Natural Hazards
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Dietary pattern recognition on Twitter: a case example of before, during, and after four natural disasters

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Abstract

Little is known about what foods/beverages (F&B) are common during natural disasters. The goal of this study was to track high-frequency F&B mentions during four hurricanes affecting the coast of South Carolina for quantifying dietary patterns in Twitter. A listing of common F&B ($n = 173$) was created from the top food sources of energy, fat, protein, and carbohydrate in the USA. A sampling of > 500,000 tweets containing hashtag names (e.g., #HurricaneFlorence) or actual names (e.g., "Hurricane Florence") of the four hurricanes was collected using Crimson Hexagon. ANOVA was used to examine differences in number of mentions in each food group pre- (6 days before), during (48 h of the hurricane), and post-hurricane (6 days after). Descriptive statistics were used to examine the most frequently mentioned F&B (threshold defined as ≥ 4 mentions/day for each F&B item or 10% of the foods mentioned) and whether F&B were top sources of energy/macronutrients. More than 5000 mentions of F&B were collected in our sample. Grains were the most frequently mentioned food group pre-hurricane, and dairy was most frequently mentioned during the hurricanes. The top five most commonly mentioned F&B overall were milk ($n = 517$), pizza ($n = 511$), turkey ($n = 425$), oranges ($n = 384$), and waffles ($n = 346$). Foods mentioned were commonly energy and protein dense. Five foods (pizza, waffles, milk, rolls, and bread) were categorized as a top contributor across energy and all three macronutrients. Social media may be a unique way to detect dietary patterns and help inform public health social media campaigns to advise people about stocking up on healthy, non-perishable foods ahead of natural disasters.

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1 Introduction

Every day, millions of users post messages on social media platforms, such as Twitter, Facebook, or Instagram (Smith 2019). While Facebook remains the most popular social media platform in the USA, all social media platforms have seen increased usage over the past decade, including Twitter (Smith and Anderson 2018). Nearly a quarter of all internet users are also Twitter users (Smith and Anderson 2018). Twitter is an online social networking platform that lets users submit posts that are 280 characters or less. Twitter, which has been in existence since 2006, has emerged as a powerful research tool for both behavioral interventions and for observational data collection of human behaviors (Sinnenberg et al. 2017). This research has included using Twitter as a source of data and using Twitter to recruit and/or intervene on participants (Sinnenberg et al. 2017).

The purpose of this study was to utilize Twitter as a way to assess dietary patterns before, during, and after four natural disasters, including Hurricane Matthew 2016, Hurricane Irma 2017, Hurricane Florence 2018, and Hurricane Michael 2018 that affected South Carolina and surrounding areas. The search was limited to these four major storms affecting a similar geographical area in order to control for potential regional food preferences. These storms caused significant financial and structural damage. For example, Hurricane Florence caused an estimated $24 billion in damages to Virginia, North Carolina, and South Carolina when it made landfall on September 14, 2018 (Duncan 2019). Because of the widespread impact of these hurricanes and the need for preparation efforts ahead of landfall, hurricanes represent an opportune event to study the use of Twitter to detect dietary patterns and food mentions before, during, and after a natural disaster.

One area of Twitter-based research is characterized by health-related and behavioral topics, including nutrition and other food-related subjects (Sinnenberg et al. 2017). Twitter has been used to identify food-borne illness reports and then encourage individuals to report these illnesses (Harris et al. 2017). Twitter has also been used to examine characteristics of the neighborhood food environment (Nguyen et al. 2017), the relationship between obesity rates and geo-coded Twitter posts related to food intake (Gore et al. 2015), the context in which food choices are made (Vidal et al. 2015), the topics posted related to diet, diabetes, exercise, and obesity (Karami et al. 2018), or how certain food topics are discussed (Kuttschreuter and Hilverda 2019). In addition, researchers have examined what factors make Twitter messages about healthy eating more likely to be re-tweeted and shared across social networks (Zhou et al. 2018). Twitter has also been used to help users track food intake and examine the relationship between dietary and behavioral factors (Hingle et al. 2013).

Another area of Twitter-based research focuses on the use of the platform during natural disasters (Karami et al. 2020; Guan and Chen 2014). Twitter was widely used as a way to disseminate crisis information during Hurricane Sandy (Wang and Zhuang 2017) and was one of the most discussed topics on Twitter, with 34% of all posts to Twitter during the 3 days around the storm being related to the hurricane (Heimlich 2012). In addition, Twitter was used to communicate time-sensitive and critical information during a historic flood that happened in the Midlands of South Carolina in 2015 (Brandt et al. in press; Karami et al. 2019). Communities affected by natural disasters have come to rely on social media as a way to exchange information about rescue and recovery efforts (Finch et al.

2016; Guskin and Hirtline 2012; Wang et al. 2016; Xiao et al. 2015). In addition, social media has been used to help victims, mobilize volunteers, and allow community members to communicate efficiently during both natural disasters and human-made or terrorist situations (Bennett 2014; Scott and Errett 2018; Sutton et al. 2015). It can also be used to spread misinformation during times of crisis (Wang and Zhuang 2018).

There are important food and beverage (F&B) guidelines that should be followed before, during, and after a natural disaster, such as a hurricane. The Centers for Disease Control and Prevention (CDC) recommends that people have five gallons of water per person on hand in preparation of a hurricane (CDC 2017). Specifically related to food, the CDC recommends having non-perishable food on hand, that has a long shelf life, requires little to no cooking or refrigeration and is low salt and not spicy (CDC 2019). Alcohol intake may increase during stressful events, like hurricanes, and because alcohol impairs judgement, the CDC recommends alcohol be avoided during natural disasters (CDC 2014). The previous research has shown that alcohol usage also tends to increase post-hurricane among those who have survived a hurricane (Flory et al. 2009). News articles in hurricane-prone areas have urged people not to overindulge in alcohol during storms, since hurricane parties (a practice of hosting parties, often involving alcohol consumption during a hurricane) are common (Dedaj 2017). In addition, popular press articles have urged people to stock up on healthy food to have on hand for a hurricane (Laseter 2018).

This study had two primary objectives. The first objective of this study was to develop a way to quantify food patterns in order to assess which foods were mentioned on Twitter and which are major contributors of energy and macronutrients. The second objective was to examine which foods and associated sources of energy and macronutrients were most frequently mentioned before, during, and after four natural disasters.

2 Materials and methods

Figure 1 details how F&B were collected, organized, and analyzed. The first step in this project was to develop a list of common food groups, foods that could be categorized into each food group, and then categorize those foods into the top F&B sources of energy, protein, fat, and carbohydrate in the USA. In order to develop this list, information detailing the top F&B sources of energy and macronutrients using National Health and Nutrition Examination Survey (NHANES) data for adults aged 19 years and older was used (O'Neil et al. 2012). In order to categorize mentions of F&B on Twitter into common food groups, the 10 food groups listed in the O'Neil et al. (2012) article were used. The 10 food groups

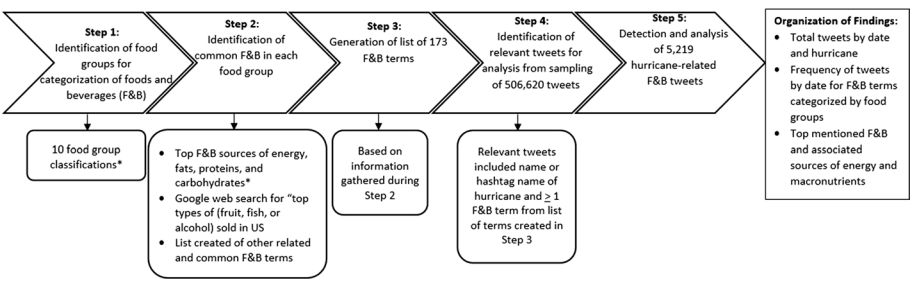

Fig. 1 How foods and beverages were collected, organized, and analyzed

were grain products; vegetables; fruit; dairy products; meat, poultry, and fish; eggs, legumes, nuts, and seeds; fats and oils; desserts and sweets; beverages; and other foods (e.g., condiments, broth, salt) (O'Neil et al. 2012). Next, the top 15 F&B sources of energy and macronutrients were used for analysis (with the exception of protein, which only had 12 top sources listed) (O'Neil et al. 2012). In order to ensure a variety of foods mentioned for a particular food group was captured, a list of other common names for the foods listed was developed. For example, a list of other common words was developed for broad food terms listed in the article like beef (e.g., created additional Twitter search terms such as hamburger, burger, and steak), poultry (e.g., chicken and turkey as additional terms), and pastry (e.g., donut, doughnut, and Danish as additional terms). In particular, three terms were very broad food categories (fruit, fish, and alcohol). In order to develop a comprehensive list of terms that could be used for those food categories, we conducted a Google web search for "top types of (fruit, fish, or alcohol) sold in the US." Those web search results helped to complete a more comprehensive list of potential terms (e.g., instead of just searching for fruit, we also included bananas, apples, grapes, strawberries, oranges, etc.). This resulted in a list of common F&B items consumed in the USA that were top contributors to energy, protein, fat, and/or carbohydrate.

In order to examine food mentions during the hurricanes, a sampling of 506,620 tweets were collected during the 6 days before and after and 2 days during the hurricanes using a Twitter data provider, Crimson Hexagon (https://www.crimsonhexagon.com/) (see Table 1). For example, Hurricane Florence made landfall on September 14, 2018, so for that hurricane, pre-hurricane tweets were collected from September 8–13, during hurricane tweets were from September 14–15, and post-hurricane tweets were from September 16–21. Tweets needed to contain either the hashtag name for the hurricane (e.g., #HurricaneFlorence) or could contain the name of the hurricane (e.g., "Hurricane Florence"). A list of 173 F&B terms and their food group categories was created, along with possible plural versions of any food name that could commonly be plural (e.g., both pizza and pizzas were searched). Next, those tweets that contained a mention of one of the 173 F&B terms were collected, and frequency of tweets by date for each food term was categorized. This process was conducted using R Statistical Software (RCoreTeam 2014). Total posts during each time point (overall, pre-, during, and post-hurricane) were examined. In order to assess F&B and associated sources of energy and macronutrients with higher levels of mentions, a threshold was defined as ≥ 4 mentions/day for each F&B item or 10% of the

Table 1 Number of total tweets for each hurricane with either the hashtag name (e.g., #HurricaneMatthew) or regular name (e.g., Hurricane Matthew) the 6 days before, the 2 days during, and the 6 days after each hurricane and for overall

Hurricane	Number of Tweets			
	Before	During	After	Total
Matthew, 2016	59,442 (October 2–7)	19,433 (October 8–9)	49,529 (October 10–15)	128,404
Irma, 2017	52,244 (September 4–9)	17,281 (September 10–11)	54,180 (September 12–17)	123,705
Florence, 2018	56,071 (September 8–13)	17,419 (September 14–15)	54,599 (September 16–21)	128,089
Michael, 2018	49,699 (October 4–9)	20,000 (October 10–11)	56,723 (October 12–17)	126,422
Total	217,456	74,133	215,031	506,620

foods mentioned. This approach allowed for a focus on the most commonly mentioned foods and to attempt to limit counting mentions of foods that might have been infrequently tweeted, but were unrelated to food (e.g., I hope this weather "rolls" through quickly). Table 2 provides a list of example search terms for the ten food and beverage (F&B) categories along with example tweets.

2.1 Statistical methods

A one-way ANOVA with Tukey's follow-up post hoc test was conducted in order to examine differences in mean mentions of foods and beverages in category (±SD) examining total posts and posts made pre-, during, and post-hurricane, regardless of threshold. A P value of <0.05 was used to indicate statistical significance. Descriptive statistics were used to examine the top most frequently mentioned foods and beverages (that met the ≥4 mentions/day threshold) and whether those foods and beverages were top sources of energy or macronutrients.

3 Results

In our sample, 5219 mentions of foods and beverages were detected. Table 3 shows the total mean (±SD) mentions of foods and beverages by food group category over the entire study period (14 days) as well as pre-hurricane (6 days before), during hurricane (48 h of the hurricane), and post-hurricane (6 days after the hurricane). While there were no significant differences among the F&B categories for total mentions ($P=0.12$) or mentions after the hurricanes ($P=0.50$), there were significant differences in food group categories tweeted pre- and during the hurricanes. Pre-hurricane, there were significantly more posts categorized as grains than those categorized as vegetables, meat/poultry/fish, eggs/legumes/nuts/seeds, or other (P's all <0.05). During the hurricanes, there were significantly more posts categorized as dairy than all other food groups ($P<0.05$). Figure 2 details the frequency of mentions within each food group category by day examined (each of the 6 days before and after the hurricanes and the 2 days during).

Considering the threshold of examining only those F&B that had ≥4 mentions per day, there were 13 F&B mentioned pre-hurricane, 18 during the hurricane, and 21 post-hurricane. Number of foods mentioned within each F&B group category was also examined. Three out of the 10 categories did not have F&B mentioned over the course of the entire examined period that met the ≥4 mentions per day threshold (vegetables, desserts and sweets, and items categorized as other). Another two food group categories had only one food or beverage item mentioned within that category. For dairy, only milk was mentioned ($n=517$) with no mentions of other dairy foods, such as cheese, and for fats and oils, only oil was mentioned ($n=135$). Of the remaining five food group categories, grains had five commonly tweeted foods (pizza, waffles, spaghetti, rolls, bread, $n=1735$), fruit had two commonly tweeted foods (apples and oranges, $n=505$), meat/poultry/fish had five commonly tweeted foods (catfish, chicken, fish, poultry, and turkey, $n=880$), eggs/legumes/nuts/seeds had two commonly tweeted foods (eggs and peanuts, $n=237$), and beverages had four commonly tweeted items (beer, coffee, alcohol, and wine, $n=515$). Figure 3 displays a word cloud (Heimerl et al. 2014) of the most commonly tweeted F&B overall. The top five most commonly mentioned F&B overall were milk ($n=517$), pizza ($n=511$), turkey ($n=425$), oranges ($n=384$), and waffles ($n=346$). Pre-hurricane, the top five foods

Table 2 Specific search terms and example tweets for the ten food and beverage (F&B) categories

	Example F&B search terms					Example tweets
Grains	Flour Bran Bread Rolls Cereal	Rice Pasta Biscuit Biscuits Pancake	Pancakes Cracker Crackers Popcorn Pretzel	Pretzels Chips Pizza Pizzas Cornbread	Oatmeal Waffle Waffles Spaghetti	When a tree falls on your fence in the backyard because of #HurricaneMichael, you forgo cooking dinner and order pizza. Happy Thursday!
Vegetables	Potato Potatoes Broccoli Spinach Squash Tomatoes	Tomato Lettuce Green bean Green beans Corn Peas	Lima bean Lima beans Olive Olives Pickle	Pickles Vegetable Vegetables French fries Wax bean	Wax Beans Yellow bean Yellow beans String bean String beans	We cannot run out of potato salad again. #FEMA #HurricaneIrma #TheRingOfFire
Fruit	Juice Fruit juice Fruit Smoothie Banana Bananas Apple	Apples Grapes Grapes Strawberry Strawberries Orange Oranges	Watermelon Watermelons Lemon Lemons Blueberry Blueberries Peach	Peaches Cantaloupe Cantaloupes Avocado Avocados Pineapple Pineapples	Cherry Cherries Pear Pears Lime Limes	Thought I'd stop at the grocery store and pick up some apples on my way home… Nope. (#HurricaneMatthew)
Dairy products	Milk Yogurt	Cheese Cheeses	Chocolate milk	Cheez whiz	Velveeta	Hurricane shopping in SC. Where not only do people snatch up bread, milk, eggs, and water, but spaghettios and Vienna sausages. #HurricaneFlorence #southcarolina #hurricanesupplies #groceries #chs #Florence #hurricaneSeason2018 #HurricaneSeason #EastCoast #Atlantic

Table 2 (continued)

	Example F&B search terms					Example tweets
Meat, Poultry, Fish	Beef Lamb Veal Pork Ham Bacon Organ meat Organ Meats	Frankfurters Sausage Luncheon Meat Poultry Fish Shellfish Burger Hamburger	Steak Steaks Liver Hot dog Baloney Bologna Chicken Tuna	Shrimp Turkey Salmon Lobster Pastrami Tilapia Scallops	Salami Pollock Crab Pepperoni Catfish Clams Cod	Ugh, here we go again…people stupid insane raiding stores for milk, eggs, bread, water, and gasoline. Went to get hamburger buns for lunch and bacon and eggs for breakfast then refill lawnmower can—I found one gas station half sold out and WalMart insane. #HurricaneFlorence
Eggs, legumes, nuts, and seeds	Egg Eggs Legume Legumes Bean Beans	Tofu Soy Tempeh Edamame Veggie burger Nut	Nuts Peanut Peanuts Peanut butter Almond	Almonds Almond butter Cashew Cashews Seed	Seeds Sunflower Seed Sunflower Seeds Flaxseed Chia seed	Bought bread, tuna, and peanut butter. Better safe than sorry ____ #HurricaneFlorence #chswx
Fats and oils	Margarine	Butter	Salad dressing	Mayonnaise	Oil	*Covers house in coconut oil #HurricaneMatthew
Desserts and sweets	Cake Cakes Cookie Cookies	Quick bread Pastry Pastries Pie	Pies Milk desserts Candy Candies	Banana bread Donut Doughnut Danish	Danishes Ice cream Chocolate Frozen yogurt	This just in the cookies i made are delicious #HurricaneMichael
Beverages	Fruit drink Ades Coffee Tea	Kool-aid Gatorade Powerade Alcohol	Beer Beers Wine Liquor	Vodka Tequila Rum Gin	Whiskey Cognac Bourbon	Went to check on my local grocery stores in #ClaytonNC. Out of all water, sweet tea and most juice. #hurricaneflorence #ncwx
Other foods	Meal-replacements Soup Soups Broth	Condiments Sauce Sauces Whey	Artificial Sweeteners Salt Slim-fast Mustard	Marinara Splenda Ketchup Barbecue	Nutri-sweet Salsa Stevia	RT @jacqatitagain Everyone: *grabs bread and milk for hurricane prep* Me: *grabs chips and salsa* #HurricaneFlorence

Table 3 Mean total mentions on Twitter before, during, and after Hurricanes Florence, Michael, Irma, and Matthew within ten food and beverage (F&B) categories

	Mean total mentions within each F&B category (±SD) examining the 6 days before the hurricanes	Mean total mentions within each food and beverage category (±SD) examining the 2 days of the hurricanes	Mean total mentions within each food and beverage category (±SD) examining the 6 days after the hurricanes	Mean total mentions within each food and beverage category (±SD) examining all posts pre, during, and post-hurricane
ANOVA model significance	$F=2.79$; $P=0.005$	$F=3.11$; $P=0.002$	$F=0.93$; $P=0.50$	$F=1.61$, $P=0.12$
Grains	27.4 ± 46.5	7.8 ± 14.9[b]	41.1 ± 105.2	76.3 ± 138.5
Vegetables	1.1 ± 2.3[a]	0.4 ± 0.7[b]	3.7 ± 7.6	5.1 ± 8.7
Fruit	9.5 ± 25.7	6.5 ± 17.8[b]	16.5 ± 42.2	32.2 ± 85.1
Dairy products	9.7 ± 19.5	73.8 ± 179.9	5.0 ± 10.8	88.5 ± 210.0
Meat, poultry, fish	3.7 ± 6.5[a]	3.3 ± 7.0[b]	24.2 ± 65.7	31.2 ± 76.2
Eggs, legumes, nuts, and seeds	3.7 ± 6.5[a]	0.7 ± 1.2[b]	11.5 ± 35.5	15.8 ± 41.1
Fats and oils	16.6 ± 32.3	1.6 ± 3.1[b]	15.4 ± 23.8	33.6 ± 58.5
Desserts and sweets	4.3 ± 6.4	0.7 ± 1.6[b]	6.6 ± 8.4	11.6 ± 13.5
Beverages	15.7 ± 26.1[a]	4.4 ± 8.8[b]	14.6 ± 27.3	34.7 ± 54.0
Other foods	2.1 ± 5.0	0.7 ± 2.3[b]	3.3 ± 6.7	6.1 ± 12.5

[a]Significantly different from grains ($P<0.05$)

[b]Significantly different from dairy ($P<0.05$)

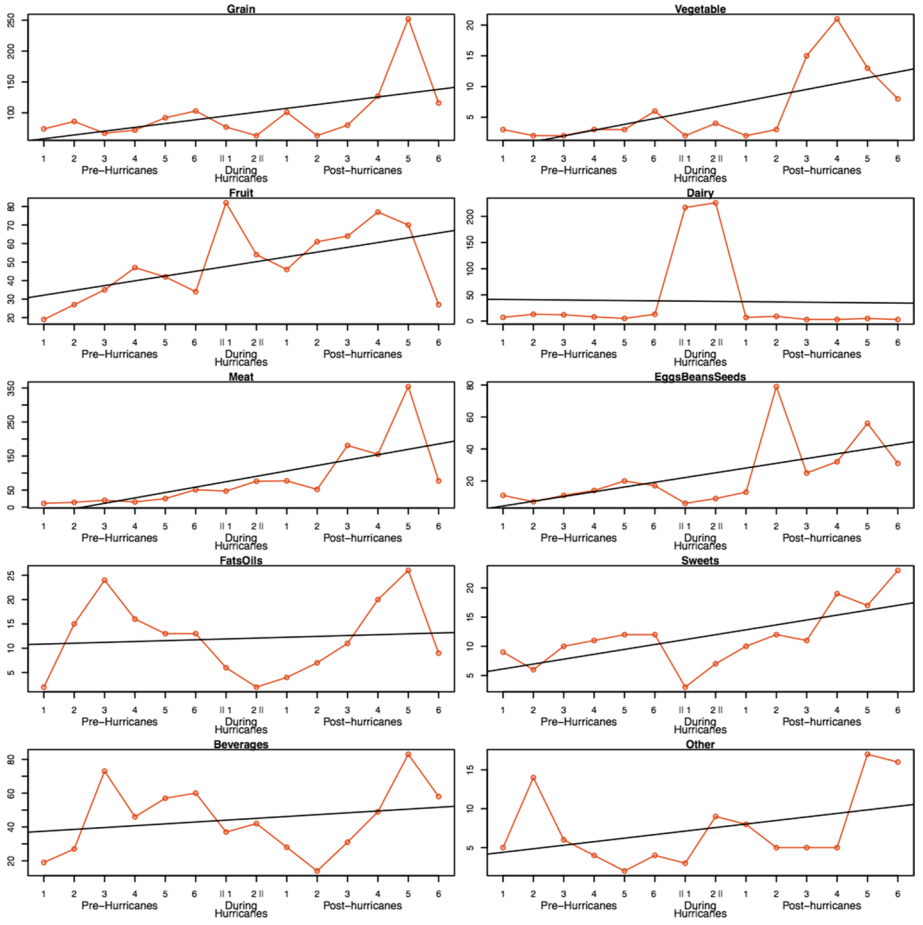

Fig. 2 Frequency of mentions within each food group category by day examined

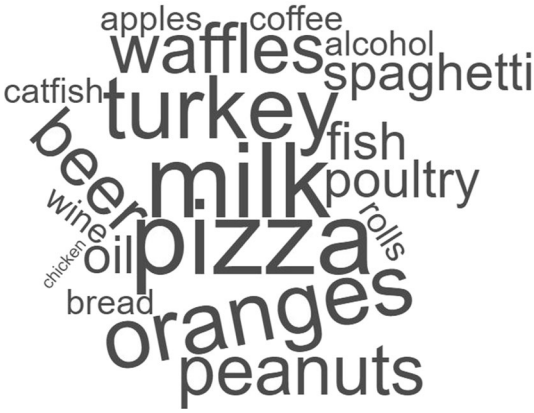

Fig. 3 Word cloud of the most commonly tweeted foods and beverages overall

mentioned were mostly grain-based foods: waffles ($n=142$), oranges $n=117$), spaghetti ($n=117$), bread ($n=96$), and rolls ($n=79$). During the hurricanes, the top five foods mentioned were milk ($n=441$), oranges ($n=75$), pizza ($n=46$), waffles ($n=43$), and apples ($n=38$). Top five food mentions post-hurricane were pizza ($n=436$), turkey ($n=377$), oranges ($n=192$), waffles ($n=161$), and peanuts ($n=158$).

Lastly, we examined whether the F&B meeting the ≥ 4 mentions per day threshold were major contributors to energy, protein, fat, and/or carbohydrate intake in the USA. Of the 20 F&B mentioned, 60% were top sources of energy, 60% were top sources of protein, 45% were top sources of fat, and 40% were top sources of carbohydrate. Five foods mentioned (pizza, waffles, milk, rolls, and bread) were categorized as a top contributor across energy and all three macronutrient categories; three foods mentioned (turkey, chicken, and poultry) were common across energy and two macronutrient categories (fat and protein); one food mentioned (oil) was common across energy and one macronutrient category (fat); ten foods mentioned were a contributor to just one energy or macronutrient category (energy: alcohol, beer, wine; protein: peanuts, fish, catfish, eggs; carbohydrate: oranges, apples, spaghetti). One F&B (coffee) was not a major contributor to US intakes of energy or macronutrients.

4 Discussion

When a natural disaster, such as a hurricane, is predicted to occur, it is recommended to have a supply of non-perishable, healthy food on hand in case there is a loss of electricity or an inability to leave the house to shop for food (CDC 2017). Food is a common item people cite when preparing for a natural disaster, more so than ensuring adequate water, flashlights, medications, and cash (Wang 2017). Most households have at least a three-day supply of food on hand (Der-Martirosian et al. 2014). However, very little is known about what foods or beverages people tend to purchase or consume before, during, or after natural disasters. Twitter provides a unique opportunity to examine what F&B are commonly mentioned during natural disasters. Unique to this study, assessment of food groups and major contributors of energy and macronutrients was conducted in order to examine broader dietary patterns during natural disasters. Therefore, this study also provided a unique opportunity to examine the use of Twitter to detect dietary patterns.

The present study examined mentions of various foods commonly high in energy, protein, fat, and/or carbohydrate on Twitter that were posted in conjunction with posts related to hurricanes. Results of this study indicated that foods mentioned on Twitter during four hurricanes were commonly energy and protein dense. While the present study did not find any differences in food group mentions overall or post-hurricane, there were significant differences in food groups mentioned pre- and during the hurricanes. In particular, foods categorized as grains were commonly mentioned before the hurricanes and foods categorized as dairy (mainly milk) were most commonly mentioned during the hurricanes. It is not surprising the milk and grain-based foods (particularly breads and rolls) were commonly tweeted foods before and during the hurricanes. Stockpiling milk, along with bread and eggs, is commonly reported in the media in advance of storms (CoxMedia 2018). This may be one of the reasons why milk and bread were so frequently mentioned. Additionally, pizza, which is essentially a combination of grains and dairy, was frequently mentioned over most of the time points for the hurricanes. The previous research has shown that pre-hurricane is a time when individuals may be attempting to use up perishable foods they

have in their household (Pyles et al. 2008). In addition, individuals may be purchasing non-perishable forms of foods that would usually require refrigeration ("canned milk") (Pyles et al. 2008) or purchasing cooking supplies that do not rely on electricity (charcoal grills) (Pyles et al. 2008).

While mentions of milk and bread seem to align with previous reports of food purchases prior to natural disasters, mentions of other foods were surprising. For example, apples and oranges were frequently mentioned. It is possible that people were tweeting about the color orange or Orange County, Florida, rather than the actual fruit. However, the results clearly mirrored the findings that oranges and apples are the two most commonly consumed fruits in the USA, although mostly consumed in the form of juice (USDA 2019). In addition, peanuts were frequently mentioned, particularly after the hurricanes. It is unclear whether peanuts are a common, non-perishable food people may have on hand to consume or the mentions referred to something else, such as categorizing the size of hail during a storm (Weather.gov 2019). For meat, white meat and poultry were most frequently cited as compared to red meat, such as hamburgers, sausage, or pork. While seafood consumption has decreased in the USA (Terry et al. 2018), poultry intake has been on the rise, surpassing beef intake (USDA 2019). Lastly, of the four common beverages mentioned, three were alcoholic beverages (beer, alcohol, and wine). While disaster preparation guidelines recommend avoiding alcohol and focusing on healthy, non-perishable foods (CDC 2014), the findings of this analysis show that many people indicated that they were not following this guideline when posting to Twitter. While alcohol was frequently mentioned, this may be more of a reflection of the common use of social media to discuss drinking, especially among young adults (Hebden et al. 2015; Lyons et al. 2015), than a reflection of a disproportionate intake of alcohol over other F&B groups. For example, users of social media may be more likely to post about alcohol use versus consumption of legumes.

Of all the food groups assessed in this study, vegetables had the fewest mentions. This is possibly because these items are typically perishable. However, meat and dairy foods were frequently mentioned, and they can also be perishable. It is likely that vegetables were not frequently mentioned because intakes of vegetables in the USA are very low and usually only in the form of French fries (potatoes) or pizza sauce (tomatoes) (USDA 2019). Vegetable intake is particularly low in the southern US, as compared to other regions (PBH 2015). Foods categorized as desserts and sweets were also not frequently mentioned. This is surprising given the fact that refined sugar intake has been increasing (USDA 2019) and that snack foods, such as cookies and cakes, make up to 25% of US adults' energy intake (Dunford and Popkin 2017). It is possible that these foods are viewed as not necessary for stockpiling in preparation of a storm. Despite the possibility that individuals susceptible to emotional eating would be at risk for increasing intake of sweets after a natural disaster, the previous research found that there was not an increase in junk foods (both savory and sweet snacks) after an earthquake among women with emotional eating (Kuijer and Boyce 2012). Findings of that study did indicate that stress in response to natural disasters can lead to a decrease in intake of healthy foods, such as vegetables (Kuijer and Boyce 2012). This may explain the low reported mentions of vegetables in the present study.

Overall, foods mentioned in the present study were high in energy and protein. Findings indicated that efforts should be made to encourage individuals preparing for a storm to purchase healthy foods to have on hand. Considering that foods high in protein, such as poultry, dairy, eggs, and seafood, are perishable and are also some of the top contributors to food-borne illness (CDC 2018), efforts to educate consumers on shelf-stable sources of protein, including peanut butter and canned legumes, may be warranted. The CDC, as well as state and local agencies, may wish to increase education efforts around having healthy,

non-perishable food on hand before storms arrive. The CDC has used viral social media campaigns to increase preparedness for natural disasters, but there has been no previous concentrated focus on healthy foods to have on hand for disasters (Fraustino and Ma 2015).

The present findings should be considered in the context of some potential limitations. It is possible that some of the F&B mentions contained names of foods, but the user could have been tweeting about something not food related (e.g., "This weather is nuts!"). In addition, only a sampling of approximately 500,000 tweets containing the hurricanes hashtag names or full names were collected. Some foods were mixed dishes, such as waffles and biscuits (which may contain grains, dairy, and eggs). In addition, while pizza was categorized as a grain, it is one of the largest contributors to dairy consumption in the USA, with Italian cheeses being consumed more frequently than any other cheese (USDA 2014). A broad range of foods and beverages were selected based on known energy and macronutrient contributors in the USA (O'Neil et al. 2012); however, it could also be that, for example, people tweeted about Oreos™ instead of "cookies." While a quarter of US adults use Twitter, users of the platform may not be generalizable to the US population, with the majority of Twitter users being under the age of 50 (67%) (Pew 2018) and tending to be more highly educated and wealthier than non-Twitter users (Wojcik and Hughes 2019). However, there is equal distribution among users by sex, race, education, and urban/suburban locations (Pew 2018). While the previous research has shown that the most commonly tweeted foods by US region align with traditional regional cuisine (e.g., grits are the most commonly tweeted food word in the southeastern US) (Fried et al. 2014), it is possible that people may be more likely to tweet about unusual foods versus foods they consume every day. Lastly, actual consumption was not measured; only mentions of F&B. Future studies may wish to employ a mixed methods approach to examining the content of messages. For example, a more thematic or content analysis approach could be conducted, including an examination of images that are posted to Twitter. An analysis of images could help provide further context of the messages posted to Twitter.

The study also has several strengths. Using a framework of known major contributors to energy and macronutrients allowed for the collection of individual foods and beverages, as well as an examination of dietary patterns by energy and macronutrients. The methods used in this study could also be applied to other major events as a way to study dietary patterns. This includes during other natural disasters (e.g., winter storms), sporting events (e.g., the Super Bowl), and variations in seasons (e.g., eating patterns in summer vs. winter). The resulting list of F&B and broader food group categories could be used for other studies and with other social media platforms. The methods could also be applied to other "big data" platforms, such as other social media sites, electronic health records, and diet tracking mobile apps.

5 Conclusion

Social media may be a unique way to detect dietary patterns and help inform recommendations for what F&B are appropriate during natural disasters. The present study found frequent mentions of grains and dairy, particularly pizza and milk, as well as foods that are energy dense and high in protein. Since healthy food items, such as fruits and vegetables, were infrequently mentioned, officials in charge of making disaster preparedness recommendations related to food may want to encourage the purchase of fruits (such as bananas or dried fruits) and vegetables (such as canned peas or carrots) that can be stored

and consumed without the need for electricity. Disaster preparedness officials may also want to reinforce the message about limiting or avoiding alcohol before, during, and after a natural disaster.

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