Empirical redefinition of comprehensive health and well-being in the older adults of the United States

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The World Health Organization (WHO) defines health as a "state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." Despite general acceptance of this comprehensive definition, there has been little rigorous scientific attempt to use it to measure and assess population health. Instead, the dominant model of health is a disease-centered Medical Model (MM), which actively ignores many relevant domains. In contrast to the MM, we approach this issue through a Comprehensive Model (CM) of health consistent with the WHO definition, giving statistically equal consideration to multiple health domains, including medical, physical, psychological, functional, and sensory measures. We apply a data-driven latent class analysis (LCA) to model 54 specific health variables from the National Social Life, Health, and Aging Project (NSHAP), a nationally representative sample of US community-dwelling older adults. We first apply the LCA to the MM, identifying five health classes differentiated primarily by having diabetes and hypertension. The CM identifies a broader range of six health classes, including two "emergent" classes completely obscured by the MM. We find that specific medical diagnoses (cancer and hypertension) and health behaviors (smoking) are far less important than mental health (loneliness), sensory function (hearing), mobility, and bone fractures in defining vulnerable health classes. Although the MM places two-thirds of the US population into "robust health" classes, the CM reveals that one-half belong to less healthy classes, independently associated with higher mortality. This reconceptualization has important implications for medical care delivery, preventive health practices, and resource allocation.

comprehensive health | aging | disease | well-being | health policy

In 1946, the World Health Organization (WHO) defined health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (1). In 1977, George Engel (2) built on this definition, calling for a new biopsychosocial model. It integrated traditional medicine with psychosocial factors, which stimulated the field of psychosomatic medicine. These ideas have been honored more as an ideal than in practice.

Here, we seek to apply this comprehensive definition to characterize the health of US older adults living in their homes. Studying a representative sample of the US population ages 57–85 y old [the National Social Life, Health and Aging Project (NSHAP)], we gathered wide-ranging information on the diseases of the traditional "Medical Model" (MM) and also, psychological well-being and physical function in a "Comprehensive Model" (CM) informed by the approach by Engel (2, 3). We empirically determined if these health measures formed distinct constellations, characterizing groups of people with different patterns of health and well-being. Our large survey of 3,005 community-dwelling older adults ages 57–85 y old was not a clinical sample or a sample of convenience but one systematically selected to represent all older, community-dwelling adults of the United States, regardless of their health status.

The standard MM of health, sometimes called the biomedical model, has its origins in the 1910 Flexner Report (4), which codified medical education and focuses on diseases, specifically their pathology, biochemistry, and physiology (5–8). It is exemplified in hospital-based care responding to failure of specific organ systems, codified in international health care reimbursement categories [International Classification of Diseases (ICD) codes (9)] and historically instantiated in the organization of the National Institutes of Health [e.g., National Cancer Institute (1937) and National Heart, Lung and Blood Institute (1948) (10)].

More typically, however, older adults often have more than one organ system-based disease (e.g., both diabetes and hypertension), forming a cluster of problems (11), although their other organ systems continue to function (e.g., kidneys and lungs). Therefore, our first step was to empirically identify distinct constellations of health states within the MM. We used data on prevalent causes of death to select diseases for inclusion (12). These selected diseases are heart disease, cancer, lung disease, stroke, diabetes, kidney disease, and liver disease. We also include common diseases in older adults, albeit with low associated mortality: arthritis, hypertension, asthma, and thyroid disease (measures 1–19 in Fig. S1 document the organ system diseases).

We then propose the CM intended to correspond theoretically to the health definitions of the WHO (1) and Engel (2) by incorporating five additional functional dimensions relevant for broadly characterizing health and well-being: health behaviors, psychological health, sensory abilities, neuroimmune function, and mobility (Fig. S1). These dimensions and the domains within them are not part of the biomedical model (2). They reflect the integrative role of the central nervous system (CNS) and the peripheral nervous system with behavior (13, 14) and undergird the robust health

Significance

Health has long been conceived as not just the absence of disease but also the presence of physical, psychological, and social well-being. Nonetheless, the traditional medical model focuses on specific organ system diseases. This representative study of US older adults living in their homes amassed not only comprehensive medical information but also psychological and social data and measured sensory function and mobility, all key factors for independent living and a gratifying life. This comprehensive model revealed six unique health classes, predicting mortality/incapacity. The healthiest people were obese and robust; two new classes, with twice the mortality/incapacity, were people with healed broken bones or poor mental health. This approach provides an empirical method for broadly reconceptualizing health, which may inform health policy.

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crucial to quality of life and continued independence in older adults (15, 16). The additional 35 health measures (Fig. S1, measures 20–54), although not exhaustive, were selected to represent all five dimensions. For conceptual clarity and analytic tractability, we focus our analysis on physical and psychological domains of these dimensions, keeping the individual at the center of the analysis. We consider the social domains only in relation to these other person-centered domains and characterize people in terms of marital status, sexual intimacy, social interactions, and socioeconomic status as well as age, race, and gender.

To group all respondents into distinct constellations or classes based on their multiple health measures, we used latent class analysis (LCA; also called finite mixture modeling) (17). LCA posits an underlying structure to a population that is not directly observable but can be identified using a sufficiently large collection of observable variables. The LCA then identifies distinct subgroups or classes within the larger population based on underlying commonalities among variables, commonalities that are assumed to arise from the underlying "latent" characteristic. After the classes have been identified mathematically (specifying the constellation of values of the health measures that group together), each respondent can be assigned to the most appropriate class based on his or her particular values for each of the health measures.

We ask several questions. What are the health characteristics that appear together in each of the classes identified? Which health measures best discriminate among the constellations? We report the prevalence of all health measures in each class relative to the general US population. We use heat maps (Figs. 1 and 2), in which each cell is color-coded to indicate prevalence of a measure significantly lower than, typical of, or higher than the general population (green, yellow, and red, respectively). The resulting heat map presents a visual snapshot of the characteristics of the classes across all health measures, allowing the reader to scan down characteristics for each class and across classes for different groups of characteristics, effectively and quickly summarizing constellations of health that appear in the US population of older adults.

We hypothesized that including the measures covering the five additional dimensions of the CM of health would significantly change the constellation of characteristics defining distinct groups of older adults in the United States. Doing so, we argue, would illuminate the significant associations between functioning, well-being, and disease in older people. If so, these new constellations would create a richer picture of the diverse types of aging and could inform the ongoing restructuring of the US health care system.

To robustly validate the health of individuals within each health class, we used three standard health measures that were independent of the LCAs: (*i*) the number of vulnerable health measures per individual, with vulnerable defined by clinical or literature-based cut points (Figs. 1 and 2 and Fig. S1); (*ii*) the number of the major chronic diseases that each individual had [defined by the Charlson Index (18, 19); labeled as Charlson comorbid diseases], and (*iii*) the proportion of individuals in each class who died or were too incapacitated to be interviewed by the time of the second wave of data collection (labeled as deceased or incapacitated 5 y later). We refer to these three measures as the mortality and morbidity of the individuals within a class. The person's subjective assessments of global physical and mental health are additional validators of the health classes (20, 21).

Aging has been conceptualized as the increasing loss of physiologic function, a trajectory followed by most people as they get older (22). If so, health classes in an aging population should be arranged linearly by chronological age as people progress from one class to the other in sequence. Alternatively, aging can be conceptualized as a diverse set of pathways (23, 24), with chronological age being a poor predictor of whether an aging pathway or sustained health will be followed. We follow individuals over a 5-y period, assessing the likelihood of stable class membership and the transition to improvement, incapacitation, or death.

Prevalence Relative to US Population		
Lower	Same	Higher

				MEDICAL MODEL HEALTH CLASSES				
				Not Diabetic		Diabetic		
				MM1 Unrecog-nized HTN	MM2 1 Non-CV Disease	MM3 Uncontrol. Diabetes	MM4 CVD, Diabetes	MM5 Exten. Multi-morbid.
		U.S. Population Share	100%	38%	26%	12%	9%	15%
		Sample Size	3005	1149	770	361	271	454
DIMENSION	DOMAINS	ORGAN SYSTEM HEALTH MEASURE	US POP.	Class Prevalence (Coded Relative to US Population)				
ORGAN SYSTEM DISEASES DIAGNOSED	Endocrine	1. Diabetes	20%	0%	0%	100%	39%	39%
		2. HbA1C >6.5%	19%	7%	2%	69%	35%	30%
		3. Thyroid	15%	14%	17%	8%	18%	22%
	Cardiovascular	4. Hypertension (HTN)	54%	48%	34%	70%	89%	76%
		5. Systolic BP >140 mm/Hg	40%	61%	0%	32%	98%	29%*
		6. Diastolic BP >90 mm/Hg	24%	35%	1%	8%	92%	0%*
		7. Rapid Pulse, >80 bpm	24%	23%	17%	34%	37%	16%*
		8. Heart Attack	12%	4%	1%	0%	21%	58%
		9. Cerebrovascular	8%	2%	5%	3%	20%	28%
		10. Heart Failure	8%	0%	0%	1%	20%	47%
	Lung	11. COPD	11%	6%	12%	6%	10%	29%
		12. Asthma	10%	5%	13%	7%	14%	19%
	Immune	13. Arthritis	52%	45%	47%	49%	66%	71%
		14. Peptic Ulcer	13%	8%	13%	9%	24%	27%
	Filtration	15. Chronic Kidney Disease	4%	0%	2%	3%	6%	14%
		16. Severe Liver Damage	1%	1%	0%	3%	1%	3%
	Cancer	17. Skin	16%	16%	12%	9%	8%	32%
		18. Reproductive	8%	9%	7%	7%	4%	8%
		19. Non-Reproductive	5%	4%	6%	6%	2%	11%
MORBIDITY PER INDIVIDUAL AND MORTALITY/INCAPACITY PREVALENCE WITHIN EACH CLASS								
		# Vulnerable Health Measures	3.3	2.8	1.9	4.0	5.9	5.5
		# Charlson Comorbid Diseases	1.7	1.0	1.1	2.2	2.4	3.9
		Deceased or Incapacitated 5 years later	19%	14%	15%	20%	24%	35%

Fig. 1. The MM with five distinct classes of organ system diseases and health. The column US population (US Pop.) reports the prevalence in 2005 of each disease in the older US Pop. ages 57–85 y old. Within each health class (columns), the prevalence of a given disease indexes the likelihood that any member of the class has that particular disease [rows; $n = 19$ health measures ordered by prevalence within each of the six domains (column 2) within the organ system dimension (column 1)] and shares similar constellations of disease and health. Colors indicate the prevalence of each class's disease prevalence relative to the US Pop.: green, lower ($P \leq 0.01$); yellow, typical [not significant (NS)]; red, higher ($P \leq 0.01$). Morbidity was indexed by the proportion of class members who were incapacitated (i.e., too sick to interview at the 5-y follow-up), and mortality was indexed by the proportion who had died. *Given the health context of extensive multimorbidity, the classification of these blood pressure measures was overridden and designated vulnerable (red). BP, blood pressure; COPD, chronic obstructive pulmonary disease; CV, cardiovascular; CVD, cardiovascular disease; HTN, hypertension.

Results

MM: Distinct Classes Distinguished by Diabetes and Hypertension. Analysis of the organ system diseases of the MM identified five distinct classes of disease and health among older, community-dwelling Americans, each statistically independent of the others (Fig. 1). Diabetes, which accounted for only 3% of deaths over the age of 55 y old in 2010 (25), nonetheless had the greatest power to distinguish among these five health classes, dividing the five into two broader sets. One set was very robust, with a complete absence of diagnosed diabetes (0%) and only 7% (MM1) and 2% (MM2) with measured diabetes [HbA1C > 6.5 (26)] (Fig. 1, measures 1 and 2). The other set was quite vulnerable to diabetes and other diseases (MM3–5: 39–100% had diagnosed diabetes and 30–69% had measured diabetes).

Cardiovascular diseases (Fig. 1, measures 4–10), which account for 35% of deaths over the age of 55 y old (25), did not distinguish robust from vulnerable classes. Rather, blood pressure measured in the home distinguished the two robust nondiabetic classes. No one in MM1 [*Unrecognized Hypertension* class] had normal systolic blood pressure; 100% were elevated (61% into hypertension stage I or II). In sharp contrast, 0% of the second robust class (MM2 *One Noncardiovascular Disease*) had hypertensive blood pressure, and even the 34% diagnosed with hypertension were well-controlled. Instead, most in MM2 had only one, if any, of a variety of noncardiovascular diseases or conditions (e.g., asthma, chronic obstructive pulmonary disease, thyroid disease, ulcers, or cancer) (27).

Prevalence Relative to US Population				COMPREHENSIVE MODEL HEALTH CLASSES					
				Robust		Intermediate		Vulnerable	
Lower	Same	Higher		CM1 Robust Obese	CM2 One Minor Condition	CM3 Broken Bones	CM4 Poor Mental Health	CM5 Diabetes, HTN, Immob.	CM6 Extensive Multimorbid, Frailty
			U.S. Population Share	100%	22%	21%	15%	16%	13%
			Sample Size	3005	625	604	411	389	515	461
DIMENSIONS	DOMAINS	COMPREHENSIVE HEALTH MEASURES	US POP.	Class Prevalence (Coded Relative to US Population)					
I. ORGAN SYSTEM DISEASES DIAGNOSED	Endocrine	1. Diabetes	20%	10%	8%	14%	18%	44%	33%
		2. HbA1C >6.5%	19%	13%	6%	12%	20%	43%	26%
		3. Thyroid	15%	11%	15%	17%	14%	15%	25%
	Cardio-vascular	4. Hypertension (HTN)	54%	52%	35%	49%	49%	73%	73%
		5. Systolic BP >140 mm/Hg	40%	45%	33%	40%	39%	44%	38%*
		6. Diastolic BP >90 mm/Hg	24%	31%	11%	23%	21%	29%	23%*
		7. Rapid Pulse, >80 bpm	23%	22%	13%	23%	22%	35%	28%
		8. Heart Attack	12%	5%	7%	11%	11%	16%	26%
		9. Cerebrovascular Disease	8%	3%	3%	6%	7%	11%	25%
		10. Heart Failure	8%	2%	3%	6%	8%	11%	26%
	Lung	11. COPD	11%	5%	7%	11%	10%	14%	27%
		12. Asthma	10%	6%	7%	8%	14%	9%	22%
	Immune	13. Arthritis	52%	37%	41%	55%	43%	70%	77%
		14. Peptic Ulcer	13%	5%	13%	11%	10%	18%	27%
	Filtration	15. Chronic Kidney Disease	4%	0%	1%	3%	2%	5%	15%
		16. Severe Liver Damage	1%	0%	0%	1%	2%	1%	3%
	Cancer	17. Skin	16%	10%	20%	19%	15%	13%	19%
		18. Reproductive	8%	7%	8%	9%	8%	5%	7%
		19. Non-Reproductive	5%	5%	4%	6%	4%	7%	8%
II. HEALTH BEHAVIORS	Obesity	20. Central Obesity	47%	60%	0%	47%	37%	84%	65%
		21. Obese	39%	54%	1%	34%	29%	70%	47%
	Sleep	22. Atypical Sleep Duration	43%	35%	29%	40%	56%	45%	67%
		23. Wakes Up Tired	39%	23%	20%	36%	62%	49%	67%
	Risky Behavior	24. Drinking Problem	25%	29%	26%	25%	33%	21%	16%
		25. "Heavy" Drinker	18%	21%	18%	22%	26%	12%	9%
		26. Smoker	20%	17%	20%	16%	20%	24%	30%
		27. STD Ever Diagnosed	9%	8%	9%	8%	12%	8%	7%
III. PSYCHO-LOGICAL HEALTH	Mental Health	28 Perceived Stress	51%	27%	38%	45%	92%	50%	87%
		29. Depressive Symptoms	20%	2%	5%	10%	58%	15%	60%
		30. Loneliness	17%	7%	7%	17%	45%	9%	38%
		31. Anxiety Symptoms	13%	3%	2%	7%	41%	6%	39%
		32. Low Self-esteem	13%	6%	10%	10%	27%	10%	24%
		33. Unhappiness	9%	0%	2%	5%	24%	3%	32%
	Memory	34. Poor Memory	53%	45%	48%	43%	59%	58%	74%
IV. SENSORY FUNCTION	Objective Sensory Measures	35. Impaired Taste	44%	51%	42%	37%	35%	48%	50%
		36. Visual Acuity ≤ 20/40	37%	25%	32%	39%	40%	43%	61%
		37. Impaired Night Vision	31%	12%	25%	31%	34%	40%	72%
		38. Impaired Touch	32%	22%	31%	30%	29%	42%	42%
		39. Impaired Odor ID	19%	14%	16%	14%	24%	19%	36%
		40. Impaired Hearing	18%	8%	20%	13%	17%	24%	33%
V. NEURO-IMMUNITY	Infection Inflam.	41. Poor Viral Surveillance	49%	52%	43%	50%	41%	58%	50%
		42. Chronic Inflammation	30%	27%	10%	33%	29%	51%	43%
VI. FRAILTY	Mobility and Stamina	43. Slow Gait	58%	33%	53%	54%	66%	81%	87%
		44. Pain While Walking	39%	20%	23%	35%	39%	57%	82%
		45. Impaired Mobility	25%	2%	6%	15%	8%	49%	90%
		46. Inactive	21%	10%	8%	14%	20%	32%	60%
		47. Bone Breaks(s) age 45+	21%	0%	0%	100%	0%	0%	39%
		48. Osteoporotic Fracture	6%	0%	0%	28%	0%	0%	14%
		49. Anemia	14%	7%	12%	13%	12%	14%	31%
		50. Difficulty 2+ ADLs	13%	0%	2%	6%	2%	22%	60%
		51. Exercise Restricted	5%	2%	2%	5%	6%	4%	17%
	Incontin-ence	52. Urinary Incontinence	41%	22%	31%	45%	45%	58%	64%
		53. Voiding Dysfunction	25%	12%	23%	21%	32%	28%	42%
		54. Fecal Incontinence	9%	2%	4%	9%	13%	10%	26%
MORBIDITY PER INDIVIDUAL AND MORTALITY/INCAPACITY PREVALENCE WITHIN EACH CLASS									
		# Vulnerable Health Measures	10.0	7.2	6.1	10.1	11.0	12.1	17.0
		# Charlson Comorbid Diseases	1.7	1.0	1.2	1.6	1.5	2.2	3.3
		Deceased or Incapacitated 5 years later	19%	6%	16%	14%	19%	19%	44%

Fig. 2. The CM of health with six distinct health classes based on 54 health measures across six dimensions (listed in column 1). The column US population (US Pop.) reports the prevalence in 2005 of each disease or condition in the older US Pop. ages 57–85 y old (definitions and validation are in Fig. S1). Within each health class (columns), the prevalence of a given disease or condition indexes the likelihood that any member of the class has that particular disease [rows; $n = 54$ health measures ordered by prevalence within each health domain (column 2)] and shares similar constellations of disease and health. Colors indicate the prevalence of each class's disease and conditions relative to the US Pop.: green, lower ($P \leq 0.01$); yellow, typical [not significant (NS)]; red, higher ($P \leq 0.01$; indicating greater vulnerability). Morbidity was indexed by the proportion of class members who were incapacitated and too sick to interview at the 5-y follow-up, and mortality was indexed by the proportion who had died. *Given the health context of extensive multimorbidity, the classification of these blood pressure measures was overridden and designated vulnerable (red). ADL, activities of daily living; BP, blood pressure; COPD, chronic obstructive pulmonary disease; HTN, hypertension; ID, identification; STD, sexually transmitted diseases.

All three indicators of mortality and morbidity (bottom three rows of Fig. 1) were significantly lower in the two robust classes (MM1 and -2) than in the overall population. These classes had the fewest number of health measures signifying disease as well as the lowest prevalence of physician-identified organ system diseases (Charlson comorbid diseases) (Fig. 1) (18, 19). Fully two-thirds of older adults in America were members of these robust classes.

Surprisingly, although cancer caused 24% of deaths among those over the age 55 y old in 2005 (25), no cancer type distinguished the five MM classes (Fig. 1, measures 17–19). Rather, cancers seemed to develop randomly with respect to other organ system diseases.

The three vulnerable classes (MM3–5) shared a high prevalence of diabetes and hypertensive blood pressure but were distinguished by their constellations of other diseases. The *Uncontrolled Diabetes* class (MM3) was comprised entirely of diagnosed diabetics (100%), primarily uncontrolled (69% HbA1C > 6.5). Most (70%) were also diagnosed with hypertension, but it was well-controlled in the home interview (only 32% with systolic blood pressure in hypertension stage I or II), reflecting the recommended clinical practice of controlling hypertension before diabetes. In addition, one-half had arthritis (49%), which is typical of older adults, and 3% had severe liver disease, three times more than the overall population. In sum, they had more diseases than the general population (4.0, vulnerable health measures; 2.2, Charlson comorbid diseases).

Members of the remaining two diabetic classes (MM4 and -5) were the most vulnerable. In MM4, the prevalence of diabetes was twice that of the older population nationally, and most had been diagnosed with hypertension that was not controlled when measured at home (76–89%), with 0% in the normal range. Strikingly, cardiovascular diseases were two to three times more prevalent in MM4 than in the older US population, defining it as the *Cardiovascular Disease and Diabetes* class. Only arthritis and peptic ulcers had a higher prevalence, whereas lung, kidney, and liver diseases were typical of the general population, and cancer prevalence was low. The fifth most vulnerable class had a very high prevalence of all diseases, making it the *Extensive Multimorbidity* class. Of note, the measured blood pressure of those in this class was usually lower than that in the other classes, consistent with advanced heart failure (28).

The characterization of the MM classes as either robust or vulnerable was independently supported by the 2.5-fold difference across the classes in the prevalence of being incapacitated or deceased (bottom row of Fig. 1). Of the two robust classes, 14% and 15% were incapacitated or deceased 5 y later, respectively, significantly lower than the three vulnerable classes at 20%, 24%, and 35%.

The constellations of diseases in the five MM classes are consistent with the traditional MM of organ system diseases with two added contributions. Diabetes and elevated blood pressure were identified as the "first tier" traits distinguishing among health classes of older community-dwelling adults. In addition, cancers did not form a distinct health class. Moreover, this analysis reveals that there are no significant differences in chronological age among the five classes, supporting the hypothesis that health and well-being of older adults do not follow a single linear progression and are associated less with age than with such sociodemographic traits as race, education, and gender (23, 29).

CM of Health: New Constellations of Disease and Health. Organ function is coordinated in part by the CNS and the peripheral nervous system, which also integrate the body with the social and physical worlds essential for health and well-being. To create a CM of health, we augmented the MM with 35 measures drawn from five additional health dimensions involving the nervous systems: health behaviors, such as smoking, exercise, and sleep; psychological health (i.e., mental health and cognition); sensory function, such as vision and olfaction; neuroimmunity; and frailty. Within each dimension, specific domains included measures of conditions common at older ages, such as depressive symptoms, memory loss, poor vision, chronic inflammation, and impaired mobility. They also included trauma, such as bone fractures, as well as health behaviors, such as body composition, sleep quality, drinking, smoking, and sexually transmitted diseases. Although some of these comprehensive measures are physical, none are part of the standard MM (2).

Six distinct, statistically independent health classes emerged (Fig. 2). Many individuals categorized as in robust health by the MM were revealed to have important health vulnerabilities when the broader definition of health was used. Conversely, some with organ system disease showed many counterbalancing strengths, leading to a reassignment to a robust health class in the CM. Many individuals were reclassified from their MM classes to different CM classes (Fig. 3), yielding a rich reconceptualization of what constitutes health and well-being in the older population at home in the United States, characterized by specific constellations of disease and function.

The CM identified two types of robust health at older ages (CM1 and -2), strikingly different from those identified by the MM and also, strikingly different from each other. Obesity characterized the first robust class, which comprised 22% of the older US population [54% of the *Robust Obese* class had an obese body mass index (BMI; 41% moderately obese and 13% morbidly obese; 0% had a normal BMI), and 60% had central obesity] (Fig. 2, measures 20 and 21). This class was also characterized by elevated blood pressure measured at home (45% systolic blood pressure hypertension stage I or II and 31% diastolic hypertension stage I or II) (Fig. 2 measures 5 and 6) (30). Although obesity is typically viewed as a severe health risk (31), this obese class had few organ system diseases or conditions per individual (Fig. 2) (individual average: 7.2, vulnerable health measures; 1.2, Charlson comorbid diseases). This class (CM1) had the lowest prevalence of dying or becoming incapacitated 5 y later (6%; one-third the prevalence in the general population), supporting the emerging concept that being overweight without complications and impaired mobility is not always deleterious to health, particularly in older adults (31–34). This class had notably better psychological health than the overall older population as well as better mobility and sensory function (other than taste) [Fig. S2*A* presents odds ratios (ORs) for the constellation of health characteristics, whose presence and absence distinguished the *Robust Obese* class from the rest of the population].

In marked contrast, people in the second robust class (*One Minor Condition*, CM2) were normal weight (0% central obesity and ≤1%

	MEDICAL MODEL HEALTH CLASSES				
	MM1 Unrecognized HTN	MM2 One Non-CV Disease	MM3 Uncontrolled Diabetes	MM4 CVD, Diabetes	MM5 Extensive Multimorbid
COMPREHENSIVE MODEL HEALTH CLASSES	**Percentage of MM Class Reclassified to CM Classes**				
CM1 Robust Obese	32%	22%	18%	15%	4%
CM2 One Minor Condition	22%	32%	11%	7%	13%
CM3 Broken Bones	17%	16%	12%	12%	11%
CM4 Poor Mental Health	12%	14%	13%	13%	13%
CM5 Diabetes, HTN, Immobility	11%	9%	35%	32%	21%
CM6 Extensive Multimorbid Frailty	6%	9%	11%	21%	38%
	Odds Ratios of MM Class Being Reclassified to CM Classes				
CM1 Robust Obese	2.4***	0.9	0.7	0.6	0.1***
CM2 One Minor Condition	1.1	2.3***	0.4***	0.3**	0.5*
CM3 Broken Bones	1.3	1.1	0.7	0.8	0.7
CM4 Poor Mental Health	0.9	1.1	1.0	1.0	1.0
CM5 Diabetes, HTN, Immobility	0.5**	0.4***	3.4***	2.7***	1.4
CM6 Extensive Multimorbid Frailty	0.3***	0.6*	0.8	2.0*	6.1***

Fig. 3. Reclassification of each individual from a given MM class (columns) into one of the CM class (rows). The percentage of individuals in each MM class that was reclassified across the six CM classes is provided in *Upper* table, and the ORs of doing so are in *Lower* table. CV, cardiovascular; CVD, cardiovascular disease; HTN, hypertension. *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$ (Bonferroni adjusted for multiple comparisons).

obese; central obesity OR = 0.048; $P = 0.001$) (Fig. 2, measures 20 and 21 and Fig. S2*A*), with a low prevalence of cardiovascular diseases and diabetes. Instead, people in this class had one minor condition or disease [(e.g., peptic ulcers, problems with voiding, skin cancer, thyroid disease, or anemia (Fig. 2, measures 3, 14, 17, 49, and 53 and Fig. S2*A*)]. Although none of these are recognized high-risk factors for death, let alone its causes, the prevalence of dying or being incapacitated 5 y later (16%) was significantly higher than in the *Robust Obese* class, suggesting that these "minor" conditions could be early harbingers of vulnerability and might mandate aggressive preventive care, although cardiovascular, metabolic, lung, and kidney functions are robust. This class also had worse sensory function than the *Robust Obese* class (Fig. 2, measures 35–40), particularly hearing (Fig. S2*A*).

With two different models for defining health classes, we can ask which best discriminates robust health at older ages. The MM classified fully two-thirds of the older US population as robust in two classes with a low prevalence of disease (Fig. 1). The definition of robust health was fine-tuned by the CM; only one-half (54%) of people identified as robust in the MM were also assigned to the robust classes in the CM (Fig. 3, columns 2 and 3). But what of the other one-half deemed in robust health by the traditional MM?

Most were reassigned to two emergent classes (CM3 and -4) defined by traits actively ignored by the MM, which together comprised fully 28% of the US population (Figs. 2 and 3). The first new class (CM3) was characterized by people who had broken a bone after age 45 y old (100% of *Broken Bones* class; OR = 61) (Fig. S2*B*) and had the highest prevalence of osteoporotic fractures (28%; OR = 27.7) (Fig. 2, measures 47 and 48). These healed bone fractures were not the well-recognized end-of-life hip fractures that can lead to immobilization and eventually death from complications. Its members were less likely to be immobile, be inactive, or have trouble walking than the general population ($0.152 \leq \text{OR} \leq 0.43$) (Fig. S2*B*). In sharp contrast, mental health problems, poor sleep, and heavy drinking characterized the second new class (CM4; *Poor Mental Health*, particularly depression; OR = 12.4 (Fig. 2, measures 22–25 and 29–32 and Fig. S2*B*) along with poor olfactory function and slow gait, known correlates of depression (35, 36), as well as voiding dysfunction (Fig. 2, measures 39, 43, and 53).

None of the traditional medical health classes predicted membership in the new *Broken Bones* or *Poor Mental Health* classes, although participants from all MM classes were reassigned to these two new classes, underscoring the unique contribution of the CM and its additional health dimensions ($0.7 \leq$ all ORs ≤ 1.3; all NS) (Fig. 3). The *Broken Bones* class had a lower prevalence of diabetes but other than that, intermediate prevalence of organ system diseases typical of the older US population (Fig. 2, measures 1–19). Their mobility was relatively robust as was their mental and cognitive health. The *Poor Mental Health* class also had typical prevalence of traditional organ system diseases accompanied by normal weight and a low prevalence of immune surveillance dysfunction (Fig. 2, measures 1–20 and 41).

Finally, the two most vulnerable classes (CM5 and -6) were characterized by multiple comorbid diseases, which are common causes of death among older adults. In CM5 (*Diabetes, Hypertension, and Immobility*), uncontrolled diabetes and hypertension were more common than in the general population as were immobility and urinary incontinence, obesity (particularly morbid obesity at 36% and moderate at 35%), arthritis, peptic ulcers, and impaired immune function along with impaired vision, hearing, and touch (Fig. 2, measures 1, 2, 4–7, 13, 14, 20, 21, 27, 29, 37, 38, 40–46, 50, and 52). Nonetheless, they had lower odds of all mental health problems than the rest of the population ($0.295 \leq \text{OR} \leq 0.74$) (Fig. S2*C*). In contrast, the most vulnerable class (*Extensive Multimorbidity and Frailty*) was distinguished by poor mental health (anxiety OR = 5.2) (Fig. S2*C*) and a high prevalence of 47 of 54 measures indicating disease and health conditions, including cardiac, lung, liver, and kidney diseases and nonreproductive cancers as well as poor mental health, memory, and sensory function. As expected, these two most vulnerable classes had more diseases than older adults in the United States (individual averages of 12.1 and 17.0, vulnerable health conditions and 2.2 and 3.3, Charlson comorbid diseases in CM5 and -6, respectively) (Fig. 2). Although the *Extensive Multimorbidity and Frailty* class (CM6) had the highest concordance with the most vulnerable MM class [38% of those with extensive multisystem disease (MM5) were reclassified to *Extensive Multimorbidity and Frailty* (CM6) with an OR = 6.1] (Fig. 3), a majority came from other classes. The marked increase in the proportion of women in the most vulnerable classes between the MM and CM (39% vs. 65% women) (Fig. 4) indicates the two most vulnerable classes in these two models are quite distinct.

Fully 44% of this most vulnerable class [*Extensive Multimorbidity and Frailty* (CM6)] died within 5 y of the original interview or became incapacitated (Fig. 2), making its constellation of diseases a much better predictor of poor health outcomes than the MM based only on organ system diseases. In sum, the CM differentiated classes with more precision than the MM, because it expanded the range of class differences in prevalence of dying or becoming incapacitated from a 2.5-fold to a 7.3-fold range (14–35% to 6–44%).

Causes of Mortality and Morbidity. In both models, the causes of death and becoming incapacitated were reassuringly consistent with the most prevalent diseases in a particular class. For example, in the three "diabetes" classes (MM3–5), deaths caused by diabetes, cardiovascular disease, and genitourinary complications were higher than the population average (Fig. S3*A*). In CM4, a class defined by mental health problems, deaths from substance abuse and suicide/homicide were higher than in either most robust or more vulnerable classes (Fig. S3*B*).

More interestingly, deaths from cancer confirmed its random occurrence with respect to the health classes identified in both the MM and the CM of health. Deaths from cancer were higher than average in the healthier MM2 class, but in MM5, the most vulnerable class, cancer deaths were lower than the population average (Fig. S3*A*). Likewise, cancer more often afflicted the healthiest classes of the CM (CM1 and -2) (Fig. S3*A*), whereas in CM5, deaths were more often caused by cardiovascular, diabetic, and elimination system diseases rather than cancer. This pattern is consistent with a "competing causes of death" model, in which prevalence of a more randomly distributed cause of death (in this case cancer) is highest when other causes of death are low.

The most common disease causing incapacity 5 y later and preventing a second interview was dementia or other mental deterioration (63% across all classes) (Fig. S3*B*). Strikingly, frailty or accidents in the intervening 5 y were three to five times more likely to incapacitate the *Broken Bones* class (CM3). Additionally, no one was incapacitated by alcohol, drug abuse, or suicide attempts, except those in the *Poor Mental Health* class (9% of CM4), showing that identifying this novel health class has prognostic power over 5 y.

Sexual Motivation and Social Ties. After assigning participants to a latent class based on their health measures [average assignment certainty = 0.83 (MM) and 0.89 (CM)], we sought to characterize the classes in terms of the participants' social and demographic traits. At older ages, sexual motivation can be a key component of social connection, vitality, and well-being (37–39). A fourfold difference in sexual motivation, indexed by sexual ideation (40), significantly distinguished the health classes in the CM [only 12% of the *Robust Obese* (CM1) class rarely thought about sex (less than once a month) in contrast with 52% of *Extensive Multimorbidity and Frailty* (CM6)] (Fig. 5*B*). In the MM, however, sexual motivation did not differ among its health classes (range = 26–33%) (Fig. 5*A*).

Likewise, social lives differed more among the CM than among the MM classes; only MM1 and -2, the robust classes, were more engaged socially than the US population and even so, on only a few measures (Fig. 5*A*) (41–45). The two robust classes of the CM (CM1 and -2) had stronger and more varied social lives than the

		A. MEDICAL MODEL CLASSES				
		Not Diabetic		Diabetic		
	US POP.	MM1 Unrecog-nized HTN	MM2 One Non-CV Disease	MM3 Uncon-trolled Diabetes	MM4 CVD, Diabetes	MM5 Extensive Multimor-bid
U.S. Population Share	100%	39%	28%	11%	9%	14%
DEMOGRAPHIC TRAITS	3005 (N)	1149	770	361	271	454
Age (years)	68.0	67.8	67.1↓	67.6	67.6	71.2↑
Gender (% Women)	52%	54%	56%↑	47%	54%	39%↓
Race/Ethnicity White	81%	84%↑	84%↑	68%↓	68%↓	82%
Black	10%	8%↓	6%↓	18%↑	24%↑	8%
Hispanic	7%	6%	8%	11%↑	5%	7%
Education <HS	19%	16%↓	15%↓	19%	27%↑	29%↑
HS Grad	57%	58%	56%	64%	55%	50%↓
College Grad	25%	26%	29%↑	17%↓	18%	21%
Household Assets (Med. $K)	$250	$275	$300	$150	$100	$150
<50K	23%	19%↓	18%↓	32%↑	36%↑	27%
51K-300K	39%	41%	34%↓	39%	36%	45%
301K-750K	25%	25%	30%↑	21%	21%	19%
>750K	13%	15%	18%↑	8%	6%↓	9%

		B. COMPREHENSIVE HEALTH CLASSES					
		Robust		Intermediate		Vulnerable	
	US POP.	CM1 Robust Obese	CM2 One Minor Condition	CM3 Broken Bones	CM4 Poor Mental Health	CM5 Diabetes, HTN, Immobile	CM 6 Multi-morbidity Frailty
U.S. Population Share	100%	22%	21%	15%	13%	16%	13%
DEMOGRAPHIC TRAITS	3005 (N)	625	604	411	389	515	461
Age (years)	68.0	65.6↓	68.3	68.7	67.3	68.6	71.0↑
Gender (% Women)	52%	40%↓	43%↓	64%↑	53%	55%	65%↑
Race/Ethnicity White	80%	82%	85%	87%↑	80%	73%↓	73%↓
Black	10%	10%	5%↓	6%↓	11%	16%↑	14%
Hispanic	7%	7%	7%	4%	7%	8%	10%
Education <HS	19%	11%↓	13%↓	13%↓	21%	25%↑	38%↑
HS Grad	57%	59%	52%	62%	58%	59%	52%
College Grad	25%	30%↑	36%↑	25%	21%	17%	10%
Household Assets (Med. $K)	250	325	350↑	300	150	100↓	60↓
<50K	23%	11%↓	15%↓	16%↓	26%	35%↑	47%↑
51K-300K	39%	39%	33%↓	42%	47%↑	37%	40%
301K-750K	25%	32%↑	30%↑	29%	19%	19%	9%↓
>750K	13%	18%↑	21%↑	13%	8%	9%↓	4%↓

Fig. 4. Demographic description of each class in (*A*) the MM and (*B*) the CM; ↑ indicates a significantly higher prevalence relative to the US population (US Pop.), and ↓ indicates a significantly lower prevalence. The US Pop. prevalence is based on 2005 Wave 1 weighted data. CV, cardiovascular; CVD, cardiovascular disease; HS, high school; HTN, hypertension.

US population [e.g., more members of *Robust Obese* (CM1) were married, and few felt socially isolated, lived alone, or had low social participation] (Fig. 5*B*).

There was a socially embedded class and an isolated class within both the intermediate (CM3 and -4) and the vulnerable classes (CM5 and -6) (Fig. 5*B*). Members of the intermediate classes [*Broken Bones* (CM3)] rarely felt isolated (13%), had low social participation (14%), or a small social network (11%). In stark contrast, members of *Poor Mental Health* (CM4) were the most likely to feel isolated (64%), live alone (38%), rarely participate socially (37%), and have small social networks (23%). A similar dichotomy was observed within the vulnerable classes. Members of *Diabetes, Hypertension, and Immobility* (CM5) were less likely to feel isolated (17%) and as socially engaged as the general population, whereas 45% of the most vulnerable *Extensive Multimorbidity and Frailty* (CM6) felt isolated, were not socially engaged (35%), and lived alone (32%). The marked differences in social characteristics captured by the CM are clinically relevant, because social connections affect not only well-being but also, access to health care and compliance (46–48).

Demographics of the Classes. CM classes did not differ in age from the population average, with the exception of the sickest class (*Extensive Multimorbidity and Frailty*), which is 3 y older, and the *Robust Obese* class, which is 2.5 y younger (Fig. 4*B*), indicating that the health classes are not simply a strong age gradient. However, they did differ significantly in terms of gender, race, education, and household financial assets (Fig. 4*B*), again with greater differences within the CM than within the MM (Fig. 4*A*).

The two healthiest classes (CM1 and -2) were, on average, disproportionately men of all races, with more education and assets than the population as a whole. The *Broken Bones* class (CM3) was predominantly white women. Members of the *Poor Mental Health* class (CM4) were more likely to live alone with moderate income. Members of the *Diabetes, Hypertension, and Immobility* class (CM5) were more likely to be black, not have a high school degree, and have assets under $50,000. The most vulnerable class, *Extensive Multimorbidity and Frailty* (CM6), was disproportionately older women of all races, also with low education and few household assets.

Class Stability over 5 y. We sought to confirm the CM by determining whether the same health classes emerged in 2010 when we followed the same LCA procedures (*SI Methods* and Fig. S4). We asked whether the health class structure of the population persisted as states of being over 5 y or whether it changed as the population aged and new participants were recruited. We found that the six class structure did persist virtually unchanged in 2010 with constellations of disease and characteristics similar to those in 2005, replicating the health classes derived from the CM (compare Fig. 2 with Fig. S4).

We then asked whether individuals also persisted in their classes in the intervening 5 y, which would be expected if membership was the cumulative result of having lived their particular lives. Indeed, those in good health in 2005 often remained in good health (CM1 OR = 6.65; CM2 OR = 6.79; both P values ≤ 0.001). Likewise, people in the most vulnerable health class with multiple comorbid diseases in 2005 remained so (CM6 OR = 5.87; $P \leq 0.001$) and faced a high risk of death or becoming incapacitated (OR = 4.44; $P \leq 0.001$). Those in intermediate health classes were also significantly likely to remain in their 2005 classes but with lower odds, particularly *Poor Mental Health* (CM4) (CM3 OR = 3.41; CM4 OR = 1.57; CM5 OR = 3.33; all P values ≤ 0.001).

Discussion

In defining health in older adults, medicine traditionally focuses on absence of chronic diseases of major organ systems; those without diabetes, cancer, or cardiovascular, kidney, liver, or pulmonary disease are generally considered healthy. Medications treat hypertension and elevated cholesterol, risk factors for developing a chronic disease. When applied to the population of older adults in the United States, this standard MM (4–8), identifies about two-thirds of the older US population as generally healthy, with no diseases of major organ systems. However, a closer look that includes health behaviors, psychological health, sensory function, neuroimmunity, and frailty paints a very different picture. It does so by both revealing constellations of health completely hidden by the MM and reclassifying about one-half of the people seen as healthy as having significant vulnerabilities that affect the chances that they die or become incapacitated within 5 y. At the same time, some people with chronic disease are revealed as having many strengths that lead to their reclassification as quite healthy, with low risks of death and incapacity.

A number of surprises appear in the CM. First, cancer, the second leading cause of death in the United States, is unrelated to the presence of organ systems disease (a pattern also seen in the MM; there is no cancer class). In fact, cancer is unrelated to health behaviors, psychological health, sensory function, and frailty. Cancer seems to appear essentially at random in the general population of older adults; those who get it either succumb to the disease or are treated and recover, in which case, they are randomly distributed across classes like anyone else.

			A. MEDICAL MODEL HEALTH CLASSES				
			Not Diabetic		Diabetic		
			MM1 Unrecog-nized HTN	MM2 One Non-CV Disease	MM3 Uncon-trolled Diabetes	MM4 CVD, Diabetes	MM5 Extensive Multi-morbid
U.S. Population Share		100%	38%	26%	12%	9%	15%
Psychosocial Descriptors		US Pop.	Class Prevalence (Relative to the US Population)				
Self-Rated Health	Physical (% ≥ Very Good) (20)	46%	49%↑	36%	15%	5%↓	9%↓
	Mental (% ≥ Very Good) (21)	64%	59%	50%	58%	44%	44%
Low Sexual Ideation	(< once a month) (40)	29%	26%	28%	32%	33%	33%
Social Ties	Married (66%) or Partnered (3%)	69%	71%	75%↑	67%	64%	68%
High Perceived Isolation (score ≥ 0.45) (41)		20%	17%↓	20%	23%	26%	22%
Lives Alone (42, 43)		23%	25%	18%↓	22%	26%	28%
Low Social Participation (≤ 1.75 times a year) (41, 44)		22%	22%	18%↓	23%	28%	26%
Small Network Size (≤ 2) (44, 45)		18%	17%	15%	21%	20%	18%

			B. COMPREHENSIVE MODEL HEALTH CLASSES					
			Robust		Intermediate		Vulnerable	
			CM1 Robust Obese	CM2 One Minor Condi-tion	CM3 Broken Bones	CM4 Poor Mental Health	CM5 Diabetes, HTN, Immo-bility	CM6 Extensive Multi-morbid, Frailty
U.S. Population Share		100%	22%	21%	15%	13%	16%	13%
Psychosocial Descriptors		US Pop.	Class Prevalence (Relative to the US Population)					
Self-Rated Health	Physical (% ≥ Very Good) (20)	46%	69%↑	67%↑	50%	33%↓	22%↓	8%↓
	Mental (% ≥ Very Good) (21)	64%	82%↑	77%↑	68%	43%↓	64%	31%↓
Low Sexual Ideation	(< once a month) (40)	29%	12%↓	26%	29%	38%↑	32%↑	52%↑
Social Ties	Married (66%) or Partnered (3%)	69%	80%↑	82%↑	69%↓	65%↓	67%	49%↓
High Perceived Isolation (score ≥ 0.45) (41)		20%	7%↓	16%↓	13%↓	64%↑	17%↓	27%↑
Lives Alone (42, 43)		23%	14%↓	19%↓	25%	38%↑	24%	32%↑
Low Social Participation (≤ 1.75 times a year) (41, 44)		22%	16%↓	19%↓	14%↓	37%↑	23%	35%↑
Small Network Size (≤ 2) (44, 45)		18%	16%	20%	11%↓	23%↑	17%	21%

Fig. 5. Psychosocial descriptors (20, 21, 40–45) of the health classes from (*A*) the MM and (*B*) the CM. Self-rated health (physical and mental), sexual ideation, and social ties are shown; ↑ indicates a significantly higher prevalence relative to the US population (US Pop.), and ↓ indicates a lower prevalence. The US Pop. prevalence is based on 2005 Wave 1 weighted data. CV, cardiovascular; CVD, cardiovascular disease; HTN, hypertension.

Second, obesity, often pointed to as "epidemic" and life-threatening (49), characterizes those older adults in the most robust health as well as in more vulnerable health. Obesity in a person with excellent mental health, no chronic disease, intact sensory function, good health habits, and excellent physical functioning seems to pose very little risk. Obesity in a person with diabetes, poor mental health, poor sensory function, and poor mobility is a very bad sign in a tidal wave of bad signs for those in the vulnerable health classes.

Third, having broken a bone during or after middle age uniquely identifies a class consisting of one in seven older US adults. This is a class that is "hidden" in the MM of health. This class is about "average" in other respects, but having broken a bone removes them from being in one of the robust groups. In a medical history, a past broken bone might signal osteoporosis risk but little else. However, according to the CM, a broken bone is a "marker" for future health; accidents are the primary cause of incapacity 5 y later, and member's mortality is as high as the general population. This group is an excellent "target" for interventions—to prevent these individuals from declining over time and move them into more robust health.

Fourth, another one in eight older adults is revealed as having pervasive poor mental health, including high levels of stress, symptoms of anxiety and depression, loneliness, unhappiness, and poor self-esteem. More of the people in this group sleep poorly, wake up tired, or drink excessively compared with those in other groups. This constellation of mental health problems and the consequences of attempts to deal with them stand out from the population of older adults more generally for the shape and scope of the health problems those in this group face, including high incapacity and mortality. They too are completely hidden in the MM of health.

Fifth, the most vulnerable group of older adults has serious problems in all health dimensions from chronic diseases and neuroimmunity to mental health, health behaviors, cognition, sensory function, and frailty. Note that 44% of this group, which comprises one older adult in eight living at home, will die or become incapacitated in the next 5 y. Only 35% of those in the sickest health class as identified in the MM died or became incapacitated. Clearly, the CM contains a great deal of prognostic information left out of the MM.

Health status in older adults does not correspond with chronological age; age differentiates only two of the classes at most by 3 y. The gender story is bigger, with disproportionately more men in the two robust classes and more women in broken bones and multimorbidity and frailty classes. The apparent paradox in having more men in the youngest and healthiest class and more women in the oldest and sickest class results directly from men having higher mortality rates. They die younger, and women survive longer, often with chronic disease and other aging conditions. This well-known pattern was not captured by the MM.

The current MM of health emphasizes organ system disease categories as the fundamental conception of health. A list of "diagnostic codes," embodied in the ICD-10 system used to bill for health services, is emblematic of this approach. One consequence is that health policy neglects important aspects of health, such as mental health (50) and medical training for managing comorbidities in geriatric populations (51). By using the WHO definition of health, we have shown how expanding health dimensions and domains and incorporating positive aspects of health reveal six unique, replicable constellations of disease and health, including two previously unrecognized classes not apparent in the organ disease-focused MM. From a health system perspective, a shift of attention is needed from disease-focused management, such as medications for hypertension or high cholesterol, to overall health, especially for mental health concerns, sensory function, and mobility.

Although public health campaigns, such as "Choosing Wisely," rightly emphasize the need to decrease unnecessary health interventions (52), they still accept the basic health conception of the MM as resting on organ system disease. Instead, the CM instantiates comorbidities and the equal importance of mental health, mobility, and sensory function in health and should inform policy redesign. For example, including assessments of sensory function,

mental health, broken bones in middle age, and frailty in annual physician visits would enhance risk management. In addition to policies focused on reducing BMI, greater support for preventing loneliness among isolated older adults would be effective. In place of additional (expensive) new medicines for hypertension, helping older adults find social support through home care services or alternative living arrangements could be developed. In summary, taking a broad definition of health seriously and empirically identifying specific constellations of health and comorbidities in the US population provide a new way of assessing health and risk in older adults living in their homes and thereby, may ultimately inform health policy.

Methods

NSHAP Sampling and Field Methods. The NSHAP designed and collected a probability sample of individuals ages 57–85 y old selected to represent US households in 2005 and 2006 [response rate of 74%; $n = 3{,}005$ (53)], and these individuals were reinterviewed (reinterview rate of 89%) together with their spouses/partners [response rate of 84%; total $n = 3{,}377$ (54)]. The data are sample-weighted values, so that they reflect estimates of the characteristics of the US community-dwelling population at the time of interview (*SI Methods*).

The interviews were comprised of a personal interview; anthropometric, clinical, and physiological measures; and a self-administered questionnaire (27, 40, 45). The study was approved by the Institutional Review Boards of The University of Chicago and NORC of The University of Chicago; all respondents provided written informed consent.

Classifying Health Measures. Each variable was coded either dichotomously or into ordinal categories, in which higher values indicate worse health. We used the 2005 clinical and literature-based cut points when available (Fig. S1 provides cut points). Respondents reported whether health professionals had told them that they had a specific disease. For other measures, such as happiness and how many hours the person usually sleeps, we identified those at the low ends of the measures as poor health scores.

Latent Classes and Heat Maps of Their Composition. The latent class models described earlier were estimated using Mplus, version 6 (55). *SI Methods* and Table S1 provide model parameters and Bayesian Information Criterion values for determining class number. LCA searches for an underlying statistical structure to a population that is not directly observable but can be identified using a sufficiently large collection of observable variables. The LCA then identifies distinct subgroups, or classes, within the overall population based on underlying commonalities among variables, commonalities that are assumed to be caused by the underlying latent characteristic. Classes are estimated through structural equation modeling. There are no a priori assumptions about class identity that constrain the model, and it is possible to test the hypothesis that there are significant co-occurrences of diseases and other health states across the identified latent classes rather than random noise (under the assumption that health measures are independent given class membership). Each person can then be assigned to a single class based on his or her value on each of the health measures (average class assignment certainty = 0.83 for the MM and 0.89 for the CM).

We then characterized the constellation of presence of disease and health states for each class by calculating the percentage of each class with a particular disease (e.g., diabetes) or a poor score for a measure (e.g., waking up tired) (MM and CM of health in Figs. 1 and 2, respectively). We illustrate the constellation of disease and healthy states that characterizes each class reading down the columns of Figs. 1, MM and 2, CM of health. Class percentages were statistically compared with the overall population percentages using logistic regression (56) and then categorized as being higher, the same, or lower ($P < 0.05$). Color codes indicate the prevalence of each variable relative to the US population prevalence based on 2005 Wave 1 weighted data.

Our goal for the CM was consideration of all variables that could be useful beyond the MM by adding 35 health measures chosen for their connections to the broad functions of the nervous systems: mental health, cognition, sensory function, health behaviors, neuroimmunity, and frailty. After we established the six latent health classes, we then asked which of the 54 health measures distinguished each health class from the remaining population by either the presence or absence of disease or health states (i.e., their power to significantly predict class membership; six logistic regression analyses) (Fig. S2). Each logistic regression analysis determined the independent contribution (OR) of each of the 54 variables, controlling for the presence of the other health measures. Future work will determine the most parsimonious set of measures for predicting class membership.

Mortality and Incapacity. Our measures were death and being "too sick to interview" (incapacity). If a respondent was unable to participate in 2010, a proxy was asked why and the date and cause of death or incapacity were coded overseen by a geriatrician who routinely assigns cause of death (Fig. S3). Such proxy reports are as accurate, if not more so, than the National Death Index (57) and were available immediately (*SI Methods*) (58).

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