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Culturally Adapted Mobile Technology Improves Environmental Health Literacy in Laurentian, Great Lakes Native Americans (Anishinaabeg)

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Abstract

The presence of persistent bioaccumulative toxics (PBT) in aquatic food chains complicates decision processes of people with a strong culture of fish consumption. This environmental contamination is especially problematic for Native American populations in the Laurentian Great Lakes region (Anishinaabeg). Pursuing the growing discipline of environmental health literacy (EHL) may help reduce toxic exposures, support healthy decision-making, and combat health deficits. Our goals for this research were first to improve environmental health literacy using novel technologies and second to help define environmental health literacy metrics that can be tracked over time, especially regarding culturally-contextualized health interests. We recently reported that a mobile app (Gigiigoo'inaan App) presenting personalized, culturally-contextualized fish consumption advice may improve EHL for the Anishinaabeg. Gigiigoo'inaan App safely supports desired fish consumption rates by putting local data into the hands of the Anishinaabeg. We conducted a pre-test post-test evaluation with 103 Aninishinaabe adults. Participants estimated their current fish meal consumption over a hypothetical month before exposure to the software and then planned their future consumption of fish meals in a month after using the mobile app. Significantly more monthly traditional fish meals on average (Median: 4 vs 2, p=0.0005) were selected when using the app versus pre-exposure to the app. Significantly more traditional grams of fish were also selected during use of the app relative to the pretest (Median: 680.39g vs 453.59g, p=0.0007). These increases were accompanied by widespread (97%) adherence to conventional advice that minimizes PBT exposure health effects (ATSDR minimum risk levels).

Keywords

Environmental Health Literacy; Native American Health; Mercury; Polychlorinated Biphenyls; Omega-3 Fatty Acids; Fish Consumption

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Introduction:

Contamination of Great Lakes ecosystems has led to the accumulation of Persistent Bioaccumulative Toxics (PBTs) in the food chain. Consumption of Great Lakes fish may therefore present health hazards from PBTs like Poly Chlorinated Biphenyls (PCBs) and Methylmercury (MeHg). Conversely, locally caught fish is a healthy and culturally important food source for many populations with a history of living near aquatic ecosystems. This interplay between toxic exposure risk and health promotion presents a unique challenge to disease prevention. Recognition of complex societal/environmental interactions has led to the establishment of environmental health literacy (EHL) as a subdiscipline of environmental health that combines elements of risk assessment, exposure science, health communication, and community-engaged research (Finn and O'Fallon, 2015). There is a growing understanding that improvement of EHL must be targeted to reduce toxic exposures, promote healthy decision-making, and combat health deficits (White et al., 2014). Important literature gaps on EHL in Native Americans include the lack of studies that empirically measure changes in perception, awareness and behavior, as well as a general lack of theory-based research (Boyd and Furgal, 2018).

We recently developed a mobile app, Gigiigoo'inaan (meaning "our fish" in the Anishinaabe language), to present personalized fish consumption advice in a culturally-contextualized format to improve EHL in Anishinaabe fish consumers. Here, we report a novel EHL model for testing interventions such as Gigiigoo'inaan App. Preliminary focus groups indicated that the app may increase the efficient transmittal of scientific data to the intended benefactors (Dellinger et al., 2017). The next step is to develop reproducible, traceable EHL indicators. Drawing upon risk assessment and health behavior models, we propose preliminary metrics to quantify the emerging concept of EHL in the context of fish consumption advisories.

Background of CORA Service Area

Since 1991, the Chippewa Ottawa Resource Authority (CORA) in Sault Ste. Marie, Michigan, has monitored PBTs in fillets of lake trout (*Salvelinus namaycush*) and lake whitefish (*Coregonus clupeaformus*) from the waters of lakes Superior, Huron, and Michigan. CORA represents the fisheries interests of five Ojibwe and Ottawa tribes (collectively called Anishinaabeg) whose ancestors ceded lands through the 1836 Treaty of Washington but retained the rights to hunt and fish on those territories. Despite the cultural history (Quaife, 1947; Taylor and Ferreri, 2000) and known benefits of eating fish (Mozaffarian and Rimm, 2006; Mozaffarian and Wu, 2011, 2012; Turyk et al., 2012), the Anishinaabeg are reported to only consume one third of the recommended daily fish intake when measured prospectively (Dellinger, 2004; USD A, 2015). This is on average, however, as many tribal members still consume higher rates pursuant to their culture. Reduced consumption rates are thought to result from an aversion to culturally naive advisories on eating fish. The extent to which this aversion drives fish consumption is debated. However, the notion that historical advisories do not resonate with the Anishinaabeg is well documented (Dellinger et al., 2012; Dellinger et al., 2017). Ultimately, reduced consumption of traditional foods like fish creates a nutritional health disparity for Indigenous North Americans. Decreased access to traditional foods, and increased dependence on commodity and government-provided food, has coincided with diminished dietary quality, increased obesity, and cardiovascular disease among Native Americans (GLITEC, 2011; Ho et al., 2008; Schell, 2012; Story et al., 2003; Whiting and Mackenzie, 1998).

Improved efforts to share fish contaminant and nutrition data with the Anishinaabe communities are important priorities for tribal governments and have also proven challenging for Great Lakes state/provincial agencies seeking to provide advice that is seen as trustworthy. The authors and others have collaborated with CORA and the Inter-Tribal Council of Michigan (ITCMI) in the past to generate culturally-relevant fish consumption advisories (CORA, 2006; Dellinger et al., 2014; Dellinger and Dellinger, 2018; Dellinger et al., 2006; Moths et al., 2013). These past interventions were well-received but little guidance existed at the time to evaluate the impact on EHL. It is further important to provide the Anishinaabe public with up-to-date fish contaminant data from their traditional fisheries as these data are collected by CORA on an annual basis. In response to these challenges, the team developed a mobile app, “Gigiigoo’inaan App”, under National Institute for Environmental Health Sciences (NIEHS) funding to integrate risk and benefit concepts using the biomonitoring data collected by CORA (Dellinger et al., 2015-2017).

Theoretical Basis of Gigiigoo’inaan App

An emphasis on persuasion alone does not fully characterize population-level EHL improvement. The academic and tribal partners developing Gigiigoo’inaan App envision EHL from a community-engagement perspective. Therefore, the aims of this intervention follow a hierarchy of goals: first, to improve access to environmental data; second, increase the number of individuals who understand evidence-based recommendations; and third, persuade individuals that the advice promotes health-optimizing behaviors. This order of priorities accommodates holistic health factors such as anxiety which may result from lack of access and/or empowerment to use data. Thus, persuasive messaging is an essential EHL target, but does not overshadow other considerations. This interpretation of EHL therefore pursues well-being by emphasizing individual and community agency.

For an overview of health communication research that informs Gigiigoo’inan App, see Dellinger and Dellinger (2018). Briefly, two distinct routes of persuasion are postulated both of which invoke dual process models: Elaboration Likelihood Model (Petty and Cacioppo, 1986), Heuristic Systematic Model (Chaiken et al., 2012), and Unimodel (Kruglanski and Thompson, 1999). These routes are systemic/central and peripheral/heuristic. All persuasion routes are valuable because individuals within a culture may identify with similar values and aesthetics, but cognitive aptitudes and motivation will vary between individuals. Gigiigoo’inaan App was designed to influence these persuasion routes by providing cues (such as culturally-tailored artwork;Figure 1) but also by presenting recommendations based on rigorous science. The peripheral/heuristic route (i.e. cultural aesthetics and governmental origin of messaging) adds weight to the systematic/central route (i.e. quantitative risk estimates) (Dellinger and Dellinger, 2018; Dellinger et al., 2017). Cultural sensitivity and scientific authority are therefore employed simultaneously.

Minimal guidance exists on how to characterize EHL. Figure 2 presents a conceptual model of EHL metrics drawing upon risk assessment and health communication methods. The current paper explores how fish consumption metrics could fit into EHL using proposed constructs of Adaptation (the extent to which respondents follow or intend to follow advice), Resonance (relevance and cultural congruence to the respondent), and Translation (the extent to which the respondent understands the information) (ART). These metrics are built from quantitative estimates of PBTs and PUFA-3 intakes as well as questionnaire data from 103 Anishinaabe participants. The accompanying analysis provides preliminary recommendations for using fish consumption risk assessment metrics to measure EHL.

Methods

The overall research design was a pre-test:post-test as follows: participants engaged in focus group discussions and questionnaires before and after receiving a touch screen tablet to use Gigiigoo'inaan App. The Medical College of Wisconsin (MCW) Institutional Review Board #5 granted an exemption from IRB oversight in accordance with 45 CFR 46.101(b)(2). All participants provided informed consent on site. Perception and a test of potential behavior change was employed to track fish meal choices with and without use of Gigiigoo'inaan (pre and post). All data was de-identified and entered into REDcap (Harris et al., 2009), then analyzed using STATA 15 (StataCorp, 2017).

App Development

Gigiigoo'inaan means "our fish" and thus the name is a cultural cue that the software is developed for Anishinaabe people with their input. A full description of app development is available in Dellinger et al. (2017) and expanded upon in Dellinger and Dellinger (2018). A synopsis and updates are as follows: Gigiigoo'inaan App was programmed by the University of Wisconsin-Milwaukee Mobile Innovation Lab in collaboration with researchers at MCW, ITCMI, and CORA. The software works on web browers, Android™ and IOS™ allowing for on-demand calculation of consumption recommendations for thirteen species of fish (lake trout, whitefish, walleye, yellow perch, rainbow smelt, lake herrring, smallmouth bass, burbot, northern pike, farmed atlantic salmon, canned tuna, cod, and farmed tilapia). The user-input includes age, weight, sex, and meal size as modifying factors for individualized recommendations. The app features custom-made images made in the Woodland Style originally founded by the Anishinaabe artist Norval Morrisseau (Figure 1b).

The first results page ranks fish in order of the most to least recommended meal rates (Figure 1b). The software cross-references user input with CORA data on Hg and PCBs for each species per lake within the 1836 treaty boundaries (Superior, Huron, and Michigan). Some PBT data were supplemented from the Michigan Department of Environmental Quality database. These were applied to reference doses thereby generating estimated meal frequencies that fall below specified risk levels (Figure 1c). For MeHg, the app uses the Agency for Toxic Substances & Disease Registry (ATSDR) chronic oral minimum risk level (MRL) of 0.3 μg/kg/day (ATSDR, 2014). For PCBs, the health protective value from the Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory of 0.5 μg/kg/day was selected by CORA (Anderson et al., 1993). A precautionary calculation for risk sensitive categories was also calculated from the more restrictive EPA MeHg reference does of 0.1 µg/kg/day (Rice et al., 2003). This MeHg calculation was presented to users who responded to a prompt within Gigiigoo'inaan "Are you pregnant or do you plan to become pregnant?" or if the respondent reported he or she was under the age of 18. Nutritional data were sourced from CORA PUFA-3 sampling (M. J. Dellinger et al., 2018) and United States Department of Agriculture (USDA) (USDA, 2005).

Recruitment and Focus Groups

ITCMI collaborated with the health and natural resource departments of the five 1836 Treaty signatory Tribes to test the app. The 1836 Treaty signatory Tribes include: Bay Mills Indian Community, Grand Traverse Bay Band of Ottawa and Chippewa Indians, Little Traverse Bay Bands of Odawa Indians, Little River Band of Ottawa Indians, and Sault Ste. Marie Tribe of Chippewa Indians. Twelve app-testing sessions were facilitated by ITCMI staff and a CORA intern and held during the summer months of 2017. These months were targeted because more fish on average are consumed by the Anishinaabe during the spring and summer months than other seasons. Consumption peaks during the spring season, reaches a moderate rate in the summer months, and decreases during the winter months. The summer months tend to represent the overall annual average (GLIFWC, 2003).

The pre and the post assessments collectively recorded: demographic data, health literacy proxy data, perceptions of fish consumption and Gigiigoo'inaan App, and hypothetical monthly fish meals of various species. The form contained a matrix to represent the month with a list of fish species mentioned during past focus groups. It included a standardized meal size referencing a picture of a fish fillet on a plate (4oz, 6oz, or 8oz). Ten additional species were included: panfish, sturgeon, sucker, catfish/bullhead, carp, pollock, shrimp, swordfish, muskellunge, lobster, and "other". Species historically harvested by the tribes were noted as "traditional" by CORA for later statistical analysis. This form was completed first without Gigiigoo'inaan App and second with access to the app using an Android™ tablet. ITCMI staff then asked a series of open-ended focus group questions and recorded the verbal responses from the group.

Data Analysis

Pre-post attitudes and perceptions were summarized using descriptive statistics. Questionnaire data were organized, post-hoc, into the closest fitting EHL ART constructs of resonance and translation. As measures of adaptation: pre and post intakes of PUFA-3, Hg, PCB, fish grams, and fish meals were estimated from participant selections. PBT data were linked to the portion sizes, fish location (i.e. store or specific lake), and species of fish meal selections to generate total fish intake (grams or meals) over a hypothetical month for each participant. PBT intakes were scaled against and average male (89kg) or female (76kg) body mass depending on the reported sex of the participant. The average weight of 82.5kg (Centers for Disease Control, 2017) was used for non-responders. This allowed for comparisons of PBT intake pre and post, relative to the app recommendations. Mean and median pre and post PCB (µg/kg/day), Hg (µg/kg/day), PUFA-3 (mg/week), fish (g/month), and meals/month were compared separately and group differences were tested using

Wilcoxon Signed-Rank. Since PBTs were expected to decrease and PUFA-3/fish grams were hypothesized to increase posttest, $p \leq 0.05$ was considered significant.

Results:

Sample characteristics

Basic demographic and health literacy proxy data are summarized in Table 1. This pool of participants was 70.4% female. Representation across tribal groups was roughly equitable, with Little River and Little Traverse Bands participating less than the other three. The most frequently reported age bracket was 35-44 years, followed by 55+ years. Relatively few young adults (ages 18-24) participated. Many participants met the proxy criteria for baseline health literacy (≥high school education, household income ≥$40k, has searched online for health information in past year) (ODPHP, 2019). Over half (52%) had obtained a college degree at minimum and the most reported income bracket was $25,000-$49,000 at 41%. Over half (52%) of the sample reported that they search the internet for health information at least once per week.

Questionnaire responses: resonance and translation

Questionnaire responses regarding self-reported attitudes towards fish consumption and health are summarized in Table 2 and Table 3. Overall, the data in Table 2 reveal strong agreement that eating and catching local fish is important culturally and as a food source. Very few (16.7%) reported that they limit fish consumption due to taste. Most deemed the app culturally appropriate (87.6%). Participants appreciated the culturally-tailored components of the Gigiigoo'inaan including the use of Ojibwe fish names and woodland art to represent the fish (Figure 1b). Many (64.1%) said they would use the tool regularly and they would eat more fish (58.25%).

Table 3 summarizes the participant responses to questions evaluating the utility (translation) of Gigiigoo'inaan. At baseline, most (80.6%) of participants stated that they believe they are regularly exposed to chemicals from food and the environment. Less than half reported that they limit store bought fish consumption due to contaminants, whereas 16.8% stated they do not limit consumption for this reason. Slightly more (21.4%) of the participants stated that they limit wild caught fish due to contaminants whereas most were either unsure (30.1%) or explicitly do not limit their consumption (48.5%). Many (86.3 %,) stated they would feel more confident feeding fish to their families if they had regular access to Gigiigoo'inaan. During the questionnaires, most (79.9%) of the participants agreed that the app was useful and helped them identify the best fish to eat (97.0%).

Adaptation of recommendations

By all measures, average projected fish consumption increased when selecting fish meals using Gigiigoo'inaan App advice. The personalized advice encouraged consumption of total fish grams as well as fish meals and traditional fish meals (Table 4). Significantly more monthly traditional fish meals (Median: 4 vs 2, p=0.0005) were selected when using the app versus pre-exposure to the app. Significantly more traditional grams of fish were also selected during use of the app relative to the pre-test (Median: 680.39g vs 453.59g, p=0.0007). The altered pattern of fish consumption was also accompanied by group increases to predicted PUFA-3 and Hg intake (Table 4) from fish meal selections; however, these increases were not statistically significant. Predicted PCB intake decreased slightly during app utilization. To accomplish this, participants would have selected more traditional fish and fish meals that were lower in contaminants with the app than without.

Although Gigiigoo'inaan App advice encouraged the selection of more fish meals, the majority (97%) of the participants appear to have followed the advice by not exceeding suggested meal frequencies (Table 4). These participants would not have exceeded the ATSDR or the Uniform Great Lakes Sport Fish Consumption Advisory recommendations. The lack of exceedance considers cumulative fish selections, a calculation that was not provided to the participants at the time. Exceedances were likewise minimal during the pretest because participants selected less fish on average at baseline (Table 4). Only 3 of the 99 participants completing the post-test reported patterns inconsistent with the provided PCB and/or Hg advice. An additional (17% pre-test, 25.5% post-test) of participants reported consumption patterns with projected Hg intake falling between the EPA and ATSDR standards. The EPA Hg reference dose resulted in the most conservative PBT-based meal frequencies for these fish. An inability to confirm who intends to bear children introduces some uncertainty as to how many participants would have been presented with EPA advice by Gigiigoo'inaan App. However, most of the participants were older and it is likely many of them selected the less sensitive, but nevertheless protective, ATSDR MRL categorization.

Discussion

Proposed EHL Constructs

For the purpose of integrating fish consumption metrics with EHL, Figure 2 presents a model to conceptualize EHL into three constructs (ART). As with other EHL models, Figure 2 proposes that certain prerequisites are required to induce health behavior change and/or knowledge acquisition (Davis et al., 2018; Finn and O'Fallon, 2015; Gray, 2018). These behavioral outcomes may vary, and the healthfulness of such behaviors would likely form their own, independent topics. A commonality among current theoretical EHL models is that information transfer must be optimized and culturally tailored in order to empower individuals and communities to manage downstream health effects. Finn and O'Fallon (2015), for example, present a model of EHL that emphasizes a hierarchy of learning processes ultimately leading to levels of EHL. Gray (2018) further articulates EHL as awareness and knowledge allowing for skills and self-efficacy resulting in community change. In the proposed model (Figure 2), resonance and translation operate independently as intervening variables on adaptation. This resembles the dual persuasion routes proposed in health behavior models (Petty and Cacioppo, 1986) (Chaiken et al., 2012) (Kruglanski and Thompson, 1999). Adaptation may include community action or health behavior.

Adaptation is the extent to which users of scientific advice report behaviors that would comply with the benchmarks established by risk assessment methods. The adaptation metric describes a cognitive process in which the participant synthesizes information into an actionable plan to optimize their exposure-related behavior. This metric suggests compliance with low-risk and/or healthy behaviors. Healthy behaviors should include indicators of culturally-contextualized well-being. Metrics relating to the proposed construct of adaptation appear in Table 4.

Gigiigoo'inaan App responds to the expressed desire to eat more fish without exceeding *a priori* risk assessment benchmarks. Therefore, increased meals and grams of fish consumption in the post-test serve as quantitative indicators for adaptation. Similarly, consumption of traditional fish meals (i.e. lake trout and whitefish as opposed to tuna or cod) was a culturally-contextualized goal. Therefore, the significant increase in traditional fish consumption suggests strong agreement between the app messaging, comprehension of that messaging, and the expressed utility goals of the group. Most importantly, these increases were achieved without exceeding the PBT recommendations. This demonstrated an increased capacity to navigate the tradeoffs inherent to fish consumption. Even if these choices shift in practice, repeated consultation of Gigiigoo'inaan would likely lead to a memorization of the fish consumption safety guidelines that CORA previously established: size, source, and species (Dellinger 2006). Such memorization would reflect improved self-efficacy.

Resonance is the extent to which recommendations are deemed valid, acceptable, and actionable to a group given the cultural context. These metrics appear in Table 2. Resonance would map closely with heuristic cues of persuasion as described in dual process models (Kruglanski and Thompson, 1999). These metrics would quantify the acceptability of recommendations within a given cultural context. It may also include indications of aesthetic acceptability.

The questionnaire data gathered during focus groups present evidence for resonance with Anishinaabe culture. The focus groups and questionnaires were culturally-tailored because they were organized in partnership with tribal government, held in tribal facilities, and led by a tribal facilitator who acknowledged the inter-generational, cultural importance of Great Lakes fishing access and rights. Table 2 affirms common sentiments the Anishinaabeg appreciate positive messaging towards traditional fish consumption. The post-test questions further suggest that Anishinaabe participants would use the Gigiigoo'inaan App advice. Resonance may not necessarily lead to exposure reductions; however, we hypothesize that it could reduce emotional distress associated with fish consumption.

Translation is the extent to which communication facilitates the transfer of scientific information to the culturally-contextualized end-user. This metric is most closely related to systemic/central cues of persuasion as described in dual process models (Chaiken et al., 2012; Petty and Cacioppo, 1986). The ideal translation metric would indicate whether the users of the advice "hear" the message (i.e. regardless of putting it into practice). The current study reports these qualities in Table 3. Figure 2 proposes that both translation and resonance are prerequisites for adaptation.

The importance of resonance versus translation is illustrated by contrasting the metric of "I would use this app regularly" (64.1%) with "I would feel more confident about serving fish to my family with this app" (86.3%). Thirty participants seemed to understand the messaging and would use it for their families but not themselves. The translation was high but personal resonance was less pronounced for these individuals. Anishinaabeg focus groups repeatedly mention individuals who will not comply with fish consumption restrictions (Dellinger et al., 2017). This highlights the importance of developing robust measures for these constructs to maximize positive EHL change. Informed dissent may represent a positive outcome.

Desire to Consume Fish and Other Studies

Though not intended as a risk assessment, the current fish meal selections conform with past attempts to characterize Anishinaabe consumption rates. During the last comprehensive survey of these tribes, the Ojibwe Health Study (OHS), the summer months (June-September) present a four-month window that is representative (9 g/day) of overall fish consumption (8.2 g/day); this was consistent across years. These Anishinaabe participants reported eating 420 g/week of fish, but when measured they consumed 78.4 g/week of fish (Dellinger, 2004). For the current study, conducted during summer months, participants selected on average 365g/week of fish during the pre-test survey. This is closer to the recall data than the measured fish grams reported during the OHS. The measured estimates could have been under-reported. It seems likely, however, that the participants are overestimating the amount of fish they would eat in practice. A combination of both biases could produce this discrepancy. and the latter may be more akin to social desirability than recall bias. The current participants may have selected fish meals to reflect a preferred version of their behavior. This may reflect a preference to consume more fish while bearing in mind that restrictions to avoid PBTs as well as other barriers to fish consumption are ever-present.

The post-test meal selection revealed a further idealized pattern of fish consumption. If participants consumed fish in accordance with the post-test estimates they would be eating 387g/week. Most participants nevertheless fell safely within recommendation limits. An often-cited concern for promoting the benefits of fish consumption is excess PBT exposure in pursuit of the nutrition. However, a clear majority of Gigiigoo'inaan App participants remained within reasonable Hg and PCB guidelines, regardless of the potential to overestimate fish consumption. As with the other studies, such as OHS, the sampling of Anishinaabe fish consumers is biased towards educated women (Table 1). Differences in risk tolerance and openness to cooperating with research projects between the sexes may influence participation. ITCMI seeks new strategies to minimize this persistent sampling bias as it limits the ability to generalize study findings to the Anishinaabe public. Nevertheless, these participants (male or female) may also be more likely to act as decision makers in the home for meal selections. Therefore, the impact of these findings is likely relevant to a broader population than is sampled here.

Conclusion

The context of Anishinaabe fishing culture presents a challenge to agencies that would provide them with consumption advice. Tribal groups often emphasize their preference to consume more fish safely along with a dissatisfaction regarding the need to comply with restrictions. The potential to downplay concerns regarding contaminant trends is also a concern. It is therefore difficult to present recommendations that promote EHL without raising issues of distrust. With few exceptions, Anishinaabe participants were able to use Gigiigoo'inaan App to select a preferable, as defined by them, monthly fish consumption rate of traditional species that does not exceed recommendations. This is facilitated by the flexibility of personalized estimates made possible by the interactive software format. The provisional EHL constructs do not capture the totality of this emerging concept, but they present a promising step in assessing EHL using risk assessment data. Future studies will refine the proposed EHL constructs to translate data monitoring programs into health improvement and disease prevention.

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Figure 1:

Screen shots from Gigiigoo'inaan: main data entry page (A), main results page (B), and advisory details page (C). Orginal art by: Matthew Dellinger

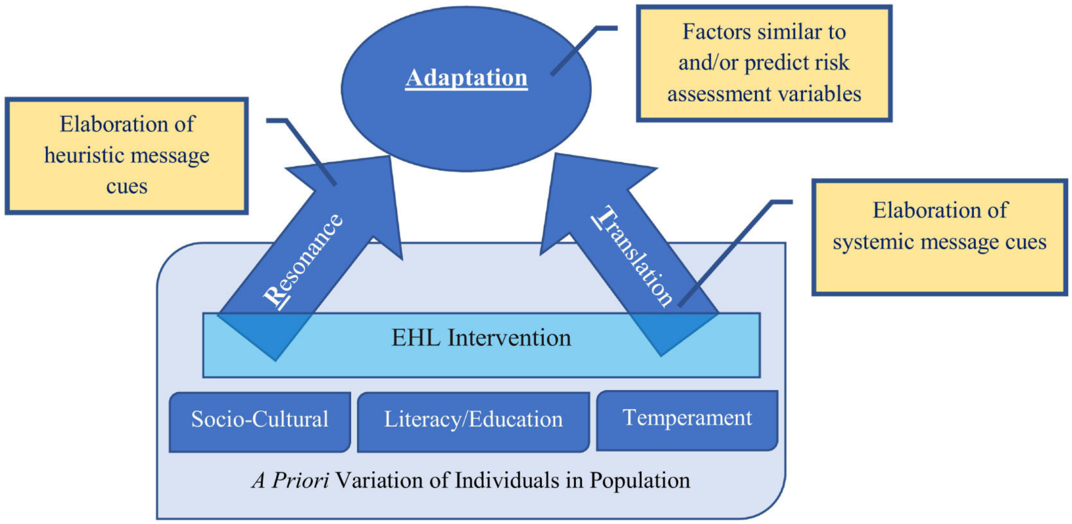

Figure 2:

A pilot model of metrics for tracking EHL. Compatible with health communication (specifically duel models of heuristic and systemic persuasion cues) and risk assessment frameworks (which quantify hazards, dose-response, and exposure).

Table 1:

Characteristics of study participants (n=103). Total N was 103, however some individuals did not complete the survey and their n have been indicated below.

Question	n (%)
*Sex	
Male	30 (29.7)
Female	71 (70.3)
Tribal Affiliation	
Bay Mills	23 (26.1)
Sault Ste. Marie	21 (23.9)
Little Traverse Bay	12 (13.6)
Grand Traverse Bay	19 (21.6)
Little River	13 (14.8)
Age	
18-24	6 (5.8)
25-34	33 (32.0)
35-44	16 (15.5)
45-54	18 (17.5)
55+	30 (29.1)
Education	
Some high school	2 (1.9)
High school graduate	16 (15.5)
Some college	33 (32.0)
College graduate or more	52 (50.5)
**Income	
<25k	19 (19.0)
25k-49k	41 (41.0)
50k-99k	32 (32.0)
100k+	8 (8.0)

*n =101,

**n=100

Table 2:

Resonance of Gigiigoo'inaan application (post-test) or general fish consumption sentiments (pre-test) within the study population (*n*=103)

	Question	*N* (%)
Pre-test	Eating fish my family or I catch is important to me	
	Yes	68 (66.0)
	No/Neutral	35 (34.0)
	Eating traditional food is important to me	
	Yes	73 (70.9)
	No/Neutral	30 (29.1)
	Harvesting, gathering, hunting, fishing traditional food is important	
	Yes	73 (70.9)
	No/Neutral	30 (29.1)
	*I limit fish consumption because of the taste	
	Yes	17 (16.7)
	No/Neutral	85 (83.3)
Post-test	**The app was engaging	
	Yes	91 (91.9)
	No/Neutral	8 (8.1)
	I would use this app regularly	
	Yes	66 (64.1)
	No/Neutral	37 (35.9)
	**The app is culturally appropriate	
	Yes	87 (87.9)
	No/Neutral	12 (12.1)
	I would eat more fish if I could use this tool	
	Yes	60 (58.3)
	No/Neutral	43 (41.8)

*n=102.

**n=99,

Table 3:

Translation of Gigiigoo'inaan application (post-test) or general fish consumption sentiments (pre-test) of study participants (*n*=103)

	Question	***N* (%)**
Pre-test	[*]I limit my consumption of store-bought fish due to contamination	
	Yes	49 (48.5)
	No/Neutral	52 (51.5)
	[*]Fish is healthy	
	Yes	85 (83.3)
	No/Neutral	17 (16.7)
	I limit my consumption of wild-caught fish due to contamination	
	Yes	22 (21.4)
	No/Neutral	81 (78.6)
	I am regularly exposed to chemicals	
	Yes	83 (80.6)
	No/Neutral	20 (19.4)
Post-test	[**]The app provides everyday useful information	
	Yes	79 (79.8)
	No/Neutral	20 (20.2)
	[**]The app helped me to identify the best fish to eat	
	Yes	96 (97.0)
	No/Neutral	3 (3.0)
	[***]I would feel more confident about serving fish to my family with this app	
	Yes	88 (86.3)
	No/Neutral	14 (13.7)

[*]n=101,

[**]n=99,

[***]102

Table 4:

Metrics to model adaptation as an indicator of EHL. Mean and median estimated pre and post intakes of mercury (Hg), Polychlorinated Biphenyls (PCBs), Polyunsaturated Omega-3 Fatty Acids (PUFA-3) and grams of fish are compared. .

Adaptation Metric	Mean pre-test (stdev)	Median	Mean post-test (stdev)	Median	z-score	p-value
** Mercury (μg/kg/day)	0.067 (0.074)	0.055	0.077 (0.073)	0.061	1.864	0.062
*** PCB (μg/kg/day)	0.016 (0.02)	0.012	0.017 (0.02)	0.011	1.415	0.157
‡ PUFA-3 (mg/wk)	2875.44 (3512.7)	1764.82	3143.10 (3303.21)	2226.50	1.761	0.0782
** Fish meals (meals/month)	7.8 (7.086)	6	8.45 (6.238)	6	1.708	0.0876
** Grams of fish (g/month)	1461.26 (1497.454)	1020.58	1548.662 (1250.895)	1360.78	1.639	0.1013
** Traditional meals (meals/month)	4.2 (5.51)	2	5.3 (5.21)	4	3.473	0.0005 *
** Grams of traditional fish (g/month)	815.119 (1245.544)	453.59	1007.24 (1103.313)	680.39	3.393	0.0007 *

* $p \leq 0.05$,

** n=100,

*** n=99,

‡ n = 102