misconduct (87).

Federal funders have also responded to the crisis. In 2016, the Science Advisory Council of the USDA National Agricultural Research, Extension, Education, and Economics Advisory Board developed a report focused on improving the reproducibility, and generalizability of agricultural and nutrition research (88). The report emphasizes the roles of data collection, statistical analyses, and replication methods in assuring research reproducibility, of context in determining the generalizability of research, of enhanced transparency in publication in limiting irreproducibility, and of rigor in cultivating public trust in scientific research. The NIH announced policy changes to address rigor and reproducibility in biomedical research (89). Identified sources that impact reproducibility included hubris, incompetence, complacency, bias, and fraud associated with some researchers; insufficient validation and authentication of experimental reagents; and concerns related to improper experimental designs, execution, analyses (including statistical procedures), and reporting. Addressing rigor and reproducibility currently requires the application of formal evaluation criteria during the proposal-review process (82). The European Food Safety Authority also released guidance documents in 2017 intended to increase transparency and consistency in reporting data and drawing conclusions from research. The guidance addressed weighing evidence, determining the biological relevance of research, and assessing limitations of targeted research to ensure that assessment processes and conclusions derived from the research are understandable (90).

Responding to similar concerns in 2017, The National Academies of Sciences, Engineering, and Medicine published *Fostering Integrity in Research* (91). The report differentiates between issues of scientific misconduct as described above from those more clearly identifiable with faulty rigor resulting in irreproducibility. Common to both is the need to focus on institutional behaviors that appear to inadvertently foster a lack of rigor and reproducibility. Specifically, the report encourages publishers and societies to (89):

- "improve and update their practices and policies to respond to the threats to research integrity";
- "maintain the highest standards for research conduct, going beyond simple compliance with federal regulations in undertaking research misconduct investigations and in other areas";
- "develop clear disciplinary authorship standards";
- "ensure that information sufficient for a person knowledgeable about the field and its techniques to reproduce reported results is made available at the time of publication or as soon as possible after publication"; and
- "develop and assess more effective education and other programs that support the integrity of research."

The Federation of American Societies for Experimental Biology published a report that offered guidance to researchers to overcome systemic flaws in research entitled *Enhancing Research Reproducibility* (92). The report gives specific recommendations to scientific journals, including *1*) engaging society publications committees and journal boards in discussion of issues related to rigor and transparency; *2)* supporting simple, common guidelines for reporting methods and reagents in publications and grant applications; *3*) promoting common guidelines to reflect needs of specific disciplines and fields of research; *4*) developing uniform instructions to authors regarding transparent reporting of materials and methods; *5*) publishing null or negative results; and *6*) developing training modules or programs on rigor and reproducibility by individual societies related to the needs of their respective disciplines (92).

Tensions among rigor, cost, and relevance are also important considerations in this debate. Trade-offs between rigor and relevance can occur when research questions are defined by research scientists and not informed by practitioners, most notably when the "primary pursuit is not knowledge" (93), but a specific implementation of knowledge that is to be gained.

Nutrition research also faces discipline-specific challenges related to rigor and reproducibility (14, 16). One example of a field-specific concern is obtaining sufficiently accurate and precise estimates of dietary and nutrient exposures. These most often rely on self-reported food intakes, which do not necessarily correlate with blood biomarkers of exposure and often do not account for limitations in deriving nutrient intake levels from food intake data that rely on food composition databases that too frequently are old, may not represent contemporarily available foods, and do not adequately account for variations in the nutrient content of many foods. There is insufficient clarity whether such shortcomings result in randomly distributed errors or findings that are biased in some undetermined manner. Scientific evidence derived from human nutrition research and its connection to health outcomes (other than single nutrient deficiencies) is primarily observational due to many factors. Such factors include the length of time required to observe outcomes of benefit and risk and methodological challenges related to securing and ascertaining adherence to dietary modifications, measuring relevant exposures, describing population heterogeneity, and measuring interactions of nutrients with other dietary components (94, 95). Observational data are prone to chance occurrences, bias, and confounding (96), consistent with the poor history of replicating results from observational studies in RCTs (14, 15). Reliance on observational data that link food and nutrient exposures to health and disease outcomes imposes limitations on the strength of evidence to support conclusions, especially when those are related to specific multietiological disease outcomes. In the absence of dose–response data, observational evidence is usually considered "low" in the GRADE rating approach (http://gdt.guidelinedevelopment.org/app/handbook/handbook.html).

Nutrition science research bears additional burdens for rigor and reproducibility. One such burden is the "unscientific beliefs" that result from the casual familiarity everyone experiences with food (15). Another burden is the expectations of the "best science" that understandably accompanies research findings with immediate applicability in daily health-relevant decision-making. There is no single solution to overcoming the challenges of obtaining quality evidence to support nutrition recommendations and nutrition policy. Solutions will likely require combinations of large and long-term RCTs (16), inclusion of dose–response relations in the design of observational studies, Mendelian randomization approaches in nutrition (96), and other approaches.

Transparency

Transparency in science refers to openness in all aspects of the conduct and review of research by scientists, publishers, funding agencies, and policymakers. This includes disclosure of how and by whom data collection, analyses, and interpretation were performed, as well as issues directly and indirectly related to the broad and narrow concept of informed consent by research participants (97). Transparency encompasses all phases of research, from the clear articulation of the anticipated research's primary outcomes, as is done through human clinical trial registration, to the firm grounding of all conclusions and recommendations in the strength of the evidence upon which they are based (e.g., avoiding conclusions from secondary data analyses) (46, 98, 99). Lastly, transparency requires acknowledgment of all funders (100), beneficiaries, and opponents of the research and its outcomes; declaration of all potential biases and competing interests that influence the research enterprise and interpretation of its outcomes (see section "COI and objectivity"); and identification of those who may be harmed by new knowledge.

Text Box 2.

This is a second example of the need for full transparency in research conduct and the communication of results. In 2009, Kellogg's Frosted Mini-Wheats cereal included a label on the front cover of cereal boxes: "Clinically shown to improve kids' attentiveness by nearly 20%," along with similar advertising claims (30), although the full research study had not been published or disclosed to support the advertising claims. The research study comparing children who ate breakfast (Frosted Mini-Wheats) with children who did not eat breakfast was conducted at an independent research laboratory and concluded that approximately half of the children who ate Frosted Mini-Wheats for breakfast showed an improvement in attentiveness, and about 1 in 9 improved by 20% or more. The Federal Trade Commission charged Kellogg with deceptive or misleading health claims and barred the company from misrepresenting tests or studies regarding Frosted Mini-Wheats and attentiveness.

Transparency in research conduct and communication of findings.

It is increasingly recognized that transparency in communicating the scientific process is one of the keys to increasing public trust in science (37). A metainterpretation aimed at determining how to increase the public's trust in the food safety system following retail food safety outbreaks in the United States, Canada, Australia, New Zealand, and Great Britain concluded that "provision of transparent scientific information to inform the public may support public trust in public health agency action" (37). Evaluating and declaring the strength of scientific evidence are essential for ensuring confidence in the translation of research findings into public policy and clinical practice. Such practices ensure that recommendations are scientifically grounded and trustworthy. Inappropriate use of statistics, lack of reasoned and substantiated biological premises, and lack of consideration of the strength of the evidence when drawing conclusions or recommending guidance can lead to policies and practices that undermine clinical and public health. Therefore, researchers and policymakers should be vigilant and transparent regarding the types and strength of evidence upon which conclusions and communications are based. The National Academies of Sciences, Engineering, and Medicine encourage all researchers, research institutions, and journals to disclose results of all relevant analyses in research publications, including negative findings in assessments of statistical significance (91).

Transparency also includes declaration of funding sources and the roles of funders. Individuals and organizations, including funders (100), with interests in the results of a study may introduce bias into research or the conclusions and policies that result from it (101). A study of industry-initiated trials revealed that for over half of the included studies, the sponsor owned the data or required preapproval of published manuscripts (102), which introduces a risk of bias and results in a downgrading of the evidence derived from the study (101). Furthermore, industry-funded studies on average have a lag bias in their time to publication (99). Hence, transparency in declaring funders and their roles in the research is required to inform and correct for potential biases, to weigh evidence accordingly, and to bolster trust in the conclusions drawn.

Likewise, history has demonstrated the essentiality of ensuring the highest level of ethics in research conduct to undergird public trust in the research process from inception of "the" question through the translation of results, especially when considering human research participants who must understand all potential benefits and risks they face through a transparent informed consent process (97). Research participants should understand how the results of a study may create harm for their culture, beliefs, traditions, or identity (103).

Finally, transparency is integral to evidence syntheses and the development of high-quality evidence-based guidelines. The National Academy of Medicine (then the Institute of Medicine) proposed 8 standards to increase the trustworthiness of clinical practice guidelines (55). The first among these was the need for transparency in describing the process of guideline development as well as transparency in limiting both risks of bias and COIs (51, 104).

Creating a culture of transparency.

Although most scientists embrace features such as transparency, openness, and reproducibility, the current academic climate does not necessarily reward these behaviors (105). Recently, Alberts et al. (82) described the academic research climate as follows: "biomedical science has created an unsustainable hypercompetitive system that is discouraging even the most outstanding prospective students from entering our profession—and making it difficult for seasoned investigators to produce their best work." In this environment, transparency and career advancement are not mutually supported. A recent report from The National Academies of Sciences, Engineering, and Medicine emphasizes the imperative for complete transparency concerning all aspects surrounding scientific data, including disclosure of "biases that favor conclusions of safety and efficacy" (91). However, it is also noted that research institutions do not consistently promote a culture and climate that are comprehensively supportive of transparency and related expectations that are "modeled by its leadership. Institutional culture starts with the dean, senior leaders, and members of their team stating how research is to be conducted, with integrity and transparency, and with clarity that shortcuts will not be tolerated and that dishonesty is the basis for dismissal" (106).

In an effort to enhance a scientific culture of increased openness and transparency, the Transparency and Openness Promotion Committee (convened by *Science*, the Center for Open Science, and the Berkeley Initiative for Transparency in the Social Sciences) met and published a set of 8 standards to "translate scientific norms and values into concrete actions and change the current incentive structures to drive researchers' behavior toward more openness" (105). The group that proposed these guidelines (https://obssr.od.nih.gov/guidelines-to-improve-data-transparency-research-and-publishing-practices) consisted of scientists, journal editors, and representatives from funding agencies. Many of the guidelines are directed at the way scientific studies are published and other journal practices, such as guidelines addressing data sharing and preregistration of studies. Publishing is central to the research process, the advancement of science, and ultimately public trust in science (105).

Transparency as a two-edge sword.

Transparency is intended to enhance the quality and impact of research by fostering healthy debates among scientists and the public (107). Clear articulation of the appropriate roles of funders, advocates, stakeholders, and the public in informing research questions is important. The conduct of research and the translation of scientific evidence to information needed for policy formulation benefit from the leadership of experts and those who have no vested interests beyond the common good in study outcomes or policy and practice recommendations.

Pursuing transparency through abusive means can have a chilling effect on research. For example, information requests motivated solely by the desire to redirect investigator time and other resources from research to nonproductive, noninforming tasks are not in the public interest (108). Abusive tactics may go further to include orchestrated harassment with challenges to a scientist's reputation and/or the intentional distortion of scientific results and their interpretation (109). Such a situation occurred recently in nutrition research when a human-lactation expert provided evidence that glyphosate, a herbicide used on genetically modified plants, was not present in human milk as suggested by others (108). A recent commentary provided a guide to identify abuses of transparent research practices and called for institutions, government agencies, and other organizations that promote transparency in research to address such threats (109).

Equity

Inequities in health research are defined as "differences in health outcomes that are avoidable, unfair and unjust" (110). The Cochrane Equity Group describes *inequity* as having both moral and ethical dimensions and being characterized by "differences which are unnecessary and avoidable" (111). Health inequities share characteristics in that they persist, often increase over time, and frequently are generalizable within and across populations (110). Inequities in health research are both international and domestic concerns, although typically in the United States, these concerns center around the lack of women, specific age groups (e.g., children and the elderly), and under-represented income or ethnic groups in clinical research and trials. Equity concerns cut across much of the research enterprise, including the composition of the research community, the diversity of research participants, and the focus of research questions. These disparities include a lack of representation based on place of residence, race/ethnicity, occupation, sex, religion, education, socio-economic status, social capital, age, disability, and sexual orientation (110, 112, 113).

Socio-economic status remains a highly significant source of inequity in public health and clinical nutrition and of public mistrust in the nutrition research enterprise. Nutrient deficiencies, avoidable inequalities in availability or access to healthy foods, and nutrition-related chronic diseases are disproportionality concentrated in economically disadvantaged communities (114) and are usually associated with poor health outcomes, although exceptions exist. The so-called "Hispanic Paradox" describes a well-studied but poorly understood observation that the life expectancy among Hispanics, who are more likely to be living below the poverty line and to lack health insurance, is 2 y longer than that of non-Hispanic whites, with lower mortality rates from most of the leading causes of death (115). This is an example of unexpected specific ethnic relations among health outcomes that likely reflect poorly understood interactions among genotype, development tracks, and behavioral, socio-economic, and environmental variables (e.g., diet). Such interactions are likely to remain poorly understood unless individuals from under-represented groups are enrolled in research in sufficient numbers. The General Social Survey of Adults reported that from 1972 to 2012 in the United States, erosions in public trust in the media, business, religious organizations, the medical establishment, and government were attributable to income inequalities, poverty, and generation (with baby boomers having the lowest levels of trust) (32).

Thus, issues of inequity transcend ethical and moral considerations, as they directly impact the integrity and generalizability of human nutrition scientific research and its translation to public health policies, guidelines, and practices (114). Following the passage of the NIH Revitalization Act of 1993, Public Law 103–43 (116), women, minorities, and other under-represented groups must be included as scientifically appropriate in clinical studies. For example, children under 21 y of age must be included in human participant research unless there is a scientific reason not to do so. Notwithstanding these regulations, research scientists are challenged in recruiting diverse pools of research subjects. African Americans and Latinos are less likely to engage in biomedical research as participants, although community participation can improve study enrollments (31). This suggests a cycle that may be difficult to break: decreased participation of under-represented groups in research fuels mistrust in research and mistrust decreases research subject participation.

Cochrane has developed methods to quantify the impact of inequity in its analyses of biomedical interventions (112, 113, 117–119). Compared with other health research fields, the nutritional sciences may exhibit fewer inequities related to sex. Nutrition research has historically focused on vulnerable populations, including women of reproductive age and their children, where nutrition-related public health concerns are abundant and consequently where important scientific questions need to be interrogated and solved to improve public and clinical health (120, 121). Comparative data directly informing research expenditures on problems of women's health and nutrition outside reproduction are scant, although major NIH-funded projects including the Women's Health Initiative and the Nurse's Health Study addressed nutrition-related risk factors for chronic diseases and mortality in postmenopausal women. Overall for all biomedical research, there is evidence that the impact and benefits of biomedical research may currently be skewed in favor of men (104).

Women and nonwhite groups of non-European origin usually are under-represented in research as investigators in the biomedical sciences, and women scientists in particular receive less research funding than do their male counterparts (104), but the situation in nutrition science seems better than in many other disciplines. ASN reports that over 50% of its membership who provided such information in 2017 identified as women. On the other hand, the participation of nonwhite scientists of non-European origin remains an issue of growing concern. Most ASN members do not declare their ethnicity, although data available from the ASN membership directory suggest that the number of scientists from under-represented communities is disproportionate to the population burden of nutrition-related health concerns in their respective groups of origins.

Active inclusion of the public for setting biomedical research funding priorities in a manner that is representative of US demographics is an ongoing strategy to redress inequities in the focus and beneficiaries of research and to achieve balance in the scientific and social values embedded in the research that is conducted (122). Passive mechanisms, including scientists' interests in addressing the most challenging and impactful scientific research questions and the need to lower health care expenditures through disease prevention, may also help to address issues of equity in the overall nutrition research portfolio. A good example of such a mechanism is the increased focus on establishing Dietary Reference Intakes based on diet-related chronic disease endpoints (123) and a recognition that the prevalence of diet-related chronic disease differs by ethnicity, sex, and other factors associated with inequities. Establishing nutrient intake recommendations based on chronic disease endpoints will require prioritization of research focused on subpopulations most at risk and hence may help to narrow existing equity gaps.

Importantly, disparities have not been ignored completely. Nutrition is one of the NIH research areas categorized using the NIH Research, Condition and Disease Categories process (https://report.nih.gov/categorical_spending.aspx), and the nutrition research "fingerprint" is available via RePORTER and the NIH Categorical Spending tables. Federal research awards have been allocated to address heath disparities in food and nutrition. Over the past 5 y, the NIH estimates that it has provided over $1.5 billion annually in financial support of nutrition research and training. With respect to nutrition research that directly addressed concerns of health disparities and nutrition, the NIH supported 202 research projects at a cost of about $103 million in 2016 (124).

Information dissemination: education, communication, and marketing

This section explores the tools available to researchers to inform the public, especially regarding nutrition and food science, to enhance understanding, and to improve the ability of media, policymakers, and the public to discern credible research. The strategies and associated platforms available to the research community for translating and disseminating research findings are loosely classified as education, communication, and marketing. The relative effectiveness of these 3 approaches, used in isolation or in combination, is an active area of research (125, 126). The National Academies of Sciences, Engineering, and Medicine recently published *Communicating Science Effectively: A Research Agenda*, which encourages more attention to developing the science of science communication (127). Effective dissemination depends on the characteristics of the information, including its practicality and utility; how it is delivered by the "provider"; and the interest, willingness, and ability of the "recipient" to accept and act on the information (126). The WHO has developed a Knowledge Translation Toolkit for disseminating targeted public health information (125).

The robust and ever-increasing evidence base that connects food to health generates a growing public demand for nutrition information. The numerous sources for nutrition information include traditional media, blogs and other new platforms, health care professionals, the federal government, research centers, and nutrition labels. The uses of these sources change over time and differ by age and other demographic characteristics (127). Nonetheless, scientific and media literacy remains a major gap for informed decision-making by consumers (128). Among the numerous information sources, health care providers and academic-based nutrition scientists may be the most trusted sources for health or nutrition information (129). The quality and accuracy of nutrition information vary markedly within and across these sources, although mere exposure to any nutrition information has the positive effect of raising the public's awareness (130).

The landscape of nutrition information and its utility are fraught with shortcomings, opportunism, and in some cases fraud, taking advantage of a public that is unable to evaluate the quality and accuracy of the information provided (131). Even for the informed consumer, nutrition information is often delivered in the absence of the evidence base upon which the information is grounded. News media sources often do not provide enough detail or content for consumers to discern the veracity of research findings, and 22% of consumers report being confused by news reports (132). Studies have shown that the average consumer struggles to accurately apply nutrition knowledge to guide dietary choices, including controlling portion sizes and obtaining adequate levels of nutrients from processed foods, even when they are aware of recommendations from authoritative sources (133). Others note that whereas the food environment is a pervasive influence on consumer behavior, ultimately the consumer makes dietary decisions, and therefore media literacy is essential for the consumer to identify and purchase foods that support healthful diets (134). The limitations of scientific literacy and its role in consumer choices are important considerations that can lead to a mistaken perception of public trust. Consumers' values, preferences, scientific knowledge, and beliefs are not necessarily in complete harmony (2). Wynne emphasizes that scientists and policymakers all too often point to the public's lack of knowledge (e.g., deficit models), irresponsible media, advocacy groups, and other scapegoats for a lack of acceptance and uptake of scientific evidence, when the root cause is a conflict among science, values, preferences, and beliefs (34). For example, public rejection of genetically modified foods in many cases may not be related to an understanding of genetics but rather may be due to a belief against manipulating genetic material.

Communication, marketing, and education are inextricably linked to effective dissemination and the uptake of scientific information. Cooper argues that strategies developed for greater acceptance and translation of scientific findings to communities could improve by *1*) being more comprehensive in their reach through use of all available media and entertainment platforms; *2*) including active public education events; *3*) increasing critical thinking and reasoning skills in the education system; *4*) avoiding a cultural deficit perspective; *5*) providing tools to enable the public to critically evaluate the media; and *6*) educating scientists in communication and media skills (135). There is an increasing sense that scientific literacy focused on critical thinking skills should be introduced in elementary school, emphasizing an understanding of the scientific process while de-emphasizing exclusive attention to outcomes (e.g., the structure of DNA) and thereby empowering citizens to assess evidence and understand the evolving nature of science (136). Goldberg and Sliwa (134) further identified 4 challenges in disseminating nutrition-related scientific information to the public: *1*) the evolving nature of science and the recommendations that follow; *2*) the abundant and sometimes contradictory perspectives and scientific information from different sources; *3*) the agendas and motivations of sources; and *4*) the competing priorities of consumers with respect to their food choices [e.g., taste, cost, and convenience (137)].

Successful public health social campaigns generally include nutrition communication strategies combined with other strategies (e.g., policy, incentives) to effect positive behavior change (e.g., exercise, smoking, health services, diet) (138). Theory-driven, evidence-based, and targeted education programs with clear and actionable guidance are rare (137). Importantly, it is unlikely that any single-pronged approach will be effective. For example, successful improvements in mortality and morbidities due to automobile accidents were not achieved solely because automobile operators became better drivers. Automobile and highway designs were improved, and regulatory and legal steps (e.g., mandating seat belt use) were adopted to help attain desired goals. In addition to policy approaches to improving public health, inclusion of financial incentives and changes in the built environment can enhance the effectiveness of dissemination strategies. Worksite health-promotion programs have been demonstrated to improve employee health and nutrition. Companies encourage such programs by creating health-promoting food and physical environments as well as by reducing health insurance premiums to employees (139–141). Thus, perhaps it is not surprising that a meta-analysis of health campaign impact indicated that the most effective theory-grounded health campaigns are goal-oriented and targeted, but only affect their targeted audience by 5% on average, with nutrition campaigns achieving slightly better outcomes (138). Although public trust in scientifically based recommendations is an essential component in behavior change, it is not sufficient unless the communications are "memorable and actionable," appropriately targeted to the intended population (142), and supported by appropriate contextual changes (137, 142).

Given the differences in uptake of nutrition education among individuals and communities, innovations including computer-tailored nutrition education are needed (143). For example, population heterogeneity in response to information can have unexpected origins. One study found that messages targeting parents with children to provide healthy food in the family environment were more influential when parents identified with other study peer participants (144). Financial incentives may be effective when combined with health information in promoting participation in health-promoting activities.

Thus, wide adoption of dietary recommendations depends on more than information dissemination intended to change consumer practices (134). Food producers and distributors are also important audiences (145). Ensuring an appropriately diverse food supply and its improved availability and accessibility are important components of comprehensive efforts to support consumer adoption of the Dietary Guidelines for Americans. A common understanding as well as effective and trustworthy communications by all stakeholders in the food and health care system and the government also are key (145).

Sources of mistrust.

The accuracy of the information communicated and the disclosure of the sources responsible for that information influence how information is valued by intended audiences. Not surprisingly, information that is later revealed to be inaccurate erodes public trust in the source and perhaps even more generally in the underlying field or sector (146). Furthermore, hype that raises unachievable expectations may erode public trust and public support; nonetheless additional evidence is needed to understand the linkages among hype, public trust, and public support (147). Some information disseminated through corporate marketing campaigns is intentionally false, misleading, or based on weak research but effective in promoting the sale of food fads or nutritional supplements with no demonstrated efficacy (148, 149).

However, more subtle influences also contribute to how communicated information is received, understood, and trusted. Easily understood, transparent scientific information contributes to trust by informing and empowering consumers (37, 135, 151). A lack of transparency, because of either a lack of disclosure or the use of technical terms that are not easily understood, limits the public's ability to use information that is necessary for informed decisions (152). An example of likely relevance to nutrition science is a study of news media coverage of medications (14). The study found that information supplied by the sources studied often was incomplete; lacked key information on benefits, potential harm, and costs; and failed to disclose potential COIs between drug makers and experts promoting specific drugs (153). Other studies found very low adherence to the reporting of financial COI related to research findings in newspapers. Scientific journalism is often better in this regard than other news media (154). Eiser notes the tension between perceived expertise and perceived motives, where knowledgeable sources of information are mistrusted by the public or when information sources are viewed as being motivated to be untruthful or not totally forthcoming (155). Transparency and openness were noted again and again to lead

Text Box 3.

This is an example of nutrition information dissemination that promotes the sale of products with front-of-package nutrition rating systems and symbols but that may be misleading to consumers and complicated further by the sponsors' COIs. In 2009, the Keystone Center, a nonprofit organization that mediates public policy disputes, underwent criticism for use of a logo on food products (150). Between 2008 and 2009, 14 corporations donated a combined amount of $1.47 million to fund the development of a labeling initiative that provided a green seal of approval on the front of food packaging, the Smart Choices seal, to indicate a "healthier" option for consumer use. The Smart Choices program was administered by the ASN and NSF International, who together approved approximately 2000 products. Criteria for use of the Smart Choices seal on a food product were concurrence with nutrition recommendations laid out in the 2005 Dietary Guidelines for Americans. The US Food and Drug Administration sent a letter to Smart Choices expressing its concerns over potentially misleading claims and that consumers may choose the Smart Choices seal of approval on processed foods over whole-food choices, such as fresh fruit and vegetables. Smart Choices suspended operations in 2009 following criticism of the program.

to improved communication and greater accountability (37, 135, 151).

Scientists and information dissemination.

Independent of the scientific evidence base, communication strategies used to inform the public of key findings can shape public perceptions and opinions of scientific information. Hence, the portrayal of research findings in the media significantly influences consumers' beliefs (156). Effective communication styles, including the warmth and accessibility of the communicator, are of central importance (157). How scientific information is presented via the media impacts trust, empowerment, and consumer decision-making, and thus, media literacy education for scientists is essential for those seeking to advance the translation of scientific evidence into public health (135). Unfortunately, scientists most often tend to direct their communication efforts to correct misinformation without consideration of factors that lead to the public's initial acceptance of it (158), seldom understanding that the public is more likely to trust information from friendly and authentic communicators, not necessarily always the most informed (159). The Academy of Nutrition and Dietetics has published strategies for effectively communicating accurate nutrition information (132).

Contradictory nutrition messages related to health benefits and risks are associated with consumer confusion, lack of confidence in nutrition scientists, backlash that leads to the discounting of nutrition recommendations, and diminishing intention and engagement in modifying nutrition behaviors (160, 161). Nutrition information in the popular media is often portrayed as "inconclusive, changeable and open to interpretation" (162). Also, members of the media may lack the level of scientific literacy necessary to evaluate nutrition research and therefore rely on scientific expertise in assessments of the strength of evidence (163). General "uncertainty" when expressed by experts is amplified by a lack of consensus among scientists regarding the appropriate role of expert opinion compared with the evolving methods to assess objectively the strength of evidence and how best to communicate those evaluations in support of nutrition decision-making and the dissemination of dietary recommendations and related communications to the public (as opposed to internal communications related to future research needs) (164). Achieving consensus in these areas may serve to bring more consistent information to the media and limit contradictory nutrition messages to the public. Equally important, cultivating a shared understanding among scientists regarding their most effective roles in the policy process could limit the dissemination of contradictory information. Currently, scientists engage in policy in roles as varied as lobbyists in support of a position or interest groups to "unbiased consultants to decision makers" (165).

Accountability

In *Accountability and Public Trust*, Brody defines accountability for nonprofit organizations through "three fundamental questions: *1*) To whom is someone accountable, *2*) for what, and *3*) how" (166). Nonprofits are accountable to regulatory agencies, peer organizations, constituents (which include donors, members, clients, media, contractors, and staff), and the public (as measured by the social value of the organization's activities). Most challenging is the heterogeneity of the various constituents and their differing expectations, with some wanting responsiveness and others wanting best practices, disclosure, or inclusion, among other outcomes. Brody posited 4 practical and measurable voluntary performance standards that are adherent to the concept of accountability for nonprofit organizations and transcend technical regulatory compliance. These are commitments to *1*) fiscal probity, *2*) good governance, *3*) adherence to the direction and mission of donor(s) (with assurance of shared expectations among all diverse donors including taxpayers), and *4*) program effectiveness relative to the organization's mission and activities, including policy impact (166). These components encompass how organizations manage diverse expectations from constituencies that are both internal and external to an organization (167, 168), how they manage their dependence on funders without compromising an organization's mission and values, and how organizations manage openness to public scrutiny and willingness to accept responsibility for decisions (169). Accountability domains and their measures differ among nonprofits relative to the organizations' missions (170). Morrison and Salipante (171) describe the need for nonstandardized "negotiable accountability" as opposed to "rule-based accountability" as a means to best address context-dependent measures of success for complex organizations while remaining true to the history, values, and mission of an organization. Accountability measures are essential not only to engender favorable views of the organization's commitment to the public good, but also to create an atmosphere of stability and clarity that facilitates partnerships, policy influence, philanthropy, and hence relevance and sustainability of the organization.

Many accountability frameworks for nonprofit organizations are published and generally include 3 key elements (172):

1) a commitment to operating standards relative to the roles and responsibilities of the membership, including adherence to codes of conduct (167);
2) a welcoming of public scrutiny; and
3) authoritative dialogue about accountability by holding all of its members, including leadership, responsible for the designated roles of each within the organization (e.g., the WHO Accountability Framework: http://www.who.int/about/who_reform/managerial/accountability-framework.pdf).

For the purposes of this report, the accountability of ASN (including both the members and the organization) is of primary interest. But given that the goal of assuring accountability is earning and keeping the public's trust, it is also important to recognize the roles and responsibilities of other organizations and interests with related roles and responsibilities. Accountability in food and nutrition therefore also includes governments and governmental organizations that are responsible for population health [e.g., meeting the 2025 World Health Assembly targets to reduce malnutrition, both undernutrition and overweight, and improving diet quality (173)]. An accountability framework for voluntary partnerships between government and food industry stakeholders for the purpose of facilitating healthy food environments was proposed by Kraak and Story (174), which includes the articulation of clear objectives, as well as governance and performance standards for all stakeholders in the food system. The framework includes assessment, communication, enforcement, and responsiveness to improvement.

Public–private partnerships (PPPs) within the food and nutrition area have likely attracted the most direct attention in considerations of accountability. Trust built upon a foundation of accountability is essential when forming PPPs that engage stakeholders across the food system (176). As such, this particular area is a useful model from which to extrapolate potential best practices intended to enhance accountability in the service of public trust. Kraak et al. examined controversial PPPs and similar types of engagements in food and nutrition that involved UN organizations and developed a 6-step benefit–risk decision-making and accountability tool to guide future decisions relative to PPP engagement (176, 177). The tool includes elements of compatibility and assurance that all PPP members have shared mission, values, and goals relative to the engagement. This includes common risk–benefit assessments, adherence to codes of conduct, and assurance of achievement of benefits. The framework requires that public interests and business interests have clear boundaries, such as avoiding inappropriate cosponsorship or cobranding of unhealthy products (177). The tool also stresses the importance of "leveling the playing field" in structuring PPP relations, decision-making authority, and influence.

Text Box 4.

Successful public–private partnerships (PPPs) within the food and nutrition area highlight positive examples of the benefits that can come from collaborations developed with trust and accountability at the forefront. A 2013 article took a first look at common principles among successful PPPs and highlighted 3 PPPs in the food and nutrition research space that it deemed successful (175). One of those successful PPPs is the Feed the Future Initiative, created to improve agricultural productivity, link growers to local and regional markets, enhance nutrition, and build safety nets to address and ameliorate global spikes in food prices. Feed the Future has a long-term commitment to achieving its goals and uses benchmarks and targets to measure progress toward shared goals along the way. Although public good is an essential goal for PPPs in food and nutrition research, specific guidelines must be established for the management of food and nutrition research PPPs to ensure their integrity.

Increasingly, accountability measures can be implemented or enhanced by using readily accessible internet-based technologies. Best practices for web-based accountability were reviewed and a conceptual framework generated and tested based on review of 117 foundations in the United States (178). The framework describes the 2 dimensions of accountability: *1*) disclosure and *2*) dialogue. Disclosure refers to the voluntary and transparent accessibility of organizational finances (financial resources and compliance documentation), as well as a declaration of performance targets and the achieved outputs, outcomes, and impacts relative to the targets as they become available. Dialogue refers to mechanisms to understand constituencies' "preferences, needs and demands" through online surveys, polls, discussion boards, etc., and use of that information in a way that informs decision-making. Dialogue also necessitates intensive interactive engagement platforms that are responsive to constituency concerns and preferences.

Recommended Best Practices

Overview

The ASN requested a comprehensive review of the literature that describes the public's trust in nutrition science and of the factors that influence it and, based on that review, the identification of best practices to support public trust, appropriate to ASN and other stakeholder organizations in the food and nutrition space.

Nutrition science stands on research conducted by academia, government, the private sector, and nongovernmental organizations. Its evidence base is of fundamental importance to solving current problems, optimizing outcomes, and preventing harm. Meeting those goals also requires best practices in the conduct of research; open, accurate, and comprehensive communication; and often collaboration across these sectors. Public trust in nutrition science, and the policies, practices, and recommendations that flow from research related to food systems, food, nutrition, and diet-related chronic disease, is the cornerstone of public health (e.g., education and intervention programs and regulatory affairs), smart business decisions, and effective management of health care costs.

The literature review comprehensively explored current practices and threats to public trust in nutrition science, including gaps that erode trust. Unfortunately, there is a paucity of peer-reviewed material specifically focused on nutrition science. Thus, aspects of current practices and threats to public trust in science writ more broadly and applicable to nutrition science also were examined. Consideration of that literature kept the unique attributes of nutrition research in focus. The review and its analysis resulted in priority best practices. Their adoption by ASN, other stakeholder organizations, and individuals working in the food and nutrition space are anticipated to strengthen and help ensure the public's continued trust in nutrition science. Nonetheless, the breadth of the food and nutrition space requires that ASN work proactively to harmonize best practices in support of public trust in nutrition science not only with its members but also with all willing national and international organizations for maximal impact, and/or to partner or support related initiatives with other societies and all stakeholder groups when and where possible.

Recommendation #1: Managing COIs.

The Advisory Committee recognized the importance of financial resources provided by ASN's membership and potentially by other stakeholders to the successful realization of ASN's mission. The Committee, however, was unable to reach consensus on how best to balance anticipated benefits and potential risks of alternative financial resource strategies intended to maximize the implementation of ASN's missions. The Committee discussed 2 alternative recommendations:

1A: The ASN should enter into partnerships and other agreements only when these partnerships or agreements are supported exclusively by membership resources or not-for-profit entities with no COIs. A COI arises when a secondary interest or interests compromise the primary interest or aim of a project and/or activity; such interests could be financial or of other origin. COIs significantly impair objectivity or also may create unfair competitive advantages for persons or organizations.

Or

1B: The ASN should develop a rigorous, transparent approach to cosponsoring and managing all activities financially supported by "entities and/or individuals at interest." For the purposes of this report, the term "entity at interest" is applied and extended to individuals (i.e., an entity or individual is at interest when a financial interest exists in a project's or activity's outcome or in the resolution of an issue to be addressed).

Key to the second alternative are management approaches intended to minimize bias and enhance transparency, such as *1*) the establishment of an independent advisory group reporting directly to the ASN board and charged with reviewing proposed activities cosponsored by entities and/or individuals at interest; and *2*) the development and implementation of guidelines for avoiding COIs of individuals. It would be desirable for ASN to develop publicly available guidelines for all members of the ASN board, ASN staff, editors, editorial board members and staff of ASN journals, and chairs and members of ASN committees. It is similarly desirable for current COI statements to be publicly available on the ASN website for ASN board members and senior staff, editors and editorial board members of ASN journals, chairs and members of ASN committees, and members of nonstanding committees, projects, and activities.

Such an advisory group would review all externally funded activities to be supported by entities and/or individuals at interest and provide recommendations to ASN's board for consideration before final approval or disapproval by the board. When the advisory group recommends approval of an activity under its review, the advisory group should outline conditions for the public transparency of the targeted activity's planning, implementation, monitoring, and evaluation including the public availability of the activity's budget, dispersal of funds, and roles for everyone involved in each of the activity's phases, including dissemination of outcomes, if any. ASN's board and all other ASN staff with fiduciary responsibilities to ASN may brief the advisory group on the backgrounds of activities under consideration but should be precluded from any direct or indirect participatory role in the independent advisory group's deliberations and decisions.

The Advisory Committee's review of the literature supports the conclusion that a significant source of public distrust in science relates to COIs that arise from financial arrangements among entities with clear financial interests in activities convened and/or endorsed by professional scientific groups (e.g., support of ASN's annual meeting and satellite gatherings, prizes, membership networking events, fellowships, travel awards, and other similar activities).

Support for either alternative recognized the essentiality of clear, workable guidelines for ASN's elected leadership, members, staff, the public, and other stakeholders for evaluating financial arrangements related to all phases of ASN activities; of clear, unambiguous protocols for their enforcement; and of the a priori determination of potential consequences for enforcement failures. Impacts on financial resources, stakeholder involvement, public trust, and breadth of sponsored activities also were considered.

Thus, both alternatives are intended to simultaneously enable ASN to meet its mission, earn the public's and all other ASN stakeholders' trust, and avoid relations that do not serve the public's interest and do not unambiguously support unbiased scientific inquiry, education, and information dissemination.

Recommendation #2: ASN as the standard for evidence-based conclusions in its publications.

ASN publications should include a front-of-the-publication label that describes 3 key study characteristics: *1*) the type of evidence presented in the study (e.g., observational, RCT, discovery, mechanistic, etc.), *2*) the study finding's most proper use(s) (e.g., draw conclusions/inform policy, hypothesis generation, or increase basic knowledge), and *3*) the quality of evidence (low, moderate, or high based on specified GRADE criteria). ASN is a leading publisher of nutrition scientific evidence, and its publications are accessible to the research community, policymakers, the media, and the public. Its publications often provide the evidence base for nutrition policies and practices, and the media often report research findings from ASN publications to the public. Unfortunately, such information uses, including dissemination, are subject to hyperbole, misinterpretation, and/or errors.

Evidence-based policies are founded on assessments of the strength of supporting scientific evidence. Such assessments are essential for ensuring confidence in the translation of research findings into public policy and clinical practice and help assure that recommendations are scientifically grounded and trustworthy. Inappropriate use of statistics, lack of reasoned and substantiated biological premises, and/or lack of consideration of the strength of the evidence when drawing conclusions or recommending guidance from research findings can lead to policies and practices that undermine clinical and public health and public trust. Therefore, ASN should strive to assure that its publications buttress the translation process to the greatest extent possible.

Recommendation #3: Effective dialogue between the ASN, public, and media.

The ASN should bolster its efforts to engage the public and media in more effective dialogue among its members, the media, and the public.

It is anticipated that an improved dialogue will lead to an enhanced understanding by ASN of the public's concerns and of the media's needs to better inform the public about nutrition science while simultaneously increasing scientific literacy among the media and public.

Such efforts could include opportunities for ASN members and media professionals to interact in public sessions at its annual meetings and other venues regarding issues of contemporary interest to the public and/or media and to review developments in state-of-the-art nutrition science. ASN should increase its social media presence to be more proactive in addressing nutrition issues of contemporary interest to the public and/or media. ASN could also enhance efforts to ensure its leaders and experts follow best practices for scientific communication to the media and/or public, and speak directly to the accepted evidence base and its limitations.

Such efforts should be designed to assist ASN leaders and experts in their interactions with the public and/or media, the media's accurate reporting of evidence-based nutrition information, and the acculturation of the media and public in the practice of including a discussion of the evidence base when reporting guidance or conclusions. It is anticipated that such efforts will enhance the portrayal of nutrition research findings in the media, positively impact the media's influence on consumers' beliefs, and promote the public's trust in nutrition science.

Recommendation #4: Guidelines development for conducting nutrition research funded by entities with COIs.

ASN should develop guidelines for its members in managing and conducting nutrition research funded by entities at interest—often those with a financial stake in the outcomes of the funded work.

As is true for professional scientific groups, a significant source of public distrust in science relates to financial COIs that arise from financial arrangements among entities with clear financial interests in specific research, with their personnel and/or grantees and/or contractors engaged in that research. This recommendation is intended to help these key stakeholder groups.

As is the case with professional scientific groups (described in Recommendation #1), 2 options for minimizing this source of COIs are to avoid such undertakings or commit to their heightened scrupulous management. ASN should provide its members and affiliated organizations with guidelines for structuring the management of such relations and the conduct of such nutrition-related research with the goal of avoiding COIs. The development of such guidelines should include an independent auditing process to assess compliance with the guidelines that ASN members and affiliated institutions would elect to undertake.

Recommendation #5: Independent audits of adherence.

ASN should commission independent audits of its adherence to adopted policies and practices intended to heighten and maintain public trust in nutrition science.

The Committee's literature review yielded multiple examples of recommended practices intended to support the public's trust in the scientific enterprise. Those examples focused on policies and their implementation targeting individuals, institutions, and/or more complex, organizational structures (e.g., academia writ large). These examples less commonly included robust accountability procedures to help determine the comprehensiveness and efficacy of implemented practices intended to support adopted policies. The Advisory Committee concluded that robust accountability procedures are a key element to meeting the goals of securing, maintaining, and enhancing the public's trust.

The Committee recommends that ASN undergo independent, regular audits of its adherence to adopted policies and practices designed to strengthen public trust in nutrition science. It encourages ASN's board of directors to consider delegating this function to an external group. Two possibilities are professional auditors or a senior group of independent individuals affiliated with ASN but with no fiduciary responsibilities to the organization.

Recommendation #6: Disclosure of COIs.

ASN should develop comprehensive COI disclosure statements that cover financial and other COI sources that serve as a model in nutrition science for use by its members, other stakeholder groups, and staff.

The Committee's literature review documented the importance of transparency in gaining and keeping public trust. The review revealed diverse sources of conflict (e.g., financial, career advancement, and upholding previously defended professional positions). The review also revealed that avoidance of all COIs may not always be achievable or desirable. However, publicly divulging all COIs can be an effective mechanism in helping interested parties assess the nature, seriousness, balance, etc. of COIs of those engaged in activities undertaken by ASN, other organizations with whom ASN members are affiliated, or other stakeholders to help assure the public and others of commitments to avoid inappropriate influences.

Conclusion

Public trust in nutrition science is the foundation on which nutrition and health progress is based, including sound public health. In this report, we have reviewed the literature about the public's trust in nutrition science and the factors that influence it. We have then proposed best practices to support and enhance public trust. We hope our report and recommendations will be helpful to the ASN and other food and nutrition organizations, the public, researchers, food and nutrition professionals, companies, and government officials in earning and keeping the public's trust.

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