The Patterns of Adapting to Health, Self-Reported Health Status, and Risk Odds of Diabetes Type 2

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Abstract

Problem. The incidence of Type 2 diabetes is expected to more than double over the next three decades. Several behavioral drivers of Type 2 diabetes have been identified. Cluster-based studies support the self-organization of health-related behavior in specific patterns with their own effects on population health. The Patterns of Adapting to Health (PATH) system of health-related behavior patterns were hypothesized to influence Type 2 diabetes incidence both directly and indirectly. *Participants*: 4,380 Hawaii-based health plan members including 1,412 Type 2 diabetics responded to a mail survey. *Methods*: Self-reported health status was measured with a subset of items from the SF-36. The Adaptive Health Behavior Inventory (AHBI) assessed multiple health-related behaviors used as inputs to identify the nine PATH. Multiple regression and logistic regression evaluated the PATH effects on self-reported health status and the odds of Type 2 diabetes after controlling for self-reported health status, respectively. *Results*: Five PATH had significant lowering or raising effects on self-reported health status, β = -.05 [99%CI: -.42 to -.04] to β = .17 [99%CI: .35 to .64]. Two of the nine PATH were associated with increased odds of Type 2 diabetes, OR = 2.86 [99%CI: 1.31 to 6.24] to OR = 3.84 [99%CI: 1.41 to 6.84]. *Conclusions*: Two population-level patterns of health behavior were associated with increased risk odds of Type 2 diabetes after controlling for health status. *Implications*: Addressing individual behavioral drivers of Type 2 diabetes may be insufficient to counter the effects of population-level patterns of behavior on Type 2 diabetes incidence.

Type 2 diabetes has been a continuous and growing problem within the U.S. for decades. From 1994 to 2015 the median percentage of adults with diagnosed with Type 2 diabetes more than doubled moving from 4.4% to 9.1% (CDC, 2017a). By 2050, Type 2 diabetes is estimated to increase to 15 per 1,000 compared to 8 per 1,000 in 2008 (Boyle, Thompson, Gregg, Barker, & Williamson, 2010).

The growing incidence of Type 2 diabetes is driving the cost of treatment. In 2012, treatment of diabetes Type 2 reached $245 billion representing a 41% increase over the previous five years (CDC, 2017b). Most expenditures were associated with managing complications of Type 2 diabetes at an annual average cost of $13,700, more than two-times the treatment costs of non-diabetics (CDC, 2017b).

Adaptive Health Behaviors

Adaptive health behaviors are goal-directed behaviors and habits adopted and executed both consciously and unconsciously (Dijksterhuis & Aarts, 2010) in response the interaction of individual psychological predispositions, biophysical characteristics, and local social and environmental conditions (Bagley, Angel, Dilworth-Anderson, Liu, & Schinke, 1995). While there are many factors contributing to the rise of Type 2 diabetes (Chen, Magliano, & Zimmet, 2012; Cosansu & Erdogan, 2014), many distinct adaptive health-behaviors have been identified as key drivers (Hu, Manson, Stampfer, Colditz, Liu, Solomon & Willett, 2001). Overconsumption of refined carbohydrates (Gross, Li, Ford & Liu, 2004; Imamura, O'Connor, Mursu, Hayashino, Bhupathiraju, & Forouhi, 2015), increasing intake of white rice (Hu, Pan, Malik, & Sun, 2012), lack of physical activity (Hu, Li, Colditz, Willett & Manson, 2003), smoking (Yeh, Duncan, Schmidt, Wang, & Brancati, 2010), and poor sleep (Spiegel, Knutson, Leproult, Tasali & Van Cauter, 2005) all contribute

to increased incidence of Diabetes Type 2.

While many of these behaviors are considered maladaptive to health, temporal self-regulation theory (TST) (Hall & Fong, 2007; 2010; 2015) explains why they occur. TST integrates adaptive behavioral response to immediate social contexts and the cognitive-affective aspects of self-regulation to explain human patterns of behavior that are "judged to be maladaptive in the long-run". but are still chosen due to strong immediate benefits and the strong costs associated with behavioral constraint (Hall et al., 2007 [Abstract]).

Attractors of Health-Related Behavior

Studies of multiple health-related behaviors at the individual level have confirmed they tend to cluster and settle around several patterns (Palsdottir, 2008; Rovniak, Sallis, Saelens, Frank, Marshall, Norman, et al., 2010; Schneider, Huy, Schuessler, Diehi, & Schwarz, 2009). The existence of patterns underlying behavior have been argued to represent the self-organizing operation of attractors (Lucas, 2004; Mandara, 2003; Miller & Page, 2007) representing multistability (Feudel, 2008; Halley & Winkler, 2008) within the complex adaptive system composed of interdependent individuals (Human Systems Dynamics Institute, 2016; Marshall & Galea, 2014) adapting to their local environment. In the case of health-related behavior across multiple dimensions, such as diet, exercise, sedentary behavior, care seeking, health information seeking, a health reactive vs. health proactive stance, health-related spending, family health, health and health care decision-making, the behavioral patterns formed in response to these attractors reflect the self-organized adaptive time-based response of subsets of a population to their local health-related environment consistent with the framework of TST (Hall et al., 2007). It is hypothesized that behavioral conformity to one or more of these patterns of health behavior impact the risk of diabetes Type 2.

Patterns of Adapting to Health (PATH). The Patterns of Adapting to Health (PATH) is a psychographically-based model that identifies groups of adults whose adaptive response to local health-related contexts has settled around nine well-defined and reliable patterns of health behavior. The nine PATH were identified in a national study exploring the reliability of patterns of self-reported health-related behavior across geographic regions of the U.S. (Navarro, 1990). The value of the PATH has been demonstrated by its over 30 years of application within the health care and health insurance industry. The years of applied research has supported robust PATH relationships to many aspects of health and health care demand. The potential relationship of the PATH to a disease risk is supported by a demonstrated predictive relationship to health care demand among seniors (Navarro, 1999) and the prediction of annual medical expenditure differences within a commercially-insured population after controlling for demographic factors (Navarro, 2017a, b).

Self-Reported Health Status

Self-reported health status. The SF-36 and SF-12 have been shown to detect lower self-reported health status among Type 2 diabetics compared to non-diabetics (Harris, 2000; Jerant, Bertakis, & Franks, P2015). To improve the validity of the study, self-reported health status was also integrated into the analysis using a subset of questions from the physical function component of the SF-36 (Medical Outcomes Trust, 1992).

This paper explores the PATH in relation to population risk odds of a Type 2 diabetes using a retrospective analysis of a sample drawn from a Hawaii-based commercial health plan population including subsample of diagnosed Type 2 diabetics.

It was hypothesized that the dominant PATH of adults will have predictive and significant effects on self-reported health status. It was also hypothesized that the PATH will have direct effects on the risk odds of diagnosed Type 2 diabetes relative to a general health plan population after controlling for self-reported health status and have indirect effects on Type 2 diabetes through self-reported health status.

Methods

Participants

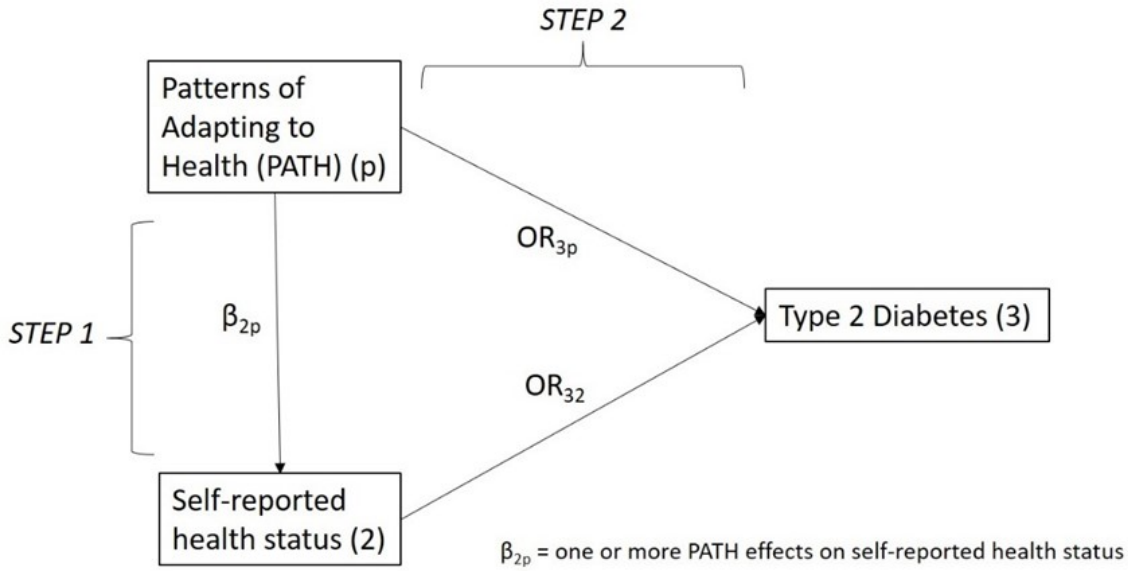
Participants were drawn from a Hawaii-based health plan membership from 1996. A random sample was drawn from member records and a second random sample drawn from a list of members with a diagnosis of Type 2 diabetes. No information is available on the size of both lists, nor information about the age or sex of members. Members were sent a mail survey, followed by two reminders approximately seven days apart.

Measures

Self-Reported Health Status. Self-reported health status was measured using a subset of the physical function items of the SF-36 (Medical Outcomes Trust, 1992). The items included were: 1) "In general, how would you say your health is?", 2) "Compared to one year ago, how would you rate your general health now", 11) "How TRUE or FALSE is each of the following statements for you?" a) "I seem to get sick a little easier than other people", and b) "I am as healthy as anybody I know." The items were scored to create a scale from 4 to 20 with higher scores indicating higher health status.

Adaptive Health Behavior Inventory (AHBI). Health-related behaviors were measured using the Adaptive Health Behavior Inventory (AHBI). The AHBI is a twenty-item inventory of adult response to different health-related contexts theoretically tied to embodied and adaptive self-regulatory dy-

Figure 1. Analytic Model



namics, goal-directed actions, habits, and beliefs (Navarro, 2017a). The AHBI uses standard 5-point agree-disagree Likert items, with most item responses closely approximating a normal distribution (Navarro, 2014).

Analysis

A proprietary set of classification functions (Navarro, 1990) was used to identify the dominant PATH of participants in both studies based on responses to the AHBI. The classification functions also identified a No Pattern group of respondents whose health behavior showed no evidence of settling around a defined pattern (Navarro, 1990). The predictive direct effects of the PATH on 1) self-reported health status and 2) the risk odds of a Type 2 diabetes diagnosis after controlling for health status were tested using the analytic model in Figure 1. Step 1 used multiple regression analysis (Fujisawa, Ichikawa, Yoshiya, Isotani, Higuchi, Nagano et al., 2000) to examine participant's dominant PATH effects on self-reported health status. Step 2 used logistic regression analysis (Snijder, Dekker, Visser, Bouter, Stehouwer, Kostense et al., 2003) to obtain the odds ratios (OR) of Type 2 diabetes associated with the PATH after controlling for self-reported health status. To obtain beta coefficients to calculate the direct, indirect, and total effects in Figure 1, a second multiple regression was used to regress dummy coded Type 2 diabetics on self-reported health status and PATH group membership (Pedhazur, 1982). The PATH classification of respondents representing their dominant PATH were the predictor variables, comparing group membership in the first nine PATH against membership in the No Pattern group.

Following the analysis procedures proposed by Pedhazur (1982), the following coefficients specified in Figure 1 were used to obtain and calculate the direct, indirect, and total effects of the PATH on Type 2 diabetes:

(1) β_{2p}

(2) $\beta_{3p} + (\beta_{32} * \beta_{2p})$

where:

β_{2p} = direct effect of the PATH on self-reported health status

β_{3p} = direct effects of the PATH on Type 2 diabetes after controlling for self-reported health status

β_{32} = direct effect of self-reported health status on Type 2 diabetes after controlling for the PATH

$(\beta_{32} * \beta_{2p})$ = indirect effect of the PATH on Type 2 diabetes through self-reported health status.

All analyses were conducted using NCSS 11 (2016). All statistical tests were evaluated at an extremely conservative $p < .005$.

Results

Table 1
Sample Characteristics : Unweighted and Weighted

	n	%	*n**	%*
Diabetes Type 2	1,412	32.2	210	4.8
Non-diabetics	2,968	67.8	4,170	95.2
Total *n*	4,380	100.0	4,380	100.0

*Weighted sample

Sample Size and Type 2 Diabetes

Four-thousand, three hundred eighty useable questionnaires were returned with 1,412 (32.2%) from participants with a diagnosis of Type 2 diabetes. At the time of the study, Type 2 diabetics accounted for 4.8% of the Hawaii adult population ((CDC, 2017a). For subsequent analyses the sample was weighted to better reflect the actual incidence of Type 2 diabetics to improve generalizability of the findings as shown in Table 1.

Descriptive Statistics

Frequencies and descriptive statistics for self-reported health status for the whole sample are shown in Table 2. Scores varied between 10 and 20 with mean self-reported health status at about the mid-point of the scale. Non-parametric testing of self-reported health status differences between Type 2 diabetics and non-diabetics were statistically significant, $\chi^2(1, n = 4{,}380) = 403.4$, $p < .0001$, CC = .31, as shown in Table 3.

Table 2

Self-Reported Health Status Frequencies and Descriptive Statistics

Scores	*f*	%
10	289	6.6
11	247	5.6
12	329	7.5
13	361	8.2
14	441	10.1
15	618	14.1
16	651	14.9
17	511	11.7
18	358	8.2
19	245	5.6
20	330	7.5
	4,380	100.0
	M	*SD*
	15.4	2.8

The distribution of the Patterns of Adapting to Health (PATH) for Type 2 diabetics and non-diabetics are shown in Table 4.

Among Type 2 diabetics, nearly twice the percentage of adults were dominated by the Traditionalist and Healthcare Driven PATH compared to non-diabetics, while nearly half the percentage were dominated by the Independently Healthy PATH relative to non-diabetics. The overall percentage of participants with no pattern was also three times as large as the 11% previously reported (Navarro, 1990). The higher rate of no pattern could be attributed to the mail survey data collection methodology. Prior experience with fielding the AHBI using mail surveys typically results in higher rates of no pattern compared to those achieved using telephone interviewing, personal interviewing, or interactive voice response (AHBI, 2017a). To improve the generalizability of findings relative to the PATH, the sample was also weighted to reduce the bias of participants with no pattern. Further references to sample weighting include both weighting Type 2 diabetics and no pattern.

Table 3

Self-Reported Health Status: Diabetics vs. Non-Diabetics

Subsamples	*n*	M*	SD
Type 2 diabetics	210	14.0	2.6
Non-diabetics	4,170	15.8	2.7
	4,380		

*$p < .0001$

Step 1 - Multiple Regression

Multiple regression analysis regressing self-reported health status on participant's dominant PATH was statistically significant, $F(9, 4370) = 32.4$, $p < .0001$, Adj. $R^2 = .06$, as shown in Table 5. When contrasted against adults with no pattern, five of the nine PATH had statistically significant effects on self-reported health status. Participants dominated by the Critically Discerning and Health Contented PATH had negative effects on self-reported health status, while participants dominated by the Traditionalist, Healthcare Driven, and especially the Independently Healthy PATH had positive effects on health status.

Table 4

Distribution of Participants by Dominant PATH

	Type 2 Diabetics*		
PATH	Yes%	No%	Total%
Critically Discerning	2.4	2.9	2.9
Health Contented	6.7	5.2	5.3
Wisely Frugal	15.2	14.2	14.2
Traditionalist	12.4	7.3	7.6
Family Centered	3.8	5.2	5.1
Family Driven	9.0	7.5	7.6
Healthcare Driven	11.9	6.6	6.8
Independently Healthy	6.7	10.5	10.3
Naturalist	7.1	5.8	5.8
no pattern	24.8	35.0	34.5
Total	210	4,170	4,380

*Weighted sample

Step 2 – Logistic and Multiple Regression

The overall logistic regression using the PATH and self-reported health status to predict a diagno-

sis of Type 2 diabetes was statistically significant, χ^2 (10, n = 4,380) = 117.2, p < .0001, R^2 = .79. Both self-reported health status, χ^2 (1, n = 4,380) = 92.6, p < .0001, R^2 = .16, and the PATH, χ^2 (9, n = 4,380) = 28.5, p < .0001, R^2 = .60, were statistically significant independent predictors of Type 2 diabetes. Odds ratios (OR) of Type 2 diabetes associated with self-reported health status and the PATH are shown in Table 6. After controlling for the PATH, increasing self-reported health status significantly reduced the risk odds of Type 2 diabetes by half. After controlling for self-reported health status, two of the PATH were associated with increased risk odds of Type 2 diabetes, Traditionalist (OR = 2.86, 99%CI: 1.31-6.24) and Healthcare Driven (OR = 3.11, 99%CI: 1.41-6.85) while participants with no pattern were associated with reduced risk (OR = .03, 99%CI: .02-.06) of Type 2 diabetes diagnosis. The multiple regression analysis treatment of the logistic regression analysis produced the same outcomes as shown in Table 7. Using beta coefficients specified in (1) and (2), the PATH direct and indirect effects on Type 2 diabetes were estimated as shown in Table 8. The family-wise error rate for hypothesis testing was α_{family} = .11.

Table 5

Multiple Regression: PATH Predicting Health Status

					99%CI of B	
	B	SE	β	*p*	LL	UL
no pattern	0.14	0.04	0.00		0.04	0.24
Critically Discerning	-0.23	0.07	-0.05	**	-0.42	-0.04
Health Contented	-0.42	0.07	-0.12	**	-0.59	-0.25
Wisely Frugal	0.04	0.05	0.02		-0.10	0.17
Traditionalist	0.18	0.06	0.06	*	0.03	0.34
Family Centered	-0.14	0.06	-0.04		-0.31	0.03
Family Driven	-0.14	0.06	-0.04		-0.30	0.01
Healthcare Driven	0.22	0.06	0.06	**	0.06	0.38
Independently Healthy	0.50	0.06	0.17	**	0.35	0.64
Naturalist	0.01	0.06	0.00		-0.16	0.17

*p < .005, **p < .001

The hypothesis that an adult's dominant PATH has predictive and statistically significant effects on self-reported health status was supported for five of the nine PATH. Health plan members dominated by the Critically Discerning and Health Contented PATH were associated with lower self-reported health status, while health plan members dominated by Traditionalist, Healthcare Driven, and especially Independently Healthy PATH were associated with higher perceived health status. The PATH effects on lower or higher perceived health status are consistent with the health behavioral patterns defined by the Critically Discerning, Health Contented, and Independently Healthy PATH (Appendix). However, the positive contributions of the Traditionalist and Healthcare Driven PATH to perceived health status is not consistent with their relationships to Type 2 diabetes.

The hypothesis that an adult's dominant PATH

Table 6

Logistic Regresssion: Self-Reported Health Status and the Patterns of Adapting to Health Predicting Type 2 Diabetes Diagnosis

					99%CI OR	
Predictors	B	B_{SE}	*p*	OR	LL	UL
no pattern	-3.47	0.24	**	0.03	0.02	0.06
Health Status	-0.70	0.07	**	0.49	0.41	0.60
Critically Discerning	0.08	0.41		1.09	0.38	3.12
Health Contented	0.34	0.34		1.41	0.59	3.35
Wisely Frugal	0.47	0.29		1.60	0.75	3.42
Traditionalist	1.05	0.30	*	2.86	1.31	6.24
Family Centered	-0.01	0.38		0.99	0.37	2.66
Family Driven	0.45	0.32		1.57	0.69	3.57
Healthcare Driven	1.13	0.31	*	3.11	1.41	6.85
Independently Healthy	0.31	0.34		1.36	0.56	3.32
Naturalist	0.63	0.33		1.87	0.80	4.41

*p < .005, **p < .0001

Type 2 diabetics = 1

Discussion

directly increased the risk odds of a Type 2 diabetes diagnosis after controlling for self-reported health status was supported for two patterns. Participant's pattern of health-related behavior conforming to the Traditionalist and Healthcare Driven were linked to approximately three times the risk of Type 2 diabetes independent of health status. The odds ratios of Type 2 diabetes associated with the PATH exceeded the risk odds of Type 2 diabetes associated with birth weight (Harder, Rodekamp, Schellong, Dudenhausen, & Plagemann, 2007), active or prior history of smoking (Willi, Bodenmann, Ghali, Faris, & Cornuz, 2007), and sedentary behavior associated with TV watching (Grøntved et al., 2011).

Table 7

Multiple Regresssion: Self-Reported Health Status and the Patterns of Adapting to Health Predicting Type 2 Diabetes Diagnosis

					99%CI	
Predictors	B	B_{SE}	β	*p*	LL	UL
no pattern	0.23	0.02	0.000	**	0.18	0.29
Health Status	-0.01	0.00	-0.154	**	-0.02	-0.01
Critically Discerning	0.00	0.02	0.001		-0.04	0.04
Health Contented	0.01	0.02	0.015		-0.03	0.05
Wisely Frugal	0.02	0.01	0.030		-0.01	0.05
Traditionalist	0.05	0.01	0.069	*	0.02	0.09
Family Centered	0.00	0.02	-0.004		-0.04	0.04
Family Driven	0.02	0.01	0.024		-0.02	0.05
Healthcare Driven	0.06	0.01	0.072	*	0.02	0.09
Independently Healthy	0.01	0.01	0.023		-0.02	0.05
Naturalist	0.02	0.01	0.031		-0.01	0.06

*$p < .005$, **$p < .0001$

Type 2 diabetics = 1

Participants dominated by the Critically Discerning, Health Contented, and Independently Healthy PATH had no indirect effects on Type 2 diabetes via self-reported health status. However, participants dominated by the Traditionalist and Healthcare Driven PATH did show indirect effects. A negative indirect effect was associated with the Traditionalist PATH on Type 2 diabetes risk via self-reported health status, and a very small positive indirect effect was associated with the Healthcare Driven PATH.

The contradictory relationship between higher self-reported health status and risk of Type 2 diabetes associated with the Traditionalist, and Healthcare Driven PATH is potentially explained by differences in health care demand. Type 2 diabetes must be diagnosed by a medical professional (Alberti & Zimmet, 1998; American Diabetes Association, 2015) and this is influenced by a person's levels of care seeking and health care demand. Adults dominated by the Critically Discerning and Health Contented PATH have been associated with lower levels of care seeking and lower medical expenditures while the opposite is true for the Traditionalist and Healthcare Driven (Navarro, 2014; 2017c). Thus, the elevated risk of Type 2 diabetes among adults dominated by the Traditionalist and Healthcare Driven may be due to their elevated care-seeking and higher probability of diagnosis compared to the Critically Discerning and Health Contented.

The dominance of a specific PATH over an individual's pattern of health behavior is not exact

Table 8

*PATH Direct and Indirect Effects on Type 2 Diabetes**

PATH	DEp	IEp ->hs	Total Effect
Critically Discerning	-	-	-
Health Contented	-	-	-
Wisely Frugal	-	-	-
Traditionalist	0.069	-0.097	-0.028
Family Centered	-	-	-
Family Driven	-	-	-
Healthcare Driven	0.072	0.005	0.077
Independently Healthy	-	-	-
Naturalist	-	-	-
no pattern	-	-	-

DEp = PATH direct effect

IEp ->hs = PATH indirect effect via health status

measure but a probabilistic one. The posterior probabilities of PATH dominance vary between .67 and .99 at the 50th percentile of adults identified with a specific PATH (Navarro, 2014), so the conformity to the central pattern (e.g., centroid, attractor) of each PATH is not the same. The data available from both studies did not permit the calculation of posterior probabilities of group assignment and their subsequent use in evaluating the influence of increasing behavioral conformity to each PATH, as done in other research (Navarro, 2014). Group membership (e.g., treating participants dominated by specific PATH with equal probabilistic effects) was the only way to evaluate the impact of such dominant PATH.

The increased risk odds of Type 2 diabetes associated with the Traditionalist and Healthcare Driven PATH are in line with Navarro (2014) where both the Traditionalist and Healthcare Driven PATH were associated with the highest medical expenditures after controlling for demographic factors. An increased risk of Type 2 diabetes associated with these two health behavior patterns may be a factor contributing to these higher costs.

Several study limitations can be identified. Relative to generalizability, this study was based on the analysis of an archival data from 1996 representing a sample of a Hawaii-based commercial health plan members. Strict generalizability of findings to other populations such as those covered by Medicaid, Medicare, military insurance, or those without insurance is limited (AERA, APA, & NCME, 2004, Standard 12.16). The lack of knowledge about the size and demographic characteristics of the original random samples further complicates generalizability. However, the weighting of Type 2 diabetics to more accurately reflect the incidence of Type 2 diabetes in Hawaii at the time of the study supports generalizability to the Type 2 diabetic population at that time. The two patterns of health-related behavior identified by the PATH with increased risk odds of Type 2 diabetes have been associated with older age (Navarro, 2014). The inability to control for age in this study leaves the question unanswered of whether the increased risk of Type 2 diabetes for the two patterns of health-related behavior were due to pattern effects, age effects, or mixture of both (CDC, 2017c). However, it has been demonstrated that the PATH have predictive effects age, and may therefore account for some age-related associations with disease (Navarro, 2017b).

Study validity is supported by identified relationships of self-reported health status with Type 2 diabetes. Self-reported health status was lower among Type 2 diabetics in the current study consistent with contemporary research. Based on the self-reported health status scale variance used by Jerant et al. (2015) the difference between Type 2 diabetics and non-diabetics were comparable to the difference found in this study.

The demonstrated link between the patterns of health-related behavior identified by the PATH and the risk of Type 2 diabetes has implications for future strategies targeting the reduction of Type 2 diabetes diagnoses through intensive behavioral interventions. Most efforts have delivered positive outcomes compared to medication-based interventions solely (Diabetes Prevention Program Research Group, 2002; Look AHEAD Research Group. 2010). However, an examination of randomized controlled trials indicated behavioral interventions are only effective in the short term (Norris, Engelgau, & Narayan, 2001).

This may be due to the influence of attractor-based patterns on health-related behavior (Shoda, LeeTiernan, & Mischel, 2002). An adult's behavioral conformity to one of the PATH is treated as an adaptive dynamic process beginning sometime between adolescence and early adulthood in interac-

tion with gender. This conformity represents the optimal behavioral home-base for that person in response to their local health-related environment. Intensive lifestyle interventions represent new short-term energy inputs into an individual's environment requiring learning, adaptation and adoption of new behavior leading to a potential phase transition into a new behavioral pattern (Vicente Solé, Cuevas Manrubia, Bartolo, Delgado Pin, & Bascompte, 1995) . As long as this new energy remains, new adaptive behaviors are sustained. Once the intervention is ended and the new energy removed, however, the individual faces the original environment and settles back to the prior optimal pattern. The new learning was insufficient to sustain the individual in the new pattern in response to familiar adaptive pressures and prior longer-term habitual patterns of adaptation .

To the extent that patterns of health-related behavior identified by the PATH are found to be predictive of Type 2 diabetes, two benefits are suggested: one, the assessment of an individual's dominant PATH may be a simple early indicator of diabetes Type 2 risk, and two, lifestyle intervention outcomes might be enhanced by tailoring interventions in accord with the PATH-defined health-related predispositions in advance of Type 2 diabetes on set (Krebs, Prochaska, & Rossi, 2010; Noar, Benac, & Harris, 2007). Such tailoring would be consistent with diabetes standards of care recommendations around communication (American Diabetes Association, 2015), but would need expanding to include "and addresses (*adaptive, behavioral patterns and*) cultural barriers to care (American Diabetes Association, 2015, p 97, parenthetical phrase added).

It has been argued that attractors are the most "feasible targets" (Kuhmonen, 2017 [abstract]) for anticipating future states of the system rather than focusing on the parts (i.e., nutrition and weight status, older adults, physical activity, sleep health, tobacco use) (CDC, 2015) shaped by these attractors. The current study supports a direct and indirect link between increased risk of Type 2 diabetes and two naturally occurring self-organized patterns of health-related behavior. Treating these patterns as driven by a system of attractors permits their use as predictors of future states of the system relative to the occurrence of Type 2 diabetes. Given the consensus that early intervention is the best approach for reducing or eliminating Type 2 diabetes onset (Alberti, Zimmet, & Shaw, 2007), the use of the PATH as an early predictor of Type 2 diabetes risk years in advance of its occurrence and as a vehicle for tailoring interventions consistent with health behavior pattern characteristics is worthy of future exploration.

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Appendix:

Patterns of Adapting to Health (PATH) with Significant Effects

PATH 1: Critically Discerning. PATH 1 (Critically Discerning) adults tend to be very concerned with the quality of healthcare and show a tendency to judge the competency of medical providers at a low level and believe they are regarded with too high esteem. PATH 1 adults are very rarely proactive about their health, tend to avoid healthcare due to cost concerns but are generally ambivalent about avoiding care as a rule. PATH 1 adults tend to be very involved in their family's health though they perceive this responsibility as a burden. PATH 1 adults tend to be ambivalent about fitness, ambivalent about exercise, have a low level of attention to nutrition, and tend to display a slightly higher external locus of control with respect to health care decisions.

PATH 2: Health Contented. PATH 2 (Health Contented) adults tend to have extremely low levels of health information seeking, extremely low levels of seeking information about nutrition, and extremely low levels of commitment to fitness. PATH 2 adults tend to avoid seeking healthcare when they have a health concern and avoid seeking healthcare due to concerns for costs. PATH 2 adults tend to be ambivalent about whether healthcare providers are competent, but tend to only slightly let concerns about cost to play a role in evaluating medical providers. Consistent with their low level of fitness commitment, PATH 2 adults tend to have low levels of engaging in physical activity or exercise. PATH 2 adults are ambivalent about involvement in family health, and ambivalent about family health responsibility.

PATH 4: Traditionalist. PATH 4 (Traditionalist) adults tend to not be health proactive, get little enjoyment from family health responsibilities, tend to have little focus on family health, but do show above average concern for the quality of healthcare they might receive. PATH 4 adults tend to have a low external locus of control in favor of an internal locus of control with respect to health care decisions, but tend to show very low levels of health information seeking and very low levels of attention to information about nutrition. While PATH 4 adults tend to express an above average commitment to fitness it is not supported by low levels of attention to nutrition and low levels of engagement in regular exercise. PATH 4 adults express a very low willingness to compare health care providers consistent with their very high levels of trust in the competence of physicians and medical providers in general; lack of attention to health information makes them fairly dependent on health-related information possessed by medical professionals, family, and others.

PATH 7: Healthcare Driven. These adults tend to have a strong tendency to seek health care when minor physical problems arise and to not be deferred from seeking care by considerations related to the cost. PATH 7 adults tend to have low concern about the quality of healthcare consistent with a tendency to believe in the competence of medical providers. When comparing healthcare providers, PATH 7 adults tend to give little thought to considerations of price. PATH 7 adults express some commitment to fitness evidenced by somewhat higher levels of health information seeking, and somewhat higher levels of attention to nutrition. However, PATH 7 adults tend to avoid high levels of physical activity and exercise. PATH 7 adults tend to express no responsibility for family health, little enjoyment with respect to family health, although somewhat higher levels of involvement in family health decisions.

PATH 8: Independently Healthy. These adults tend to have a very strong commitment to fitness as evidenced by elevated levels of health information seeking, attention to nutrition, and very high levels of participation in active exercise. This strong commitment to health and fitness among PATH 8 adults does not spill over into the focus on family health: PATH 8 adults tend to have lower involvement in family health decisions, tend towards less responsibility for family health, and ambivalence towards enjoyment from family health. PATH 8 adults tend to be ambivalent about health care costs, avoiding care due to health care costs, yet showing a lower tendency to avoid healthcare in general. PATH 8 adults tend to be ambivalent about concern for health care quality, ambivalent with respect to the competence of healthcare providers, and a balanced level levels of internal and external locus of control with respect to health-related decisions.

