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Impact of nutrition misinformation and fraud on consumers health-A review

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Abstract
Nutrition misinformation is an illegal deception for economic gain using food. It is a tool for nutrition fraud. Nutrition fraud describes abuses that occur as a result of misleading claims for food and nutrition products and are difficult to control. Nutrition fraud may lead to loss of money, failure to seek correct medical care, lack of money for proper treatment, substituting poor nutritional practices for sound ones, disease itself can also occur. This article discussed the types of nutrition misinformation, health fraud, target populations for nutrition misinformation, sources of nutrition misinformation, nutrition and food fraud. Types of nutrition misinformation include food fad and fad diet, health fraud, misdirected health claims. Targeted population for nutrition misinformation are older adults, adolescents, athletes, obsessed persons intending weight loss, persons living with HIV/AIDS, persons with chronic pains and cancer. This study seeks to review the impact of nutrition misinformation and fraud on consumers.

Keywords: Nutrition, misinformation, fraud, consumers, health

Introduction

Enormous scientific advances have been made in the area of food and nutrition, leading to a fine-tuning of recommendations about healthful eating (Andrews *et al.*, 2013) [2]. Consumers have become increasingly aware of nutrition-health link and reliant on nutrition information to base their decisions, and have assumed partial responsibility for changing their eating behaviors (Catholic Relief Service, 2004). Unfortunately, these same trends also create opportunities for food and nutrition misinformation to flourish. News reports rarely provide enough contexts for consumers to interpret or apply the advice given and preliminary findings often attracts unmerited and misleading attention (Food and Drug Administration, 2015). Optimal nutrition is important for improved health and wellbeing and reduced the rate of diet related health conditions including chronic diseases. With the growing awareness supporting the connection between diet and overall health, many people are taking their personal health and nutrition decisions into their own hands. From various websites, television, radio, newspapers, advisements, or friends and family, finding reputable nutrition information has become a task on its own (Duyff *et al.*, 2015).

Nutrition and food fraud globally is one of the most active food industry and regulatory issues. Food companies and agencies regardless of a traditional focus on public health risks are being held accountable by consumers and agencies for food fraud prevention. This has been a major government focus in the European Union, United Kingdom, China and while there has been focus on food safety issues within the Food Safety Modernization Act there are clear food fraud compliance requirements, the USA. Beyond the potentially catastrophic economic impact of a recall or manufacturing shut-down, corporate officials are being held personally criminally liable for incidents. The prosecution has shifted from liability for the corporation to criminal incarceration for corporate leaders such as for Peanut Corporation of America and Jenson Brothers (Duyff *et al.*, 2015). For these and many reasons discussed below there has been an intense focus on food fraud research and specifically on prevention.

Food nutrition misinformation and fraud is an illegal deception for economic gain using food (Bansal *et al.*, 2015) [3]. The broad types of incidents include adulterant-substances (including dilution, substitution, concealment, etc.), tampering, theft, diversion or gray market, over-runs or unauthorized production, simulations and intellectual property rights counterfeiting (Table 1) (FDA, 2015) [15]. A 2016 Michigan State University survey reinforced the broad scope of food fraud when over 50% of survey respondents prioritized adulterant-substances, tampering, theft, *and* counterfeiting (Clarke and John, 2005) [6]. A challenge is that other than adulterant-substances the countermeasure and control systems are outside of food science authenticity or integrity testing. This study seeks to review the influence of nutrition misinformation and fraud.

Nutrition Misinformation: A Tool for Nutrition Fraud

Nutrition fraud describes abuses that occur as a result of misleading claims for food and nutrition products. These products can include traditional foods, dietary supplements, dietary products, food substances, diet plans and devices. Nutrition fraud is a leading example of health fraud. Food faddism, or an exaggerated belief in the effects of food or nutrition on health or disease fuels nutrition fraud. Food fads are based on some basic disbeliefs: certain foods have special attributes which may cure disease; certain foods should be removed from the diet because they are harmful and also certain foods have special health benefits (Association of Certified Fraud Examiners, 2015).

Nutrition fraud may lead to loss of money, failure to seek correct medical care, and/or lack of money for proper treatment, substituting poor nutritional practices for sound ones, or disease itself, can also occur. Highly skilled promoters and marketing techniques that promote fraudulent products have replaced the traveling medicine man. The manner in which nutrition misinformation reaches you can be very subtle. Books, talk shows, magazine and newspaper articles, advertisements, and mail order companies often

distort nutrition information. Unfortunately, so can friends or family members, who tell of the wonders of a special food or diet. What is unfortunate is the hope we put in a few special foods when what we really need is a balanced diet (Chen, 2015) [5].

Unfortunately, many people falsely believe that anything printed or sold is truthful. There are many federal and state agencies that regulate against health fraud. However, misleading claims about food and nutrients are difficult to control. There are limits on what government agencies can do about fraudulent nutrition practices. The government must observe the basic rights of freedom of speech and press. Nutrition information, whether scientifically correct or not, is protected under the first amendment. This means that, for you as a consumer, you must evaluate the accuracy of nutrition claims. "Caveat Emptor" is a Latin term that means "Let the Buyer Beware." Food is not magic and it is not a cure-all. Yet some promoters make such claims. If they do not make the claims outright, they may use advertising to imply false claims. Therefore, being a well-informed consumer is your best defense against nutrition misinformation and fraud. Food fads, fad diets, health fraud, and misdirected health claims are all types of nutrition misinformation. A nutrition expert is known as a registered dietitian (RD) or a licensed dietitian (LD), and has a specialized degree in dietetics, nutrition, public health, or related sciences (COSO, 2012) [8].

With the growing body of knowledge supporting the connection between diet and overall health, many consumers are taking personal health and nutrition decisions into their own hands. Individuals are becoming more reliant on nutrition information from sources such as websites, television, radio, newspapers, advertisements, friends, and family, thereby creating opportunities for nutrition misinformation and health fraud. Health fraud is defined as misrepresentation of health claims, and can range from a self-proclaimed medical expert who has discovered a so called "miracle cure," to a food supplement or drug that is promoted with unsubstantiated health claims. Accurate nutrition information is science-based, peer reviewed, and replicable. Nutrition misinformation is not supported by science and may be misleading and incomplete. It can be challenging for consumers to tease out reputable versus fraudulent nutrition (GAO, 2011) [22].

Identifying Nutrition Misinformation

Andrew *et al*., (2013) reported that by listening, asking questions and investigate nutrition claims, one may be able to spot false nutrition information. Many misleading claims play on our fear of disease. The following are some nutrition and food regulatory agencies tips for evaluating nutrition information, however below are some tips to sporting nutrition misinformation.

1. Watch out for claims nutrition and food regulatory agencies approval. Current law does not permit the use of the term "FDA" in any way that suggests approval.
2. Look for key words. Be cautious about products that use words such as "natural," "miracle," "cure," or "breakthrough." These are not scientific words. Cures for serious medical problems are not available through the mail or door to door.
3. Ask to see the product's label. By following the instructions on the label, a user should be able to realize the benefits claimed by the product. If the label doesn't clearly explain how to achieve all the benefits, be careful.
4. Check to see if the information in the advertisement or promotional material differs from information on the product's label. FDA can prohibit the introduction of any food, drug, device, or cosmetic that is not labeled correctly. Only factual and non-misleading information can be on the label. As a result, most false claims are not on the product label. False claims often appear in books, television, brochures, and promotional materials. Regulation of these types of materials is difficult due to first amendment rights of free speech and press.
5. Insist on full identification. If the advertisement mentions medical clinics or medical personnel, see that full names, addresses, and phone numbers are available and factual.
6. Ask for proof of the product's status with FDA. All legitimate medical manufactures engaging in interstate commerce must register with FDA, and have products listed with FDA. Some drugs, medical devices, and diagnostic products require FDA's approval before marketing. Ask to see the firm's FDA registration letter, the product's listing letter, or the FDA marketing approval letter.
7. Be careful of sponsors who say their products don't need FDA approval. Some say supplements and some "natural substances" don't need FDA approval because they are a food or food ingredient. Under the Food, Drug, and Cosmetic Act, a product is a drug if there is a medical claim. Drugs are articles intended to affect the function of the body. FDA also requires approval for combinations of approved drugs.
8. Watch out for cures for serious diseases. Be especially careful of products that claim to cure multiple health problems. Don't treat serious medical problems by mail or door to door products.
9. Be careful of self-diagnosis based only on symptoms. This can be hazardous if the diagnosis is false. Remember, everyone gets tired and gets occasional pains. There are many causes for such universal symptoms. A proper diagnosis requires a physical examination by a health professional. Delaying treatment can allow a disease to progress beyond help. If you need medication, your physician should prescribe it.
10. Investigate any "star support" or "big name" approval for any medical product. Any promotor must be able to demonstrate that the endorser has agreed to the ad campaign. Remember these are not scientific evidence. FDA can regulate claims made on a product label, but not what someone says happened to them.
11. Be cautious of recommendations for vitamin or mineral doses larger than the Dietary Reference Intakes (DRI) or non-nutritive compounds. Reliable sources will only recommend vitamin and mineral doses in line with the DRI's. Only certain conditions like pregnancy or serious illness use doses beyond the DRI's (FDA, 2015).

Types of Nutrition Misinformation

1. Food fad and fad diet

Food Fads and Fad Diets involve unreasonable or exaggerated beliefs that eating or not eating specific foods, nutrient supplements, or combinations of certain foods may

cure disease, convey special health benefits, or offer quick weight loss. Defined as unusual diets and eating patterns that promote short-term weight loss, with no concern for long-term weight maintenance or overall health. These diets are often trendy and may be popular for short periods of time. Food fads and fad diets have no scientific basis. Examples include the "grapefruit diet" or "low carb diet." The surgeon general's report on nutrition and health defines the promotion of these foods as involving false or therapeutic claims. Although food fads can be exploitative and entrepreneurial, many people who promote these fads may themselves be victims of misinformation and may sincerely believe that they are providing accurate information (GFSI, 2014).

2. Health fraud

Health misinformation and fraud is similar to fad diets, except that it is intentionally misleading, with the expectation that a profit will be gained. According to American Dietetic Association (ADAs) health fraud means promotion for financial gains, a health remedy that doesn't work or hasn't yet been proved to work and that is promoted to improve health, well-being or appearance. Health fraud is the promotion of false or unproven products for profit. Health fraud refers to products that claim to prevent, treat, or cure diseases or other health conditions but are not proven safe and effective for those uses. Health fraud includes products or diets that have no scientific basis, yet are still promoted for good health and well-being. Common examples include promises of "fast, quick, and easy weight loss," or a "miracle, cure-all product." Knowledge is your best protection against health fraud. Being able to recognize health fraud before you waste your money, or endanger your life is the key to preventing health fraud. Through education you can become aware of the methods used by promoters and the language of fraud (IFIC, 2005) [25].

3. Misdirected health claims

Misdirected Health Claims are misguided statements made by producers that lead consumers to believe a food is healthier than actually the case. Misdirected Health Claims include those that lead consumers to make incorrect inferences or generalizations about the health benefits of food. This type of claim misdirects consumers by leading them to believe that the foods are more healthful than is the case. The federal trade commission has advocated providing adequate disclosures to correct advertising misinterpretations. Such disclosures can be important tools in qualifying misleading impressions from current claims. Such misleading impressions or health halos can occur, for example when a product is advertised as low in carbohydrates but is still very high in calories (NIH, 2013). Examples include foods that are low in fat or low in carbohydrates, yet still high in calories. Weight-loss schemes and devices are the most popular form of fraud. Weight-loss is a multibillion-dollar industry that includes books, fad diets, drugs, special foods, and weight-loss clinics. Some products or treatments may lead to weight-loss, but the effect is usually temporary (FSAI, 2005) [21]. In addition, fad diets may not provide adequate calories or nutrients and can be harmful. Most dietary supplements are not reviewed and tested by the government before they are placed on the market. Athletes are often more susceptible to these claims of weight-loss or performance enhancing supplements, as an attempt to gain a competitive edge. Athletes that already adhere to proper training, coaching, and diet, may look for an advantage by resorting to nutritional supplements (GFSI, 2002) [24].

The only way to lose weight effectively and safely is to increase activity while decreasing food intake. Weight-loss should be gradual, 1 to 2 pounds per week, to allow for the development and maintenance of new dietary habits. Consult a professional in nutrition to determine a safe and effective weight loss program (Freight, 2015) [20].

Target Populations for Nutrition Misinformation

Alternative treatments are designed to appeal to many individuals, however, certain age groups or those with a particular medical condition are more likely to be targeted. A healthy lifestyle-including a nutritious diet, regular physical activity, and avoiding tobacco products, may help delay conditions associated with aging, chronic pain, and other conditions (GAO, 2011) [22].

1. Older adults

A large portion of healthcare fraud is targeted to those over the age of 65, and many victims belong to this population. Many products claim to reverse or delay conditions associated with aging, such as vitamins and minerals that claim to cure or prevent disease or lengthen life. There are no anti-aging treatments that have been proven to slow or reverse the aging process (Roth *et al.,* 2008) [28].

2. Persons with chronic pain and inflammation (Arthritis)

Individuals who suffer from chronic, painful, and/or incurable illnesses may turn to questionable treatments. Many of these illnesses, such as arthritis for example, may go into spontaneous remission, where pain and swelling can disappear for days, weeks, months or even years. When individuals experience such a remission, they may believe that a certain remedy or treatment has provided relief. These treatments not only are ineffective, but they may also do considerable harm and delay proper diagnosis and treatment. Those who suffer from arthritis should see a physician for therapy tailored to their needs (Rutledge and Rimbaud, 2013) [34].

3. Persons with cancer

Rates of Complementary and Alternative Medicine (CAM) use by Americans are particularly high among patients with cancer. Effective cancer treatment depends on early diagnosis and treatment, and the use of alternative treatments may allow the disease to progress beyond the treatable stage. For example, diets that are low in protein and many drugs marketed for cancer patients have no proven results. However, a small number of alternative treatments are finding a place in cancer treatment as a compliment to therapy in helping patients feel better and recover faster. Acupuncture, for example, has been effective in managing chemotherapy-associated nausea and vomiting and in controlling pain associated with surgery (NIH, 2013).

4. Persons Living with HIV/AIDS

Some individuals who are HIV-positive or who have AIDS may spend millions of dollars collectively, abroad or illegally in this country, to obtain unproven drugs and therapy. These drugs provide little benefit and are often

toxic. People who are HIV positive or who have AIDS may delay and/or interfere with effective treatment by using alternatives. For example, garlic and St. John's work have been shown to adversely interfere with HIV medication (NBJ, 2007).

5. Obsessed persons intending Weight-Loss

Weight-loss schemes and devices are the most popular form of fraud. Weight-loss is a multibillion dollar industry that includes books, fad diets, drugs, special foods, and weight-loss clinics. Some products or treatments may lead to weight-loss, but the effect is usually temporary. In addition, fad diets may not provide adequate calories or nutrients and can be harmful. Most dietary supplements are not reviewed and tested by the government before they are placed on the market. The only way to lose weight effectively and safely is to increase activity while decreasing food intake. Weight-loss should be gradual, 1 to 2 pounds per week, to allow for the development and maintenance of new dietary habits. Consult a registered dietitian or medical professional to determine a safe and effective weight loss program (Short, 1994) [35].

6. Adolescence

Adolescents may experience feelings of insecurity about physical development, causing many to experiment with products that promise to enhance appearance or speed development. Weight loss methods are extremely popular and as many as 46% of teens report that they are currently trying to lose weight. Fad diets are especially dangerous during adolescence because teens have high nutritional needs required to support rapid growth and development (Short, 1994) [35].

7. Athletes

Athletes may be susceptible to unsubstantiated claims for ergogenic aids, or performance enhancing supplements, as they attempt to gain a competitive edge. Ergogenic are defined as substances or procedures that are reported to increase energy or otherwise enhance athletic performance. Athletes that already adhere to proper training, coaching, and diet, may look for an advantage by resorting to nutritional supplements. Nutritionally based ergogenic aids have increased in popularity with the ban of anabolic steroid use. The popularity of ergogenic aids may also be due to media sources such as magazines containing nutrition information for athletes. Popular products include aspartic acid, bee pollen, brewer's yeast, choline, gelatin, ginseng, glycine, inosine, kelp, lecithin, protein supplements and wheat germ oil (Short, 1994) [35].

Sources of Nutrition Misinformation

Consumers receive nutrition information from a variety of sources. According to the ADA, (2002) survey and data from the Food Marketing Institute, consumers report that they received the majority of their nutrition information from media sources such as magazines (47%), television (34%), books (29%), and newspapers (28%). Other important sources of nutrition information are physicians (31%), the Internet (21%), product labels (19%), and friends and family (18%). Only 13% of consumers claimed their nutrition information came directly from dietetics professionals (ADA, 2002).

1. Food and nutrition misinformation on the internet

The Internet is a rapidly expanding source of food and nutrition information. Forty-six percent of those participating in a 2005 Food Marketing Institute survey said they used the Internet on a regular basis. Although people are increasingly relying on the Internet for nutrition information, consumers must be informed that the accuracy of information appearing on Web sites is not governed by any regulatory agency. As a result, sites featuring sound, science-based content coexist with sites containing questionable, inaccurate, or alarming nutrition information promoted by individuals and groups supporting unscientific views. Chat rooms, blogs, discussion lists, and electronic bulletin boards can provide a forum for exchanging inaccurate nutrition information (spring and Douglas, 2011). In fact, this popularization of electronic interaction has resulted in rapid and widespread dissemination of misinformation and "urban health myths." Several health organizations are addressing the proliferation of misinformation on the Internet. It is critical, therefore, that dietetics professionals be skeptical of information on the Internet, and that they are especially careful to provide accurate, research-supported evidence when contributing to these venues. For example, the American Medical Association issued guidelines for medical and health information sites on the Internet. The Health on the Net Foundation (2009) sets ethical standards for Web site developers and strives to guide health practitioners and consumers to useful and reliable online health information (Stahl, 2000) [38].

Short-Term and Long-Term Costs of Nutrition Misinformation

There are both short-term and long term costs when nutrition information is misinterpreted by the media, by consumers, or by the food and supplement industry. In the short term, physical harm can occur if there are unknown drug nutrient interactions or toxic components in foods. Physical harm can also occur if the use of products leads individuals to delay or to avoid seeking proper health care, or if it interferes with sound nutrition education and practices (UK FCU, 2016) [39]. Economic harm can occur when purported remedies, treatments, and cures fail to work and when products are needlessly purchased. Because the burden of proof falls on the federal government, there are fewer safeguards preventing the development of costly and useless products. The cost of health fraud can be estimated to be in the billions of dollars, especially when including the cost of purchasing products that may do no harm but also provide no benefit. Long-term costs of food and nutrition misinformation also include insidious lingering psychological issues of suspicion and diminished self-efficacy. Nutrition misinformation can lead consumers to lose faith in traditional sources of nutrition information and to provide less attention and credence to the results of new findings. It may even erode their perception of their ability to confidently manage a healthful lifestyle. When food and nutrition misinformation is common, it is much more difficult to gain public trust for future initiatives to improve public health (Pustjens *et al.*, 2015) [32].

1. Food and nutrition misinformation from industry

Many food companies are diligent about communicating accurate information about their products. In other cases,

food and nutrition misinformation may be disseminated by multilevel marketing companies promoting dietary supplements or unproven weight-loss products. These companies claim that their products can prevent or cure disease. Product literature may contain illegal therapeutic claims, or product distributors may supply such information through anecdotes and independently published literature. Advertising using testimonials also may spread misinformation. People tend to believe information that is endorsed by sports figures, celebrities, teachers, coaches, ministers, legislators, health care workers, media commentators, and others they respect (NBJ, 2007). When public role models give scientifically unfounded testimonials about the benefits of specific nutritional practices, the effects can be far-reaching and potentially harmful. Role models should carefully examine the accuracy and reliability of any food and nutrition information they disseminate and sharpen their skills at making appropriate inferences from scientific reports. When they are uncertain about the scientific merit of nutrition products they are asked to endorse, role models should seek the advice of a qualified dietetics professional, who must be prepared to provide them with science-based information (USDHHS, 2005).

2. Nutrition misinformation from friends, family, and culture

Some food beliefs rooted in traditional cultures or religions are not supported by scientific evidence. They can be followed as long as they do not result in possible harm and economic exploitation. For example, some Latinos and Asians believe that "hot" foods (some grains, oils, and meats) and "cold" foods (citrus fruits and dairy foods) have health properties that make them appropriate for different occasions. Despite a high level of cross-cultural agreement regarding whether a food is "hot" or "cold," there are different cultural recommendations about which foods are most appropriate to eat under various circumstances. For instance, many Latinos consider pregnancy a "hot" condition and believe that pregnant women should avoid "hot" foods. Conversely, the Chinese believe that pregnancy is a "cold" condition during which the expectant mother should avoid "cold" foods to keep herself in balance for good health. Cultural beliefs may be well-intended, but it must be realized that some of the misinformation they contain may lead to undesirable consequences (DOJ, 2013).

3. Misinterpretation of scientific studies in the media

Scientific progress does not prevent or eliminate food and nutrition misinformation. The media capitalize on preliminary research findings in an effort to enhance audience and readership ratings. Therefore, it becomes important that universities and research groups that release research results to the media use particular caution when presenting their findings. The International Food Information Council indicated that the most pervasive cause of food and nutrition misinformation related to scientific reporting was the lack of sufficient context for consumers to understand the findings. For instance, when a food or dietary choice was linked to a specific harm or benefit, only 13% of the stories mentioned how much to eat, and only 21% cited the reference. A content analysis of selected nutrition- related news stories reported during 2000 to 2005 found four common forms of inaccuracy, including reporting a correlation as causation, generalizing a study's results to a broader population not represented by the study, exaggerating the size of an effect, and using a single link in a chain of events to make predictions about events in the future (Wansink and Chandon, 1999) [44].

News reports on nutrition rarely provide sufficient context for consumers to interpret the advice given. The stories often fail to note how much more (or less) of a food should be eaten, how often it should be eaten, or to whom the advice applies. Both the news media and researchers must share responsibility for reporting accurate, balanced, and complete information to the public (Wansink and Huckabee, 2005) [45].

Increase Rate of Nutritional Misinformation

The proliferation of functional foods and dietary supplements has led to an explosion of misinformation because the number of these products has outpaced federal regulations. Consumer spending on functional foods, dietary supplements, natural/organic foods, and natural personal care products totaled $168 billion in 2004. This wide range of herbal, botanical, and sports supplements, which comprise over half of the dietary supplement industry, has helped sales increase$13.9 billion in 2004. The Dietary Supplement Health Education Act of 1994, which established guidelines for health claims and labeling of dietary supplements, shifted the burden of proving the accuracy of claims, safety, and quality to the US Food and Drug Administration. This shift may have unintentionally led to an undeserved, implied level of credibility to food and nutrition misinformation because the federal government has simply not discovered it and reviewed the claim. Although the Food and Drug Administration and the Federal Trade Commission have critical roles in dealing with food and nutrition misinformation, the overwhelming burden placed on them necessitates greater involvement by nutrition professionals (Wolfe and Dana, 2004) [47].

1. The role of allied health professionals

Consistent nutrition guidance reduces consumer confusion and reinforces the credibility of science-based nutrition information (Wolfe and Dana, 2004) [47]. For this reason, allied health professionals should collaborate with dietetics professionals and educators to provide consumer-focused health education, to train medical and health personnel, and to implement community nutrition education outreach efforts. Physicians, nurse practitioners, and other health care professionals need to seek the knowledge, skills, and services of dietetics professionals. Although health professionals do not always seek the skills and advice of a dietetics professional, it is important that dietetics professionals be assertive in providing their expertise. This may be in the form of in-house newsletters, e-mail updates, monthly brown-bag presentations, or simply continuously underscoring their availability (Wu *et al.*, 2008) [48].

Strategic partnerships between allied health professionals and related scientific and professional organizations and the nutrition community can help to ensure the delivery of consistent food and nutrition and health messages to consumers. For example, the Food and Nutrition Science Alliance is a partnership of seven professional scientific societies whose members have joined forces to speak with one voice on food and nutrition science issues (Wolfe and Dana, 2004) [47].

2. The role of government/regulatory bodies

Various government agencies work to regulate and disseminate food and nutrition information. Through the Food and Drug Administration's labeling programs, the government regulates food and nutrition information and health claims on food and dietary supplement labels. Federal agencies pro- vide science-based nutrition health guidance eg, Dietary Guidelines for Americans *(*2005) and My Pyramid as well as sound nutrition and food safety information through publications and Web sites. Public–private partnerships, campaign, also communicate positive, simple, and consistent messages to help consumers achieve healthful, active lifestyles. Federal, state, and local government agencies employ dietetics professionals for their expertise in nutrition. Dietetics professionals work in or collaborate with government agencies to help educate the media and the public and to develop the public policy that relates to nutrition education and misinformation (USDHHS, 2005).

3. The role of media and journalists

Consumers report the media as their most frequent source of food and nutrition information. Collaboration between dietetics professionals and the media is key to consumers receiving science-based information about nutrition issues. This is one important function served by ADA spokespeople, who are credible, trained resources and are easily accessible to the media on a wide range of issues. It is through these joint efforts that the dissemination of food and nutrition misinformation can be minimized or avoided. In addition, the public's understanding of emerging nutrition science can be increased when journalistic reporting is accurate, balanced, offers a healthful skepticism, provides practical consumer advice, and presents reports that reflect sound scientific principles. One way of addressing this is in the manner that nutrition studies are interpreted and in the way in which they are reported. Dietetics professionals can proactively educate the media about extremist groups that routinely distort food and nutrition information to promote an ideology or to further an activist agenda (Wolfe and Dana, 2004) [47].

4. The role of researchers

Researchers should describe their study findings in a broader context to help readers understand the connection with studies that have the same or different outcomes. Researchers should lay the groundwork for ensuring that their findings are presented accurately by underscoring the difference between correlation and causation and by noting the context of the results and what size dose (or serving) would be optimal for what type of effect. They should also emphasize the limitations of the findings, how they relate to contrary findings, and the populations with whom they would be effective. Knowing the basic biases of journalists and the shortcuts they are likely to take in reporting research results can be useful for researchers in their interviews. Researchers should communicate findings in a manner that does not lose the context of the findings and the implications for consumers (GFSI, 2002) [24].

5. The role of the food and supplement industry

The food and supplement industry can be the dietetics professional's ally for providing complete and reliable food and nutrition information to the public. The food industry can help consumers understand emerging nutrition issues by providing accurate information. Many food companies employ dietetics professionals for their expertise in nutrition issues, communications, and consumer affairs. Dietetics professionals need to continue to work with the food industry to help shape the public's food choices, knowledge of nutrition and health, and ability to think more critically about food and nutrition issues. Partnerships between the food industry and health-focused associations, such as the *Home Food Safety: It's In Your Hands* campaign, can communicate positive, simple, impartial, and consistent health messages for consumers (GFSI, 2002) [24].

6. The role of consumers

Consumers need to recognize qualified dietetics professionals as credible resources for food nutrition information who can help consumers make sound decisions that match their personal needs. One important skill is knowing how to access credible information through ADA's Web site or other reputable Web sites. Many consumers may not be aware that food and nutrition misinformation exists. Consumers need to scrutinize product claims and the qualifications of the source providing the food and nutrition information. Additional information can be obtained by contacting local hospitals or universities for local resources and by contacting ADA, whose Web site not only offers consumers a referral service to registered dietitians but also provides sound nutrition information on timely issues (ADA, 2002).

Nutrition and Food Fraud

Nutrition and food fraud globally is one of the most active food industry and regulatory issues. Food companies and agencies regardless of a traditional focus on public health risks are being held accountable by consumers and agencies for food fraud prevention. This has been a major government focus in the European Union, United Kingdom, China and while there has been focus on food safety issues within the Food Safety Modernization Act there are clear food fraud compliance requirements, the USA. Beyond the potentially catastrophic economic impact of a recall or manufacturing shut-down, corporate officials are being held personally criminally liable for incidents. The prosecution has shifted from liability for the corporation to criminal incarceration for corporate leaders such as for Peanut Corporation of America and Jenson Brothers (GFSI, 2014). For these and many reasons discussed below there has been an intense focus on food fraud research and specifically on prevention.

For Food Scientists and Technologists, the most applicable and complex aspect of food fraud is product authentication and integrity testing (IFIC, 2002). The value of those tests and methods should be judged by the contribution to reducing the fraud opportunity, i.e. the overall food fraud prevention. It is said that we will not test our way to safety and we will not arrest our way to prevention. The research justification for this Scientific Information Bulletin (SIB) is to provide an overview of food fraud vulnerability and prevention so Food Science and Technology can be most efficiently and effectively applied (SIB, 2003).

Definitions and Types of Nutrition Fraud

Food and nutrition fraud is illegal deception for economic gain using food. The broad types of incidents include

adulterant-substances (including dilution, substitution, concealment, etc.), tampering, theft, diversion or gray market, over-runs or unauthorized production, simulations and intellectual property rights counterfeiting (Table 1) (ADA, 2012). A 2016 Michigan State University survey reinforced the broad scope of food fraud when over 50% of survey respondents prioritized adulterant-substances, tampering, theft, and counterfeiting. A challenge is that other than adulterant-substances the countermeasure and control systems are outside of food science authenticity or integrity testing. While the greatest health hazard is usually from adulterant-substances and counterfeits, to prevent the fraud act by a human actor, the most efficient focus is on reducing the fraud opportunity. Food Fraud (intentional, no harm) is one type of food risk along with Food Quality (unintentional, no harm), Food Safety (unintentional, harm), and Food Defense (intentional, harm) (ACFE, 2015) [1]. The interrelation can be explained using the Food Risk Matrix (Figure 1). To be most efficient from a business process standpoint – to thoroughly manage and counter all types of risks, it is most efficient to assign an accountable person to each cell in the matrix and to assign each incident to a specific cell. This may seem intuitive but this process is only recently being researched and implemented (Andrews *et al.*, 2013) [2].

Fig 1: Food Risk Matrix used to differentiate Food Quality, Food Safety, Food Fraud and Food Defense

Food Quality	Food Fraud	Motivation: Economic Gain
Food Safety	Food Defense	Harm including health, economic, terror
Unintentional	Intentional	Food Risk Matrix

Source: (ACFE, 2015) [1]

There is a seemingly limitless list of types of adulterant-substances but they are all used to exploit essentially a basic fraud opportunity. The fraud opportunity exists for adulterant substances since there is the ability to deceive authentication or integrity tests. The fraudsters have exhibited tremendous ingenuity and efforts to avoid detection. Also, if the risk of getting caught or the cost of conducting the crime is too high, the fraudsters innovate. For example, rather than utilizing complex and covert manufacturing operations, many fraudsters have switched from counterfeiting to stolen goods. Food is now the largest dollar value of cargo theft in the USA "food and drink are the most stolen type of freight since 2008. The adaptation to stolen goods creates a problem for authenticity and integrity tests because the products are defined by the US Food, Drug & Cosmetics Act as 'Adulterated Foods', unfit for commerce and subject to a recall. The stolen goods are 100% genuine. Authenticity tests could not identify the stolen goods (ACFE, 2015) [1].

Table 1: Nutrition and Food Fraud Types, Definitions, and Examples

Term	Definition	Example
Adulteration (adulterant substance)	A component of the finished product is fraudulent; substance or an impurity	Melamine added to milk
Tampering/Labeling/Expiration	Legitimate product and packaging are used in a fraudulent way. Includes mislabeling.	Changed expiry information, product up-labeling, religious designation, etc.
Over-run and Unauthorized Production	Legitimate product is made in excess of production agreements	Under-reporting of production
Theft	Legitimate product is stolen and passed off as legitimately procured	Stolen products are comingled with legitimate products.
Diversion or Gray Market	The sale or distribution of legitimate products outside of intended markets. Includes smuggling	Relief food redirected to markets where aid is not required
Simulation	Illegitimate product is designed to look like but not exactly copy the legitimate product	"Knock-offs" of popular foods not produced with same food safety assurances
Counterfeiting	Intellectual Property Rights (IPR) infringement, that could include all aspects of the fraudulent product and packaging being fully replicated	Copies of popular foods not produced with same food safety assurances

Source: (ACFE, 2015; ADA, 2013)

Review of Incidents and Foods Commonly Misinformed

While food fraud has been recorded since the Chinese Zhou Dynasty (1046 to 256 BC) (Chen, 2015) [5], there has been a lack of strategic or holistic approach to prevention. Throughout history there has been a priority on public health risks such as food borne illness and deaths. When an agency such as the US Food and Drug Administration takes a 'public health, risk-based approach' traditional food safety incidents would be a much more dangerous threat than from food fraud. The vast majority of food fraud incidents do not have a public health threat. Food safety incidents are a much bigger health hazard for societies (Wolfe and Dana, 2004) [47].

Several megatrends have led to food fraud becoming more of a recognized threat. Globalization has led to more products moving faster around the world. Globalization has enabled the economically viable manufacturing scale to increase so some facilities make more and more product. At the same time, traceability allows more transparency of the providence or source of the product. This combined with the advanced detection technology and dissemination of higher

powered testing equipment has led to the more accurate identification of the source of anomalies (Chen, 2015).

Before reviewing food fraud incidents, it is important to review how food is determined to be 'safe.' The 2013 SIB on Safety, Risk, and the Precautionary Principle provided several key concepts that apply to food fraud prevention and vulnerability. Quotes from that SIB include

- "'Safety' literally means complete absence of risk. Nothing in life is entirely risk-free, and indeed science cannot demonstrate freedom from risk, particularly from as yet unknown risks, because 'absence of evidence' is not 'evidence of absence.' Science cannot know, and can never know; all there is to know about any topic."
- "So any policy purportedly based on requiring science to prove safety is unrealistic. In practice, therefore the purpose must be to achieve absence of unacceptable risk or, to use a term borrowed from the World Trade Organization "an appropriate level of protection" (ALOP)."
- "What constitutes ALOP is determined by legislators in the form of laws and regulations, although a manufacturer may choose to operate stricter standards than the law requires."
- "For practical purposes, references to 'safety' and 'safe' in this Bulletin should be interpreted as meaning achieving ALOP."

Essentially for food safety, finished products and ingredients are tested for the biological, chemical, and physical agents that most often lead to unsafe foods. Food is not tested to be 'safe' it is tested to make sure it does not contain agents at levels that most often lead to unsafe food or that do not meet the ALOP. Considering that, it is not surprising that a focus on identifying or avoiding specific unacceptable adulterant-substances does not stop food fraud. If the fraudsters do not know detection tests are being conducted then these countermeasures may not lead to prevention (Wolfe and Dana, 2004) [47].

Several of the most influential food fraud incidents are reviewed here

1. Sudan red colorant

It was generally around 2003 that this became a food fraud concern (Clarke and John, 2005) [6]. The colorant is illegally used to brighten spices and sauces, which is more appealing to consumers. This was a global incident that raised the awareness that food fraud could be a wide-spread public health and economic incident.

2. Melamine in Infant Formula and Skim Milk powder

Melamine had occasionally been found in foods but there was a low public health concern until this outbreak generally around 2007. The US Pharmacopeia Food Fraud Database reported melamine adulterant-substances as early as 1980 (Wolfe and Dana, 2004) [47]. Melamine, when combined with other contaminants, created the health hazard. Once melamine was identified and tested there was a realization of a very wide-scale threat that was throughout Asia. Melamine is a plasticizer used in plastics production and there should not be any appreciable or dangerous amount in foods. The amount of melamine that would migrate or leach from plastic packaging would not create the contaminant levels for this type of illness (Chen, 2015) [5].

3. Melamine in Pet Food

Also generally in 2007-2008, melamine and the contaminants were found in wheat gluten used in pet foods (ACFE, 2015) [1]. At the start of the intervention, the challenge was to even just figure the root cause of the illnesses and deaths. As with infant formula and milk powder, melamine was never expected to be in the foods at elevated levels.

4. Horsemeat in Beef

Generally, in 2012, horsemeat was found to have been illegally substituted in beef (Wolfe and Dana, 2004) [47]. A routine quality control test in Ireland found horsemeat that led to world-wide testing and recalls. Horsemeat was found to be substituted in a wide-range of products. While there was considered to generally be no public health threat the consumer and recall impacts on the industry were near economically catastrophic for the company, meat industry, food industry, and the UK economy. Some species or process – substitution also has religious concerns regarding the preparation or handling (BBC, 2015) [4].

5. New incident reports

Over time, more incidents have just reinforced that food fraud is a constant issue that must be addressed. The range of issues include: peanut husk filler in cumin, species swapping in fish, fillers in oregano, extra virgin olive oil fraud, and others (Wolfe and Dana, 2004) [47]. In certain cases, such food fraud could be catastrophic, for example, where a substituted ingredient results in a severe allergic reaction. The horsemeat scandal was the incident that led to the UK/DEFRA funded Elliott Review which recommended the creation of the UK National Food Crime Unit (BBC, 2015) [4] Also, this incident accelerated the activity of the Global Food Safety Initiative (GFSI) to expand their Food Safety Management System to specifically and uniquely cover food fraud (GFSI is a consortium of food companies focused on creating a harmonized Food Safety Management System and certification which followed the recommendation of their Food Fraud Think Tank) (GFSI, 2014)

Interdisciplinary Approach

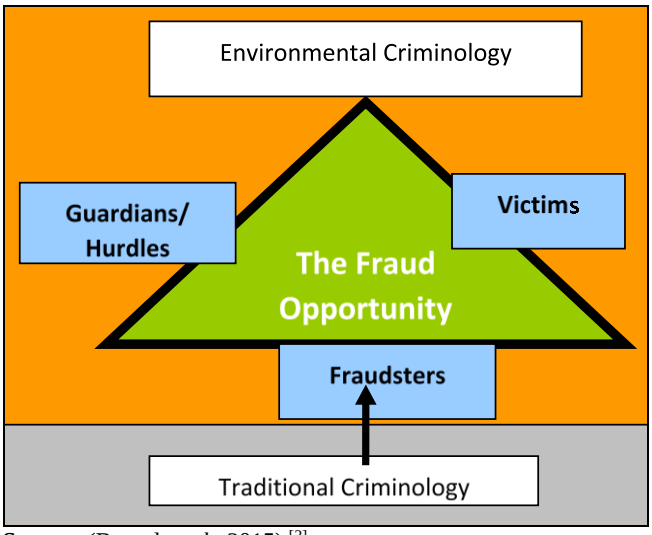
An interdisciplinary approach is recommended by the likes of the UK Elliott Review, EU, China, the USA, and the GFSI (GFSI, 2002) [24] It has been said that "if the biological organism in question is a microbe it is most efficient to engage the field of microbiology; since the biological organism in question is a human, and therefore, it is most logical to engage the field of Social Science and specifically Criminology (GFSI, 2014).

Criminology theory helps to understand the root case and how to focus preventing the crime. A wide range of other disciplines must be engaged to understand the fraud opportunity including supply chain management, food science authenticity testing, countermeasures such as from packaging science, information technology for traceability, decision-sciences and risk analysis to assess the vulnerability, and then business decision-making such as Enterprise Risk Management (EC, 2015)

Food Fraud Prevention

Food fraud prevention starts with criminology and the motivation of the human actor. Criminology prevention

considers broad system that covers the entire market or physical environment (Clarke and John, 2005) [6]. The Criminology theories are Situational Crime Prevention (the space of crime), Routine Activities Theory (what other actions are criminals conducting), and Rational Choice Theory (why do the criminals think they can get away with this crime). Environmental Criminology considers the space of crime whereas Traditional Criminology considers the psychology of the criminal. Another set of theories approaches food fraud not from a Criminology standpoint but from Business Fraud. It is sometimes confusing that both theories include a triangle: The Crime Triangle and the Fraud Triangle. Also, over time, each of these theories has evolved to more complex triangles. The Association of Certified Fraud Examiners defines the Fraud Triangle with the three legs to be: pressure (on the individual), opportunity and rationalization (Wolfe and Dana, 2004) [47]. This is sometimes expanded to a diamond adding a component of capability of the fraudster. The original and basic Crime Triangle is based on Situational Crime Prevention and Routine Activities Theory. This considers that the 'crime opportunity' is defined by: victim, criminal and absence of a capable guardian. Adapted to food fraud, the fraud opportunity is determined by: victim, fraudster and guardian and hurdle gap (Figure 2) (GSIF, 2014).



Source: (Bansal *et al.*, 2015) [3]

Fig 2: Situational Crime Prevention applied to Food Fraud in the Crime Triangle

The movement of so many products so far around the world also creates a new and expanding fraud opportunity. As the melamine in pet food incident demonstrated, one incident can very quickly impact product around the world. As the horsemeat in beef scandal demonstrated, one rogue supplier can cripple an entire industry.

Food Fraud Prevention Strategy

Many governments are requiring that food fraud hazards be assessed and control plans be put in place to manage those hazards. Specifically addressing food fraud is new so there naturally are not too many details or prescribed regulatory compliance requirements. Beyond the massive economic loss to industry for incidents such as melamine or horsemeat, individuals are being held criminally liable. While there may be few compliance requirements, companies – and their individual leaders – are being held criminally liable for incidents. For example, the CEO of Peanut Corporation of America was sentenced to over 30 years in US Federal prison for his role in a food fraud incident (Clarke, 2005) [6]. Also, five other company employees received US Federal prisons sentences of at least five years. Regardless of the current or future regulatory compliance requirements, to maintain a viable business companies must reduce their fraud opportunity. The increase in the awareness of the economic impact of food fraud coincided with the advancing academic focus on proactive prevention. Taken together, the food industry has taken a very proactive and active approach to address food fraud (Wolfe and Dana, 2004) [47].

Conclusion

Misleading claims about food and nutrients are difficult to control, as a consumer you should evaluate the accuracy of nutrition claims. Food is not magic and is not a cure all. Therefore, been a well-informed consumer is your best defense against nutrition misinformation and fraud. Food and nutrition fraud is an important and evolving food industry focus. Even though the vast majority of these incidents do not have a health hazard in some ways they are more dangerous because the substances and actions are unknown and untraceable. The types of food fraud stretch the traditional role of food science and technology to include criminology, supply chain traceability and other control systems. The food authenticity and integrity testing will be the most complex actions and their value should be assessed in terms of the contribution to prevention. Food and nutrition fraud identification and prevention is complex not only in the analytical methods of detection but in the interdisciplinary applicable theory. Because there is usually no health hazard, the traditional detection and alert systems often do not detect food and nutrition fraud. The key actions in reducing the fraud opportunity are to identify, deter, and prevent. (Wolfe and Dana, 2004) [47]. The effort to identify or authenticate will always be the most scientifically complex and challenging. Although identification is the most complex the first step should be considering how to prevent, and how to reduce the fraud opportunity. Once the specific human criminal acts and methods are understood, efficient and effective countermeasures and control systems can be defined. The role of food science and technology will be in developing the specific tests and methods that prevent. In some cases, more technology is not needed. In other instances, the authentication challenges will be so great or costly that the solution is that other countermeasures or control systems will need to be employed (ACFE, 2015) [1].

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