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Occurrence and Co-Occurrence of Types of Complementary and Alternative Medicine Use by Age, Gender, Ethnicity, and Education Among Adults in the United States: The 2002 National Health Interview Survey (NHIS)

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Abstract

Background: There are widespread assumptions that a large proportion of American adults use a variety of complementary and alternative medicine (CAM) therapies. The goal of this study is to explore the clustering or linkages among CAM categories in the general population. Linkset analysis and data from the 2002 National Health Interview Survey (NHIS) were used to address two specific aims. First, the dominant linkages of CAM categories used by the same individual were delineated, and population estimates were generated of the percentage of American adults using different linksets of CAM categories. Second, it was determined whether dominant linkages of CAM modalities differ by age, gender, ethnicity, and education.
Methods: Linkset analysis, a method of estimating co-occurrence beyond chance, was used on data from the 2002 NHIS ($N = 29{,}862$) to identify possible sets of CAM use.
Results: Most adults use CAM therapies from a single category. Approximately 20% of adults combined two CAM categories, with the combination of mind–body therapies and biologically based therapies estimated to be most common. Only 5% of adults use therapies representing three or more CAM categories. Combining therapies across multiple CAM categories was more common among those 46–64, women, whites, and those with a college education.
Conclusions: The results of this study allow researchers to refine descriptions of CAM use in the adult population. Most adults do not use a wide assortment of CAM; most use therapies within a single CAM category. Sets of CAM use were found to differ by age, gender, ethnicity, and education in ways consistent with previous research.

Introduction

Complementary and alternative medicine (CAM) use is believed to be widespread and growing. National estimates from 1990, 1997, and 2002 suggest that 38.8%, 42.1%, and 62%, respectively, of adults use CAM.[1–3] When prayer is not included, 37% of adults in 2002 report using CAM for either illness treatment or disease prevention.[4] Similarly, in 2007, nearly 40% of adults reported using CAM in the previous year.[5] CAM has distinctive patterns of use. It is clear, for example, that any CAM use is highest among adults aged 35–55, among women, and among individuals with higher levels of education.[1–4,6]

Although there are discernible patterns of any CAM use and use of discrete CAM modalities such as relaxation or massage, research has not yet described patterns of use across multiple CAM modalities. Understanding the clustering of CAM therapies across discrete therapies or modality groupings within individuals and segments of the population has both theoretical and practical value. Theoretically, recognizing that CAM includes a variety of self- and other-directed health behaviors,[7] health researchers can use the clustering of CAM modalities as a tool for understanding healthy lifestyles, or the constellation of health behaviors that shape disease and quality-of-life outcomes. Knowledge of statistical associations among multiple CAM modalities can

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be used to avoid confounding in studies that relate CAM use to other outcomes. Practically, health researchers need to develop a sophisticated understanding of CAM adoption. It is commonly believed, for example, that CAM users employ a wide variety of modalities, but it remains virtually unknown how many and what types of modalities are used by the same individual. Regardless of whether the use of multiple CAM therapies has positive or negative health effects, understanding the clustering of CAM modalities within individuals and segments of the population is essential for making sense of population variation in health outcomes.

Few analytic tools exist for describing how different types of CAM use co-occur. Traditional techniques, such as odds ratios and logistic regression, are of limited value because they are restricted to two factors at a time or require one factor to be an "outcome." Other methods, such as log-linear analyses, are problematic because they are restricted to questions of association among multiple factors, which is different from clustering issues. For example, when a set of factors all play roles in a common causal pathway, it is not their log-linear associations that matter, but the fact that they cluster in disease cases but not in controls.

The approach that this report takes is based on the concept of a linkset.[8] The linkset model applies to multiple binary (yes/no) events. The basic concept is that sometimes events co-occur in an individual at random, and sometimes they co-occur more often than expected by random variation. When they co-occur only by chance, then combinations of CAM uses can be simply computed from the prevalence of each component CAM modality. On the other hand, when co-occurrences exceed chance, it is desirable to understand which combinations cluster together, and in what fraction of the population this clustering happens.

The goal of this study is to explore the clustering or linkages among CAM categories in the general population. Linkset analysis and data from the 2002 National Health Interview Survey (NHIS)[3] were used to address two specific aims. First, the dominant linkages of CAM categories used by the same individual are delineated, and population estimates of the percentage of American adults using different linksets of CAM categories are generated. Second, it is determined whether dominant linkages of CAM modalities differ by age, gender, ethnicity, and education.

Materials and Methods

Data for this analysis come from the 2002 NHIS, with the 2002 Alternative Health Supplement.[3] The NHIS is a representative, population-based survey of the civilian, noninstitutionalized U.S. population. The 2002 NHIS included a supplement assessing CAM in the sample adult core ($N = 31{,}044$).

This analysis is limited to respondents who were members of one of four ethnic groups ($n = 29{,}862$), non-Hispanic black (black, $n = 3{,}991$), Hispanic ($n = 5{,}089$), non-Hispanic Asian (Asian, $n = 843$), and non-Hispanic white (white, $n = 19{,}707$). A detailed description of this analytic sample can be found elsewhere.[9]

CAM use

Use of 30 specific CAM modalities in the past year was grouped into four CAM categories delineated by the National Center for Complementary and Alternative Medicine and used in previous research,[4] including the following: (1) alternative medical systems (AMS) reflects any use of acupuncture, Ayurveda, naturopathy, or homeopathy; (2) biologically based therapies (BBT), which includes any use of chelation therapy, folk medicine, herbs, special diets, or use of mega-vitamins; (3) manipulative and body-based methods (MBB), which includes any use of chiropractic care or massage; and (4) mind–body medicine and energy therapies (MBT), which reflects any use of relaxation techniques such as meditation, movement therapies such as yoga, healing rituals, as well as *qi gong* and *Reiki*. Dichotomous measures were constructed for each of the four categories based on whether an individual used at least one remedy within that category in the past year. If all individual therapies that make up one of the four categories had missing information or had a combination of missing and ''no'' responses for the past year, the outcome variable was coded as missing, and not included in this analysis.

Demographic characteristics

Ethnic groups included black, Hispanic, Asian, and non-Hispanic white (white). Age was divided into the cohorts 44 years and younger, 45–54 years, 55–64 years, 65–74 years, and 75 years and older. Educational attainment was divided into the categories of less than high school; high school, general equivalency diploma, or some college; or college graduate.

Statistical methods

The linkset model tests whether or not groupings of events are linked beyond what is expected by chance alone. The linkset model proposes for n events 2^n-1 parameters (β), one for each nonvoid subset of the events, representing the population prevalence of linkage of the included events. The binary events are reports of specific categories of CAM use. For this study of the 2002 NHIS CAM data, there are four events, or four categories of CAM use, resulting in 15 probabilities for each of each of the possible combinations of the four events. These probabilities are converted to linkset (β) parameters in accordance with the assumptions of the linkset model (see Appendix). Maximum likelihood estimation equations are provided in Aickin and Taetle,[8] along with estimates of the sampling standard deviation estimates of the β parameter estimates. All of the linkset computations were carried out using routines written for STATA (Stata Corp. LP, College Station, TX).

The linkset model allows the possibility that some co-occurrences of CAM use occur more frequently than expected from random variation, as expressed by a linkset. The key parameter, β, represents the probability of occurrence of the linkset. Thus, β represents the population fraction of individuals in which the associated types of CAM use are linked beyond chance. β is different from prevalence such that it is a probability that the linkset will occur given that the other events did not occur, whereas the prevalence is the proportion of the sample that has a given combination of events. The linkset model only indicates excess co-occurrences; it does not by itself explain why the underlying linkage occurs, nor does it automatically have any causal interpretation.

As described above, the linkset model applies to a random sample, so that an adjustment is necessary to take into account the NHIS survey design. Weighted percentages that were adjusted for sampling weights and population nesting structure for each linkset by demographic category were obtained from SAS (SAS Institute, Cary, NC) callable PROC CROSSTAB in SUDAAN (Research Triangle Institute, Research Triangle Park, NC). The design effects of multiple selected NHIS continuous variables were determined as the ratio of the standard deviations accounting for the survey design to the standard deviations assuming random sampling. The average design effect for CAM use was 1.57. This upward adjustment was applied to the standard deviations of the linkset β parameters. Weighted proportions with their corresponding overall sample sizes were entered into the linksets application using STATA software. Any parameters with negative β coefficients were dropped, and the application was rerun with the subgroup of linksets to obtain only positive estimates. The calculations of the standard deviations and test statistics for each linkset were completed using the aforementioned design-effect adjustment. Data were then exported from STATA into MS EXCEL to complete the remaining computations of the p-values for each linkset. Differences between the same linkset for various demographic categories were determined and compared using conventional large-sample Normal-theory tests for independent samples. Due to the exploratory nature of this study, the p-values were not adjusted to account for multiple comparisons.

Results

All of the linkset parameters for individual categories of CAM are significantly different from zero, as are all of the linksets of two or more categories of therapies (Table 1). The linkset of BBT and mind–body therapies (MBT) is the most prevalent, representing approximately 2000 individuals in the sample (number in sample $\times \beta$ coefficient $= 29{,}862 \times 0.067$). The second and third most common linksets were MBB with MBT, and BBT with both MBB and MBT.

MBT and BBT are the most common individual modalities for both females and males, with no significant gender difference in prevalence (Table 2). The most common linkset of combined therapies for both females and males was BBT with MBT, but a significantly higher percentage of females than males were likely to have this linkset. Recall that β is the probability of occurrence expected beyond chance, which is different than the raw prevalence of occurrence. Females were also more likely than males to combine MBB and MBT, and to combine therapies from three or more categories (i.e., combination of AMS, BBT, and MBT; and combination of AMS, BBT, MBB, and MBT).

The two most common linksets of multiple therapies for Asians, blacks, whites, and Hispanics are BBT with MBT, and MBB with MBT (Table 3). Overall, whites tend to combine CAM categories more than other races. Whites are more likely to use AMS with BBT and MBB with MBT than both blacks and Hispanics. Whites are also more likely to use the three categories of BBT, MBB, and MBT than Asians and blacks, and AMS, BBT, and MBB together more than Hispanics. Hispanics are the only ethnicity that is more likely to use groups of categories than whites, as they were more likely to use both BBT with MBT and AMS with both BBT and MBT than were whites. Whites are more likely than blacks and Hispanics to use all four major categories. No difference between Asians,' blacks,' and Hispanics' use of combined categories exists.

The top three most common linksets across all five age groups are BBT with MBT, MBB with MBT, and BBT with both MBB and MBT (Table 4). In general, younger age groups are more likely to use groupings of categories than older age groups. Those in the youngest age group ($\leq$44 years old) are significantly more likely to use AMS with BBT, BBT with MBB, and AMS with MBT; and all four categories combined than the oldest age group ($\geq$75-year-olds). The

Table 1. Linkset Probabilities for 2002 NHIS Participants ($N = 29{,}862$)

	Alternative medical system (AMS)	*Biologically based therapy (BBT)*	*Manipulative and body based therapies (MBB)*	*Mind–body therapies with prayer (MBT)*	*Observed prevalence*	β[a]
Nonusers					0.383	0.212***
Single-modality users (subtotal of observed prevalence = 0.411)	■				0.001	0.003***
		■			0.055	0.126***
			■		0.024	0.058***
				■	0.331	0.464***
Linkset users (subtotal of observed prevalence = 0.206)		■		■	0.107	0.067***
			■	■	0.035	0.019***
		■	■	■	0.030	0.015***
		■	■		0.008	0.010***
	■	■	■	■	0.009	0.007***
	■	■		■	0.008	0.006***
	■	■			0.002	0.004***
	■			■	0.003	0.003***
	■		■		0.001	0.002***
	■	■	■		0.001	0.002***
	■		■	■	0.002	0.001*

Shading indicates use of complementary type, either alone or in combination.
[a] β is the probability that complementary and alternative medicine types are linked.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$ (two-tailed).

Table 2. Linkset Probabilities by Gender

Alternative medical system (AMS)	*Biologically based therapy (BBT)*	*Manipulative and body based therapies (MBB)*	*Mind–body therapies with prayer (MBT)*	*Females (N = 12,952)* β[a]	*Males (N = 16,910)* β[a]	*Gender difference p-Value*
■				0.004***	0.003***	
	■			0.134***	0.121**	
		■		0.060***	0.056**	
			■	0.553***	0.374*	
■	■			0.003***	0.004**	
■		■		0.001***	0.003***	
	■	■		0.012***	0.009**	
■			■	0.003***	0.002**	
	■		■	0.076***	0.056**	$p < 0.001$
		■	■	0.024***	0.014**	$p < 0.01$
■	■	■		0.003***	0.002***	
■	■		■	0.008***	0.004**	$p < 0.01$
■		■	■	0.001*	0.000***	
	■	■	■	0.019***	0.011**	
■	■	■	■	0.008***	0.005**	$p < 0.05$

Shading indicates use of complementary therapy type, either alone or in combination.
[a]β is probability that complementary and alternative medicine types are linked.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$ (two-tailed).

youngest age group is also more likely to use AMS, BBT, and MBT together than 65–74-year-olds. The group of 45–54-year-olds is more likely to use BBT with MBB, BBT with MBT, MBB with MBT, BBT with both MBB and MBT, and all four categories combined than the oldest age group. They are also more likely to use BBT with MBT than 65–74-year-olds. The 55–64-year-olds are more likely to use BBT and MBT; AMS, BBT, with MBT; BBT with both MBB and MBT; and all four categories combined than the oldest age group. They also use more AMS with both BBT and MBT than the next older age group of 65–74-year-olds. The one exception to younger groups using more CAM modalities together than the older groups is that the youngest group is less likely to use BBT with MBT than 45–54-year-olds. Respondents in the two age categories older than 64 did not differ in the combinations of CAM use they chose. The 55–64-year age group did not differ in their patterns of CAM use from the two youngest groups.

The top two most common linksets for educational attainment groups of less than high school, high school or some college, and college graduates were BBT with MBT and MBB with MBT (Table 5). The third most common linkset

Table 3. Linkset Probabilities by Race

Alternative medical system (AMS)	*Biologically based therapy (BBT)*	*Manipulative and body based Therapies (MBB)*	*Mind–body therapies with prayer (MBT)*	*Asian (A) (N = 843)* β[a]	*Black (B) (N = 3991)* β[a]	*White (W) (N = 19,707)* β[a]	*Hispanic (H) (N = 5089)* β[a]	*Comparison*
■				0.006	0.001	0.003***	0.005**	
	■			0.198***	0.071***	0.134***	0.092***	
		■		0.025**	0.011***	0.070***	0.022***	
			■	0.396***	0.632***	0.436***	0.466***	
■	■			0.008	0.001	0.004***	0.001	W > B**, W > H**
■		■		0.005	0.001	0.002***	0.001	
	■	■		0.018*	0.008**	0.011***	0.004**	W > H**
■			■	0.011*	0.003**	0.003***	0.002	
	■		■	0.083***	0.080***	0.065***	0.083***	H > W*
		■	■	0.022**	0.015***	0.024***	0.013***	W > B*, W > H***
■	■	■		0.005	0.001	0.002***	0.000	W > H**
■	■		■	0.002	0.006***	0.006***	0.009***	H > W*
■		■	■	0.003	[b]	0.001	0.002*	
	■	■	■	0.002	0.009**	0.017***	0.012***	W > A*, W > B*
■	■	■	■	0.007	0.002	0.008***	0.004***	W > B***, W > H**

Shading indicates use of complementary therapy type, either alone or in combination.
[a]β is probability that complementary and alternative medicine types are linked.
[b]Empty cell denotes 0 estimate.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$ (two-tailed).

Table 4. Linkset Probabilities by Age Group

Alternative medical system (AMS)	*Biologically based therapy (BBT)*	*Manipulative and body based therapies (MBB)*	*Mind–body therapies with prayer (MBT)*	*≤44 years (age 1) (N = 15,184)* β[a]	*45–54 years (age 2) (N = 5276)* β[a]	*55–64 years (age 3) (N = 3834)* β[a]	*65–74 years (age 4) (N = 2848)* β[a]	*≥ 75 years (age 5) (N = 2720)* β[a]	*Comparison*
				0.003***	0.005**	0.005*	0.003	0.003	
				0.123***	0.147***	0.151***	0.104***	0.072***	
				0.060***	0.061***	0.058***	0.057***	0.032***	
				0.413***	0.465***	0.506***	0.554***	0.618***	
				0.004***	0.005**	0.002	0.003	0.001	Age 1 > age 5*
				0.002**	0.003*	0.003	0.003	[b]	
				0.011***	0.013***	0.009*	0.008*	0.003	Age 1 > age 5,** age 2 > age 5*
				0.003***	0.004*	0.002	0.001	0.001	Age 1 > age 5**
				0.066***	0.089***	0.073***	0.056***	0.045***	Age 2 > age 1, age 4, age 5**; age 3 > age 5*
				0.021***	0.027***	0.018**	0.014*	0.011*	Age 2 > age 5**
				0.002***	0.003*	0.003	0.003	[b]	
				0.006***	0.006**	0.010***	0.002	0.002	Age 1 > age 4*; age 3 > age 1, age 5**
				0.002**	[b]	0.000	[b]	0.001	
				0.016***	0.017***	0.015***	0.015***	0.006*	Age 2, age 3 > age 5*
				0.007***	0.008***	0.007***	0.004*	0.001	Age 1, age 2 > age 5***; age 3 > age 5*

Shading indicates use of complementary type, either alone or in combination.
[a]β is probability that complementary and alternative medicine types are linked.
[b]Empty cell denotes 0 estimate.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$ (two-tailed).

Table 5. Linkset Probabilities by Education Level

Alternative medical system (AMS)	*Biologically based therapy (BBT)*	*Manipulative and body based therapies (MBB)*	*Mind–body therapies with prayer (MBT)*	*Less than high school (LHS) (N = 5724)* β[a]	*High school or some college (HS) (N = 17,053)* β[a]	*College (COL) (N = 6846)* β[a]	*Comparison*
				0.001	0.004***	0.004**	
				0.070***	0.120***	0.190***	
				0.031***	0.064***	0.067***	
				0.502***	0.455***	0.455***	
				0.002*	0.002***	0.008***	COL > HS**, COL > LHS***
				0.003**	0.001**	0.005**	COL > HS*
				0.003*	0.010***	0.015***	COL > HS**, COL > LHS**
				0.001	0.002**	0.008***	COL > LHS***, COL > HS**
				0.042***	0.068***	0.089***	HS > LHS***, COL > LHS***
				0.008***	0.018***	0.036***	HS > LHS*, COL > LHS***, COL > HS***
				0.000	0.002***	0.004**	HS > LHS, COL > LHS*
				0.004***	0.004***	0.010***	COL > LHS**, COL > HS*
				0.000	0.001*	0.000	
				0.004**	0.013***	0.025***	HS > LHS***, COL > LHS***, COL > HS**
				0.001*	0.006***	0.011***	HS > LHS***, COL > LHS***, COL > HS*

Shading indicates use of complementary type, either alone or in combination.
[a]β is probability that complementary and alternative medicine types are linked.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$ (two-tailed).

was the same for high school or some college and college graduates: BBT with both MBB and MBT. For respondents with less than high school education, there was a near tie between AMS with BBT and MBT, and BBT with MBB and MBT. Greater education is associated with greater probability of using most of the identified linksets: Across all but one of the linksets reflecting therapies from different CAM groupings, individuals with a college degree were more likely than those with less education to combined different therapies.

Discussion

Understanding the broad assortment of health practices classified as CAM remains poor. Of particular interest is the lack of attention to the way CAM-related behavior and practices may be configured in sets or lifestyle patterns. It is widely assumed, for example, that CAM users integrate a variety of distinct modalities into an overall strategy for self-managing health. Astin[10] formalizes this assumption by arguing that CAM use is part of an overall lifestyle reflecting an alternative, holistic worldview of both health and health care. Arcury et al.[11] show that rural older adults display distinct patterns of CAM use based on a qualitative analysis. The extent to which CAM users adopt and use combinations of modalities has not been critically evaluated or documented quantitatively. This study examined the clustering of distinct CAM categories within the general population, and the extent to which the clustering of CAM varies across subgroups of the population using a new analytic method: linkset analysis. The results of this study add to the CAM use literature, as well as health behavior more broadly, and demonstrate a method that may be used more widely in population co-occurrence studies.

However, the contributions of this study must be considered within the context of its limitations. First, to minimize the exponential growth of parameter estimates and subsequent statistical comparisons, this analysis focused on combinations of therapies across different CAM categories. Gains in parsimony resulted in lost variation of CAM use within categories, such as individuals who use multiple forms of BBT, or multiple mind–body methods. Future research should elaborate the clusters or sets of therapies used within conceptually elaborated groups of CAM. Additionally, researchers are encouraged to consider sets of therapies combined within and across more refined strata, such as educational differences by gender or age differences by ethnicity. Next, the alternative health supplement of the NHIS required individuals to report on their use of CAM during the past 12 months. Evidence suggests that there is substantial variability in the accuracy of retrospective recall by age, gender, and education,[12] suggesting that some of our results regarding differences in CAM by age and race could be an artifact of reporting biases. The cross-sectional design of the NHIS makes it impossible to differentiate age from cohort effects. Finally, given that the CAM portion of the NHIS was a required part of the survey with a limited number of CAM questions, not all CAM modalities were considered. This restriction may reduce the amount of CAM modalities reported by certain ethnic minorities, especially as the survey was written based on CAM types used by the ethnic majority of the NHIS population.[13] Similarly, the comparatively small number of Asian Americans in the NHIS sample may have contributed to insufficient power to detect differences in some linksets by ethnicity. For example, the linkset of BBT and MBT differed between Hispanics and whites but not Asians and whites, despite the fact that Asians and Hispanics had identical parameters. Future studies should be designed to specifically examine ethnic variation in the use of multiple CAM modalities.

Using the most comprehensive data available, our estimates indicate that most adults are either nonusers of CAM or they are single-category users. Although the prevalence of each linkset is relatively small, the number of people reflected in each linkset is large, as each prevalence needs to be multiplied by the current U.S. population. As was documented in Table 1, 38.3% of adults did not use CAM in the past 12 months,[3] while another 41.1% reported using practices or behaviors within a single category. Only 20.6% of adults use two or more CAM categories, half of which (10.7%) combine BBT with MBT. According to a previous detailed description of CAM use in the 2002 NHIS,[3] use of herbal supplements and prayer are the primary practices underlying BBT and MBT, respectively. By extension, the results of our study suggest that CAM use is not widespread among American adults. Rather, a significant minority of adults use one type of CAM, mostly self-prayer, while another 20% use herbal supplements in addition to self-prayer. This leaves only 5% of adults using an assortment of different CAM modalities. This explicit description of adult CAM use patterns across multiple categories fundamentally reshapes epidemiological understanding of CAM use: Many adults use one or two types of CAM, but only a very few adults use diverse therapies that cross discrete CAM categories.

The results of this study also shed light on the modalities that may serve as the gateway to adults' broader use of CAM. Use of MBT was included in the three most common linksets and use of BBT was included in two of three most common linksets. Individuals who use MBT and BBT (with or without other CAM categories) represent at least 74.7% of all individuals using two or more CAM therapies. The relatively common occurrence of this linkset suggests that MBT such as self-prayer and use of BBT, such as herbal supplements, may provide the foundation for the breadth and degree of CAM use. That is, individuals can easily experiment with practices such as self-prayer or meditation and use of herbal teas; it is possible that the ease of these practices may, if appraised as effective, serve as entrée to a larger array of CAM-related behaviors. Unfortunately, the NHIS data are unable to delineate individuals' progressive use of CAM, so the extent to which MBT and BBT serve as gateways to more comprehensive use of CAM or whether individuals simply end up using these types of therapies after experimenting with others awaits future research.

Another contribution of this study is evidence indicating significant variability in the prevalence of the CAM linksets across demographic groups. Several linksets were found to be stronger for women than men; stronger for young and midlife adults than for older adults; and stronger for those with greater education. Results also indicate ethnic variation in the CAM linksets such that links among several CAM categories are greater among whites than other ethnic groups. These results are consistent with previous descriptions of any CAM use,[1–4,6] and they suggest that members of

some groups are not only more likely to use CAM, but they are also more likely to have incorporated modalities from several CAM categories into their overall approach to health self-management. The age, gender, ethnic, and socioeconomic variation in the strength of the links between distinct CAM categories is compelling because it suggests that members of different groups may use group-specific criterion when deciding which CAM modalities to adopt. This thinking is consistent with previous CAM research[14,15] positing that cultural beliefs and previous experiences, all of which likely differ across groups, shape individuals' interpretations and responses to health concerns. Future research should replicate the observed pattern of differences between groups, perhaps using more recent CAM data from the 2007 NHIS, and extend the analyses with covariate adjustment to better interpret group differences in the CAM linksets.

This study also makes methodological contributions to the literature. It is not uncommon to see tables that associate pairs of events, such as CAM modalities, but even an analysis of all possible pairs cannot cast light on the co-occurrence of three or more events. By positing the existence of linksets, binary variables that stand for a co-occurrence for some underlying process beyond chance, the linkset approach makes it possible to quantify co-occurrences may be worthy of further investigation. This points to future research directions in which hypotheses can be proposed and tested to account for specific linkages that have been discovered or assumed. For example, Health Promotion fundamentally argues that a "healthy lifestyle" contributes to better health. The underlying assumption is that positive behaviors such as exercise, abstinence from tobacco and other substances, low fat consumption, and sufficient sleep actually cluster to create "healthy lifestyle." Unfortunately, the veracity of this assumption remains virtually untested, but linksets makes the test possible.

Conclusions

In summary, this study used comprehensive data from the 2002 NHIS to examine the clustering of CAM categories within individuals. The results clearly demonstrate that most adults do not use broad sets of CAM. Rather, most adults use one or possibly two types of CAM for health self-management. These findings fundamentally reshape epidemiological understanding of CAM and they suggest that CAM use, like other forms of health behavior, may not be part of a broader overall lifestyle.

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Disclosure Statement

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(Appendix follows →)

Appendix: The Linkset Model

The model applies to a 2^n contingency table; that is, the collection of all possible outcomes of n binary variables (a binary variable is one that assumes only the values 0 or 1). Let $x_1, \ldots, x_n$ stand for these binary random variables. For each nonvoid subset L of the subscripts $\{1,2, \ldots, n\}$, let b_L be a latent (that is, unobserved) binary random variable. These latent binary variables are independent of each other. This is a condition of the model, not an empirical condition to be tested. The model connection between the latent and observed variables is that the event $x_i = 1$ happens if (and only if) $b_L = 1$ for some L containing i. Stated in words, saying that the variable x_i is observed to be 1 is the same as saying that at least one of the latent events was equal to 1, for which the x-subscript i is in the b-subscript of the latent variable.

The event $b_L = 1$ is interpreted to mean that all of the x-variables with indices in L occurred together as a consequence of some underlying process that is being modeled. That is, they were linked, assuming that L contains at least two indices. It is also possible for a collection of the x-variables all to be 1 by chance, without any $b_L = 1$ event linking them together. Thus, the linkset model provides for two ways in which a cell in the 2^n table can happen: all of the x-variables defining that cell were 1 due to chance, or due to being linked. The model does not specify the nature of the linkage. It only provides a modeling mechanism that can portray linkage.

For example, the event $x_i = 1$, $x_j = 1$ occurs either because only $b_{\{i\}} = 1$ and $b_{\{j\}} = 1$ (the x-variables were unlinked) or because $b_{\{i,j\}} = 1$ (they were linked). The three latent variables $b_{\{i\}}$, $b_{\{j\}}$, and $b_{\{i,j\}}$ are independent as a condition of the model.

There are 2^n–1 nonvoid subsets L of indices, corresponding to the fact that there are 2^n–1 independent cell probabilities. There is a 1–1 relationship between the cell probabilities and the linkset parameters, which are β_L = probability that $b_L = 1$. Consequently, β_L is the population fraction of individuals in which the x-variables with indices in L are linked beyond chance. This is not the same as the probability that these variables are all equal to 1. These latter cell probabilities are usually taken as the prevalences of the co-occurrence of the x-variables that define each cell in the 2^n table. In contrast, the β_L parameters are the population fractions of individuals in which linkage occurs for the indices in the linkset L. The mathematical relationship between the cell probabilities and the linkset parameters is complicated, and requires a computer routine to convert back and forth between them. The maximum likelihood estimates of the β-parameters exist so long as there is a positive probability that all the x's are 0. An expression is available for the sampling standard deviations of the β-estimates, but it is complicated and also requires a computer program.