The Development of a Patient-Reported Functional Limitations Index

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ABSTRACT

OBJECTIVES: To develop an easy-to-interpret, patient-reported Functional Limitations Index (FLI) that can be used to assess and monitor the full spectrum of functioning in a community-dwelling population.

STUDY DESIGN: Observational design using nationally representative survey data.

METHODS: We used self-rated health as a criterion for empirically assigning weights to 5 National Health Interview Survey items assessing difficulty with seeing, hearing, walking, cognition, and self-care. In addition to succinctly summarizing cumulative limitations, we addressed 2 main questions: (1) Which limitations have stronger associations with self-rated health? and (2) How does severity (from 0, no difficulty, to 3, unable to do) relate to self-rated health? We generated a respondent-level summary score based on a model predicting self-rated health from the 5 linearly scored (0-3) items and used splines to account for nonlinear severity–self-rated health associations.

RESULTS: The strongest association of specific functional limitations with self-rated health involved mobility; the weakest associations involved sensory limitations. The association of severity with self-rated health was nonlinear and largest moving from *no difficulty* to *somewhat difficult*. Nationally, 5% of noninstitutionalized adults were considered *most limited*, 8% *somewhat limited*, and 87% *least limited*. Great mobility limitations (defined as *a lot of difficulty* or *unable to do*) most distinguished limitation groups (present in 0% of *least limited*, 25% of *somewhat limited*, and 70% of *most limited*).

CONCLUSIONS: The FLI is an easy-to-administer, easy-to-interpret, and valid summary measure of disability that health plans and health care organizations can use for quality-of-care monitoring across a variety of settings to improve care for patients with disabilities.

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An estimated 12% to 30% of Americans have a disability,[1-5] and prevalence is expected to increase.[6,7] In clinical populations, greater disability is associated with higher costs and lower quality of life.[8-11] There is a national commitment to improving the health and health care of persons with disabilities,[12,13] who make up one of the largest groups of underserved adults in the United States.[14] This requires a consistent, efficient means of identifying and monitoring the spectrum of community-dwelling individuals with disabilities.

Some widely used measures of disability are used to classify working-aged adults as unable to work because of a health condition (eg, CMS original entitlement code); such measures do not capture individuals with disabilities who are able to work or who developed disabilities after age 65 years. Other measures involve a clinical diagnosis (eg, the Sheehan Disability Scale[15]) or are limited to 1 or 2 domains (eg, SF-36 Physical Function[16] score of mobility), limiting their usefulness in the general population.

Responding to the need for a standardized, broadly applicable measure of disability,[17-19] a group of disability measurement experts developed the International Classification of Functioning, Disability and Health (ICF) to classify the consequences of disease and complement the *International Classification of Diseases*.[20-23] As shown in **Figure 1**,[24,25] functioning, defined here as activity limitations, results from dynamic interactions among health conditions, body function and body structure impairments, participation in social roles, and environmental and personal factors. The ICF model focuses on functioning independent of health condition.[23,26] For example, a patient with severe pain from a back injury and a patient with cerebral palsy may both have limited mobility, whereas a full-time student with depression may experience concentration limitations and a part-time worker with depression may not. The ICF model treats the first 2 people the same and the second 2 as distinct.

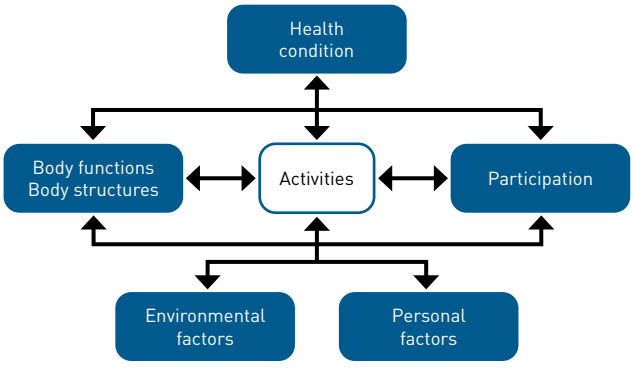
In this paper, we describe the development of a brief, easy-to-administer, and easy-to-interpret summary measure of patient functioning that health care organizations and providers can use to assess and monitor a wide spectrum of functioning independent of clinical diagnoses. In keeping with the ICF model, we focus

TAKEAWAY POINTS

The 5-item Functional Limitations Index is an easily administered and easily interpretable measure that distinguishes patients along the disability continuum (least to most limited).

- The strongest associations of specific functional limitations with self-rated health involved mobility and self-care, possibly reflecting acute illness sequalae.
- The weakest associations involved sensory limitations, possibly due to long-term adaptation through accommodations.
- Greater severity was associated with worse self-rated health, with the largest increase from no difficulty to somewhat difficult, possibly reflecting challenging adjustment to new health problems.
- Limitations groups were most distinguished by being unable to or having a lot of difficulty walking or climbing stairs.

FIGURE 1. International Classification of Functioning, Disability and Health Conceptual Model[25]



Source: International Classification of Functioning, Disability and Health. Reprinted from open-source material.[25]

on functional limitations independent of disease or condition. We considered only items in the 6-item Short Set of Disability Questions included in the National Health Interview Survey (NHIS) since 2010, as this measure was based on the ICF model.[27] This short set of questions reliably and validly[28] measures limitations associated with undertaking basic activities.[24] It represents the majority of individuals (but not all) with functional limitations and assesses the most frequently occurring (but not all) domains of functional limitation.[29]

We describe an empirically informed method of combining the items in this set to preserve distinctions among different types and severities of functional limitations while maximizing the correlation to self-rated health. Typically, individuals are classified as having a disability if they have at least 1 serious functional limitation.[30,31] Another approach would be to classify individuals experiencing difficulty with at least 2 domains or activities of daily living as having a disability.[32] Both of these dichotomous approaches ignore the possibility that the severity and different types of limitations may be associated with different levels of well-being and medical need.

Because the effect of a disability on well-being and medical need is likely to fall on a continuum, a continuous measure is needed to better capture the effect of disability and its severity, even if the continuous score is ultimately categorized for some purposes. One way to create a continuous measure is to count the number of limitations that a person reports[33]; although simple, a count assumes that each functional domain implies the same level of medical need or requires the same degree of intervention. Alternatively, functioning domains could be weighted to reflect their associations with health, using published weights (eg, those used in the World Health Organization [WHO] Disability Assessment Schedule[34]) or specific weights for the specific items in a given survey. For example, Altman and Bernstein[1] constructed a weighted summary measure of disability based on 8 functions from the 2001-2005 NHIS, based on untested assumptions about the relative effects of different functional limitations and levels of severity.

Here we describe the development and application of a weighted summary measure of functioning with empirically derived weights reflecting the association between several functional limitations and self-rated health. Self-rated health was chosen as a criterion variable because it predicts health care utilization, morbidity, illness recovery, functional decline, and mortality,[35-37] and because it is widely available in survey data. To inform our model, we addressed 2 questions: (1) Which limitations have stronger associations with self-rated health? and (2) How does the association of limitations with health vary by level of severity? Measuring the importance of severity in different patient functioning domains has practical clinical and policy implications for monitoring and improvement of quality of care.

METHODS

Data Source

Data are from the 2014-2015 NHIS Adult Functioning and Disability (AFD) supplement, fielded with the Sample Adult module to a randomly chosen subset of all sampled adults (18,303 in 2014 and 16,939 in 2015).

We excluded 1818 AFD respondents (5.2%) who were missing all 6 WHO functional limitation items. We imputed a 0 (no difficulty) for 91 (0.3%) respondents who completed some but not all functional limitation items, as it is common for respondents to misunderstand long sequences of similar items as a "check-all-that-apply" format.[33] Sampling weights incorporating study design and nonresponse were applied to all analyses, and robust variance estimation was used.

NHIS-AFD Items

The NHIS-AFD module includes the following 6 functional limitation questions: vision (difficulty seeing), hearing (difficulty hearing),

FIGURE 2. Change in General Health Score (0-100) by Severity Levels for Single Functional Limitation Trajectories

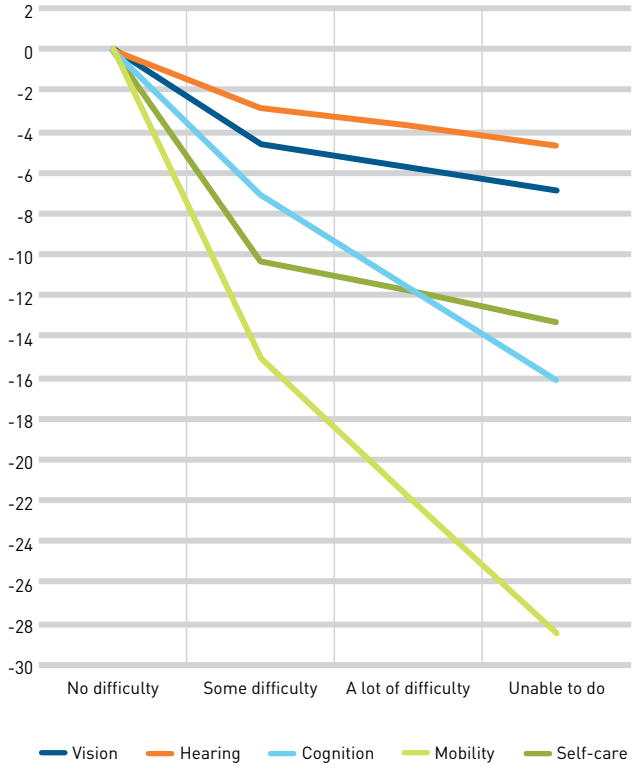


TABLE 1. Final Multivariate Regression Model Function Limitation Coefficients for Predicting Self-rated Health, 2014-2015 NHIS AFD[a]

Equation for predicting self-rated health (D_j) (for jth respondent and i = 1 to 5 function limitations)	
$D_j = A_1X_{1j} + B_1Y_{1j} + \ldots A_5X_{5j} + B_5Y_{5j}$	
Functional limitations	**Coefficient**
A_i, per 0-3 unit of limitation (each scored 0-3, *no difficulty* to *unable to do*)	
Vision	−4.58***
Hearing	−2.82***
Cognition	−7.03***
Mobility	−15.05***
Self-care	−10.32***
B_i, per unit of limitation beyond 1	
Vision spline	3.44***
Hearing spline	1.92
Cognition spline	2.45*
Mobility spline	8.31***
Self-care spline	8.84***

AFD, Adult Functioning and Disability; NHIS, National Health Interview Survey.
*.01 ≤ P < .05; **.001 ≤ P < .01; ***P < .001.

[a]Cell entries represent the coefficients from a regression model that predicts self-rated health (linearly scored 0-100, where 0 represents poor health and 100 represents excellent health) from all respondent characteristics shown in the table. A statistically significant negative coefficient indicates a characteristic that is associated with worse self-rated health; a statistically significant positive coefficient indicates a characteristic associated with better self-rated health.

A total of 1818 respondents were removed from the model due to missing functional limitation responses; an additional 16 respondents were not used in the underlying predictive model due to missing general health status. Estimates were weighted according to guidelines published by the NHIS to represent the noninstitutionalized US adult population. Responses are taken from adults 18 years and older in the NHIS AFD 2014 and 2015 data. Only functional limitations and spline terms are shown; full model results can be found in eAppendix A.

mobility (difficulty walking or climbing steps), communication (difficulty communicating), cognition (difficulty remembering or concentrating), and self-care (difficulty washing all over or dressing). All items had response options of no difficulty (level 0), some difficulty (level 1), a lot of difficulty (level 2), and unable to do (level 3). We sought to create a brief index based on these 6 well-validated items.

Constructing a Summary Functional Limitations Score

We developed a linear regression model that predicted self-rated health from the functional limitation items. The final model retained 5 functional limitation items scored linearly (0-3). Communication was excluded from the final model because an initial model that included all 6 items yielded a coefficient for communication that did not significantly differ from zero (**eAppendix A** [eAppendices available at **ajmc.com**]). For each functional domain, we added a linear spline term that allowed the estimated difference between *a lot of difficulty* (level 2) and *some difficulty* (level 1) to differ from the estimated difference between *no difficulty* (level 0) and *some difficulty* (**Figure 2**; **eAppendix B**).

Covariate-adjusted self-rated health scores were estimated using recycled predictions.[38] The covariate-adjusted score is the expected self-rated health score for a given person if the person's sociodemographic characteristics corresponded to those of the average person in the population. The coefficients of the functional limitations from the final model shown in **Table 1** can be used to derive a predicted self-rated health score for every adult AFD respondent based on their self-reported vision, hearing, mobility, cognition, and self-care items (eAppendix B). We created a standardized (z score) score, the Functional Limitations Index (FLI), by subtracting the sample mean from each score and dividing the difference by the sample SD. The mean index score was 0 with an SD of 1. We classified respondents into 1 of 3 limitation groups based on the index scores. The cut points defining these groups were 1 SD apart on the index. Because the groups were meant to distinguish those with limitations, all cut points were below 0 (z score ≤ −2, *most limited*; z score > −2 to −1, *somewhat limited*; z score > −1, *least limited*). These cut points were selected to meet the potentially competing goals of having reasonably sized limitation groups (to

TABLE 2. Distribution of Each Functional Limitation by Severity Level and Limitation Group Among the US Adult Population: 2014-2015[a]

	US population, % (100%)			Least limited, % (*z* score > −1) (87%)			Somewhat limited, % (*z* score > −2 to −1) (8%)			Most limited, % (*z* score ≤ −2) (5%)		
Functional limitation	No[b]	Some[c]	Great[d]	No[b]	Some[c]	Great[d]	No[b]	Some[c]	Great[d]	No[b]	Some[c]	Great[d]
Mobility	83.7	10.7	5.6	95.9	4.1	0.0	4.0	71.4	24.6	0.1	30.1	69.8
Cognitive	85.5	12.4	2.2	90.8	8.4	0.8	67.3	29.0	3.7	24.9	53.1	22.0
Self-care	96.6	2.6	0.9	99.3	0.6	0.1	94.9	4.0	1.2	53.2	32.7	14.1
Hearing	82.0	15.9	2.0	87.1	11.9	1.0	54.9	40.0	5.2	38.4	47.6	14.0
Vision	84.7	13.6	1.7	89.0	10.2	0.8	66.7	28.6	4.8	39.9	47.5	12.6

[a]Data are from the 2014-2015 National Health Interview Survey (N = 33,424); 1818 respondents were removed from the index due to missing functional limitation item responses. Response options for the 5 functional limitations are *no difficulty*, *some difficulty*, *a lot of difficulty*, and *unable to do*. Percentages are weighted to be representative of the noninstitutionalized US adult population.

[b]Percentage indicating *no difficulty*.

[c]Percentage indicating *some difficulty*.

[d]Percentage indicating *a lot of difficulty* or *unable to do*.

ensure reliable subgroup estimates) and representing distinct levels of limitations. Most respondents were without limitations because the NHIS represents the general population. Respondents with no or very little limitation were assigned 0 or just above 0 scores. Although a small proportion of individuals with more limitations had large negative scores, there were no large positive scores; thus, the distribution of scores on the index is left-skewed.

As a preliminary validation and illustration of our approach, we compared the functional limitations and sociodemographic characteristics of the representative noninstitutionalized US adult population who were categorized as *least limited*, *somewhat limited*, and *most limited* per our FLI. We also determined which sociodemographic characteristics were associated with which limitation group using bivariate and multivariate logistic regression models to predict being classified *somewhat limited* vs *least limited* (referent) and *most limited* vs *least limited*.

RESULTS

Predicting Self-rated Health From Functional Limitations

Negative coefficients for each functional limitation indicated a negative association with self-rated health (0-100 scale, where 0 represented poor health and 100 excellent health). Each retained functional limitation main effect coefficient was negative and statistically significant ($P < .05$). The strongest predictor of self-rated health was mobility limitation (−15 points for each additional severity level), followed by self-care (−10 points), cognition (−7 points), vision (−5 points), and hearing (−3 points).

As a respondent moved from *some difficulty* to *a lot of difficulty* or from *a lot of difficulty* to *unable to do*, the negative association with functional limitations diminished (Figure 2). For example, a respondent with a single level 1 (*some difficulty*) mobility limitation was predicted to have a 15-point lower self-rated health score than those with no such limitation, but a respondent with a single level 2 (*a lot of difficulty*) mobility limitation was predicted to have one 22 points ($-15 \times 2 + 8$) lower, and a respondent with a single level 3 (*unable to do*) limitation was predicted to have one 29 points ($-15 \times 3 + 8 \times 2$) lower. This means that the difference in quality of life between reporting *no difficulty* and *some difficulty* (15 points) was greater than the difference associated with reporting *some difficulty* and *a lot of difficulty* (7 points) or *a lot of difficulty* and being *unable to do* an activity (7 points). Although the association with self-rated health diminished with increased severity in general, the largest change in self-rated health associated with moving from *a lot of difficulty* to *unable to do* was for mobility and cognition.

Deriving Limitation Groups

We used the model predicting self-rated health to assign the FLI score and create 3 limitation groups: 5% of noninstitutionalized US adults, hereafter referred to as adults, were considered *most limited* (*z* score ≤ −2), 8% *somewhat limited* (*z* score > −2 and ≤ −1), and 87% *least limited* (*z* score > −1). As shown in **Table 2**, the proportion of adults with no limitations (*no difficulty*) ranged from 82% (for hearing) to 97% (for self-care). The proportion reporting great limitations (*a lot of difficulty* or *unable to do*) ranged from less than 1% (for self-care) to 6% (for mobility). Great mobility limitations most distinguished limitation groups: They were present in 0% of the *least limited*, 25% of the *somewhat limited*, and 70% of the *most limited*.

Distribution of the Number of Functional Limitations Among Limitation Groups

Table 3 presents the proportion of adults with any limitation or great limitations in none, 1, 2, and 3 or more areas of functioning, overall and by limitation group. Overall, 65% of adults had no limitations, 22% had 1 limitation, 9% had 2 limitations, and 4% had 3 or more limitations. About 75% of the *least limited* group had 0 limitations, 23% had a single limitation, and 2% had 2 limitations. Of the *somewhat limited*, 60% had 2 limitations, 30% had 1 limitation, and 10% had 3 or more limitations. Of the *most limited*, 62% had 3 or more limitations and most of the remainder (31%) had 2 limitations.

Overall, 8% of adults had at least 1 great limitation and 1% had 2 or more. Of the *least limited*, 2% had a single great limitation and the remainder had no great limitation. Of the *somewhat limited*, 31% had 1 great limitation and 2% had 2. Of the *most limited*, 76% had at least 1 great limitation, 14% had 2 great limitations, and 3% had 3 or more great limitations.

TABLE 3. Distribution of the Number of Any or Great Limitations by Limitation Group Among the US Adult Population: 2014-2015[a]

Number of limitations	US population, % (100%)	Least limited, % (z score > −1) (87%)	Somewhat limited, % (z score > −2 to −1) (8%)	Most limited, % (z score ≤ −2) (5%)
Any limitation				
0	64.7	74.4	0.0	0.0
1	22.4	22.6	30.4	7.2
2	8.9	3.0	59.6	31.3
3 or more	4.0	0.0	10.0	61.5
Great limitation[b]				
0	91.9	98.2	67.5	23.8
1	7.0	1.8	30.5	58.9
2	0.9	0.0	2.0	14.4
3 or more	0.2	0.0	0.0	2.9

[a]Data are from the 2014-2015 National Health Interview Survey (N = 33,424); 1818 respondents were removed from the index due to missing functional limitation item responses. Response options for the 5 functional limitations are *no difficulty*, *some difficulty*, *a lot of difficulty*, and *unable to do*. Percentages are weighted to be representative of the noninstitutionalized US adult population.

[b]Percentage indicating *a lot of difficulty* or *unable to do*.

Distribution of Types of Limitations Among Limitation Groups

About one-fourth of the *least limited* had any functional limitations, most often *some difficulty* in a single area of sensory functioning (hearing or vision, 9%-13%), and rarely any mobility or self-care limitation (<5%). The *somewhat limited* all had at least 1 limitation, and most had 2 limitations (usually *some difficulty* but occasionally great limitation). A majority (96%) of the *somewhat limited* had mobility limitations; when a great limitation existed, it was usually in the realm of mobility. Approximately one-third or more of the *somewhat limited* group had a sensory limitation (33%-45% with any limitation) and rarely a self-care limitation (5%). A majority of the *most limited* had 3 or more limitations, including at least 1 great limitation. Nearly all (99%) of the *most limited* had mobility limitations; a majority had great mobility limitations along with cognitive, hearing, and vision limitations. More than half of the *most limited* group (60%-75% with any limitation) had a sensory limitation and approximately half (47%) a self-care limitation.

Sociodemographic Characteristics of the 3 Limitation Groups

Compared with the *somewhat limited* and *most limited*, the *least limited* were more often male, younger, and Hispanic or Asian and lived in the Northeast (**eAppendix C**). The *least limited* were more often married and socioeconomically advantaged; that is, they more often had a bachelor's degree or more, reported an income of at least $75,000, and utilized private rather than public insurance.

DISCUSSION

The 5-item FLI is an easy-to-administer, easy-to-interpret, valid measure of functioning that health care organizations can use to identify and monitor the care and outcomes of individuals with disabilities of different severities independent of health conditions.

Our approach to scoring the FLI improves on other methods used to measure and summarize disability by utilizing patient function over clinical diagnoses and allowing empirical evidence to drive the weighting of different functional limitations and their severities for the summary score. By adjusting for sociodemographic characteristics, the FLI represents variation in health solely due to functional limitations; it can be used as a continuous measure of disability or to create limitation groups for analysis.

Interpretation of the FLI Model

Self-rated health has a strong negative association with each of 5 functional limitations, with mobility limitations having the strongest association, followed by limitations in self-care, cognition, vision, and hearing. Our results are consistent with those of Balestroni and Bertolotti,[39] who found that mobility was a stronger predictor of the EuroQol EQ-5D, a health-related quality-of-life measure, than self-care or daily activities limitations.

The disability paradox is the phenomenon wherein individuals with disabilities report greater well-being than unimpaired individuals assume they would experience in the same situation. In a 2014 survey, largely unimpaired community-dwelling adults cited vision loss as the limitation they believed would have the greatest effect on their day-to-day life, followed by memory loss; they ranked hearing loss as least likely to have a large effect.[40] Our finding that visual limitations are not strongly associated with self-rated health suggests that the disability paradox may be especially relevant for visual sensory limitation; the relatively small impact of hearing loss is consistent with unimpaired individuals' assessment. The associations between sensory limitations (vision and hearing) and self-rated health may in part reflect long-term adaptation to accommodations (eg, eyeglasses and hearing aids). In contrast, mobility and self-care limitations may reflect acute illness sequelae, including physical deconditioning, early mortality, and falls resulting in loss of independence and ability to participate in social activities.[41-43] The large coefficients corresponding to a change from *no* limitation to *some* limitation may reflect the difficulty of adjusting to the new onset of a health problem, whereas the smaller coefficients corresponding to differences between *some*

and *great* limitations may reflect some combination of worsening of an existing health problem and the success of environmental adaptations to functional limitations.

Limitations

This study has some limitations. Although the 6 NHIS functional limitation items are likely to capture most adults with disabilities, they probably underrepresent adults with psychiatric and cognitive disabilities associated with higher-order functioning limitations (eg, learning, decision making).[44] Mental health disability is potentially very important, especially among those who also report disability due to a chronic condition.[45] Information on US adults with intellectual disabilities is not routinely collected, despite recognized disparities in care.[46] We did not evaluate other ICF items (eg, anxiety, depression) given our interest in a function-based measure. The FLI does not distinguish between permanent and temporary disability.[47] Finally, although the construction of the FLI was supported by a strong theoretical foundation and the pattern of associations between limitation groups and sociodemographic characteristics provides preliminary evidence of the validity of the measure, additional validation work (eg, investigation of the convergent, discriminant, and predictive qualities of the index) is needed prior to any high-stakes application.

CONCLUSIONS

Policy makers and clinical researchers must understand how varying levels of disability influence quality of life. As individuals experience disability at higher levels of severity, the negative association between limitations and self-rated health increases, but to a diminishing extent. Dichotomous or summed counts of disability ignore this phenomenon. A key strength of the FLI is that because it empirically summarizes multiple functional limitation items and severity levels on the same ordinal scale as a single dimension, it can meaningfully facilitate research into variability in quality of and access to care by improving the insight into the relative contributions of different areas of functioning, severity, and additivity. The FLI may also help assess heterogeneity in disability-related disparities for different population subgroups. This method can be used as a guideline and be adapted to other populations of interest, such as Medicare or Medicaid beneficiaries. Policy makers might also find the FLI useful for assessing programmatic outcomes. For example, the association between disability and general health might be used to monitor change over time related to policy changes, such as the Americans with Disabilities Act, or programs, such as the Social Security Disability Insurance program. ■

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Supplementary Material

eAppendix A. Discussion on Communication Limitation

Regression results from Table A1 under our initial model, using all six functional limitations, showed very small positive coefficients for communication main and linear spline terms, neither of which was significantly different from zero. Unlike with other functional domains, some respondents with communication difficulties rated their quality of life higher than respondents with no communication difficulties, after regression adjustment. Thus, using this initial model parameterization, 35 respondents that had only a communication limitation at any level resulted in higher predicted health scores than respondents with no limitations at all. To ensure decreasing function was not associated with better predicted health, we dropped terms for the communication limitation from the model and do not discuss this function in the main results, since no additional information about self-rated health was gained on top of the five other functions. Our final modeling approach predicted the rescaled self-rated health score from each of five functional limitation items: seeing, hearing, walking, cognition, and self-care (i.e., all but communication).

Table A2. Initial and Final Multivariate Regression Model Results Predicting Self-Rated Health

Respondent Characteristics	**Initial Model** 6 limitations severities included		**Final Model** 5 limitations severities included (excluding communication)	
	Coefficient[1]	**Standard Error**	**Coefficient[1]**	**Standard Error**
Functional limitations (each scored 0-3: *no difficulty* to *unable to do*)				
Vision	**-4.58 *****	**0.37**	**-4.58 *****	**0.37**
Hearing	**-2.82 *****	**0.36**	**-2.82 *****	**0.36**
Cognition	**-7.06 *****	**0.40**	**-7.03 *****	**0.39**
Mobility	**-15.05 *****	**0.42**	**-15.05 *****	**0.42**
Self-Care	**-10.35 *****	**0.81**	**-10.32 *****	**0.81**
Communication	**0.34**	**0.69**	**--**	**--**
Functional limitations linear spline (each scored 0-2: *no difficulty* and *some difficulty* to *unable to do*)				
Vision spline	**3.38 ****	**1.04**	**3.44 *****	**1.04**

Respondent Characteristics	Initial Model 6 limitations severities included		Final Model 5 limitations severities included (excluding communication)	
	Coefficient[1]	**Standard Error**	**Coefficient[1]**	**Standard Error**
Hearing spline	**1.76**	**0.99**	**1.92**	**0.99**
Cognition spline	**2.17 ***	**1.06**	**2.45 ***	**1.05**
Mobility spline	**8.29 *****	**0.76**	**8.31 *****	**0.76**
Self-Care spline	**8.45 *****	**1.52**	**8.84 *****	**1.50**
Communication spline	**1.45**	**1.49**	**--**	**--**
Male	-1.83 ***	0.25	-1.83 ***	0.25
Age (continuous) [Referent: 65-79 years]	-0.36 ***	0.03	-0.35 ***	0.03
18-34 years	-12.50 ***	1.40	-12.47 ***	1.40
35-49 years	-14.03 ***	1.06	-14.01 ***	1.06
50-64 years	-12.71 ***	0.78	-12.70 ***	0.78
80 years and older	8.55 ***	0.77	8.54 ***	0.77
Dual eligibility	-5.94 ***	0.87	-5.95 ***	0.87
Medicare beneficiary	-5.53 ***	0.69	-5.51 ***	0.69
Missing Medicare status	4.02 *	1.65	4.00 *	1.65
English language proficiency [Referent: Very well]				
Well	-1.77 **	0.56	-1.71 **	0.55
Not well	-2.25 **	0.72	-2.14 **	0.72
Not at all	-3.05 **	0.93	-2.93 **	0.93
Missing	-2.75	7.70	-2.76	7.70
Education [Referent: High school graduate]				
Less than high school	-3.29 ***	0.44	-3.29 ***	0.44
Some college or associates degree	2.26 ***	0.33	2.26 ***	0.33
Bachelor's degree or higher	6.87 ***	0.35	6.87 ***	0.35
Missing	0.5	1.82	0.55	1.82
Marital status [Referent: Single]				
Separated	-4.62 ***	0.89	-4.67 ***	0.89
Divorced	-0.74	0.49	-0.76	0.49
Married	1.24 ***	0.36	1.22 ***	0.35
Widowed	2.32 ***	0.67	2.29 ***	0.67
Missing	-2.85	3.30	-2.92	3.30

Respondent Characteristics	**Initial Model** 6 limitations severities included		**Final Model** 5 limitations severities included (excluding communication)	
	Coefficient[1]	**Standard Error**	**Coefficient[1]**	**Standard Error**
Race/Ethnicity [Referent: non-Hispanic White]				
Hispanic	-2.13 ***	0.41	-2.14 ***	0.41
Black	-4.04 ***	0.40	-4.03 ***	0.40
American Indian/Alaska Native	-3.60 *	1.59	-3.61 *	1.59
Asian	-2.10 ***	0.57	-2.09 ***	0.57
Multiracial	-1.94	1.03	-1.95	1.03
Missing	-1.76	3.77	-1.76	3.77
Census Region [Referent: Northeast]				
Midwest	-0.66	0.39	-0.67	0.39
South	-0.49	0.35	-0.49	0.35
West	0.43	0.39	0.42	0.39
Personal Earnings [Referent: $15,000-$34,999]				
$0 - $14,999	-1.95 ***	0.47	-1.95 ***	0.47
$35,000-$54,999	1.63 **	0.49	1.63 **	0.49
$55,000-74,999	1.79 ***	0.54	1.80 ***	0.54
$75,000 and over	4.88 ***	0.50	4.89 ***	0.50
Missing	-4.44 ***	0.40	-4.43 ***	0.40
Intercept	102.69 ***	2.12	102.65 ***	2.12

Notes: Cell entries represent the coefficients from a regression model that predicts self-rated health (linearly scored 0-100, where 0 represents poor health and 100 represents excellent health) from all respondent characteristics shown in the table. A statistically significant negative coefficient indicates a characteristic that is associated with worse self-rated health; a statistically significant positive coefficient indicates a characteristic associated with better self-rated health. [1]Significance levels are represented as follows: * $0.01 \leq p < 0.05$, ** $0.001 \leq p < 0.01$, *** $p < 0.001$. Estimates and standard errors are calculated from weighted 2014 and 2015 NHIS survey data. 1,818 respondents were removed from the model due to missing functional limitation item responses; an additional 16 respondents were not used in the underlying predictive model due to missing general health status. Estimates were weighted according to guidelines published by the NHIS to represent the noninstitutionalized U.S. adult population. See Center for Disease Control and Prevention (June 2016). Responses are taken from adults 18 and older in the NHIS AFD 2014 and 2015 data. Only bolded functional limitations and spline terms were allowed to vary when calculating the FLI score. Socio-demographic adjusters were fixed to the population average.

eAppendix B. Additional Methodological Detail on Construction of the FLI

In addition to the five functional limitation scores, the final linear regression model predicting self-rated health included several additional measures. To remove the effects of exogenous contributors to a person's appraisal of his or her own health (e.g., response tendencies, frames of references),[42,43] the regression model controlled for race and ethnicity, gender, age (linearly and categorically), dual enrollment in Medicaid and Medicare, Medicare status, English language proficiency, education, marital status, Census region, and personal earnings. Because of high missingness, NHIS multiple imputation income files were used for personal earnings. Missing value indicators for each sociodemographic characteristic were included as control variables.

The functional limitation coefficients produced from the final model (shown in Table 1) were used to derive a predicted self-rated health score as follows: Let X_{ij} be the functional limitation score for person j on domain i, scored 0 for *no difficulty*, 1 for *some difficulty*, 2 for *a lot of difficulty*, and 3 for *unable to do*. Domain i is 1 for vision, 2 for hearing, 3 for cognition, 4 for mobility, and 5 for self-care. The linear spline adjustment term is defined as

$$Y_{ij} = \begin{cases} X_{ij} - 1 & \text{if } X_{ij} = 2,3 \\ 0 & \text{if } X_{ij} = 0,1 \end{cases}$$

Finally, the predicted self-rated health score for person j is calculated as

$$D_j = A_1 X_{1j} + B_1 Y_{1j} + \cdots A_5 X_{5j} + B_5 Y_{5J}.$$

The range of predicted self-rated health scores on this covariate-adjusted index was 4.5 to 72.8 (mean (*M*) = 66.3, standard deviation (*SD*) = 11.1).

eAppendix C. Socio-demographic Characteristics of the Three Limitation Groups

Table A3. Distribution of Demographic Characteristics by Limitation Group and Odds Ratios across Limitation Groups among the U.S. Adult population: 2014-2015

	U.S. Population [n=33,424; 100%]	**Least Limited (z-score> -1) [n=28,241; 87%] *reference group***	**Somewhat Limited (z-score> -2 to -1) [n=2,974; 8%]**			**Most Limited (z-score≤ -2) [n=2,209; 5%]**		
	Weighted %	**Weighted %**	**Weighted %**	**Bivariate Odds Ratios[a]**	**Multivariate Odds Ratios[b]**	**Weighted %**	**Bivariate Odds Ratios[a]**	**Multivariate Odds Ratios[b]**
Male	48.4	49.7	40.8	0.70 (0.63, 0.78)***	0.83 (0.74, 0.94)**	39.0	0.65 (0.57, 0.73)***	0.85 (0.73, 0.98)*
Age[c]								
18-34 years	30.3	33.5	10.0	1.06 (0.57, 1.97)	2.18 (1.11, 4.28)*	6.6	0.80 (0.40, 1.62)	1.71 (0.74, 3.96)
35-49 years	24.9	26.6	13.8	0.87 (0.57, 1.33)	2.66 (1.65, 4.28)***	13.1	0.92 (0.56, 1.51)	3.94 (2.20, 7.04)***
50-64 years	25.8	24.7	34.5	1.19 (0.95, 1.50)	3.54 (2.63, 4.76)***	31.3	1.17 (0.89, 1.54)	4.87 (3.44, 6.89)***
65-79 years	14.6	12.6	28.4	*reference*	*reference*	26.8	*reference*	
80+ years	4.5	2.6	13.4	1.27 (1.00, 1.61)	1.19 (0.93, 1.52)	22.3	2.18 (1.68, 2.82)***	2.09 (1.59, 2.73)***
Race/ethnicity								
American Indian/Alaska Native	0.6	0.5	1.0	1.81 (1.01, 3.24)*	1.79 (0.89, 3.58)	1.1	2.08 (1.1, 3.92)*	1.57 (0.75, 3.3)
Asian	5.6	6.0	2.9	0.44 (0.33, 0.59)***	0.58 (0.42, 0.80)***	3.1	0.51 (0.37, 0.70)***	0.58 (0.4, 0.85)**

	U.S. Population [n=33,424; 100%]	Least Limited (z-score> -1) [n=28,241; 87%] *reference group*	Somewhat Limited (z-score> -2 to -1) [n=2,974; 8%]			Most Limited (z-score≤ -2) [n=2,209; 5%]		
	Weighted %	**Weighted %**	**Weighted %**	**Bivariate Odds Ratios[a]**	**Multivariate Odds Ratios[b]**	**Weighted %**	**Bivariate Odds Ratios[a]**	**Multivariate Odds Ratios[b]**
Black	11.5	11.3	13.0	1.05 (0.91, 1.22)	0.97 (0.82,1.16)	13.6	1.17 (0.99, 1.37)	0.94 (0.77, 1.15)
Hispanic	15.6	16.2	11.2	0.63 (0.54, 0.74)***	0.71 (0.57,0.89)**	12.1	0.72 (0.61, 0.86)***	0.65 (0.49, 0.86)**
Multiracial	1.4	1.3	1.2	0.81 (0.53, 1.26)	1.04 (0.68,1.61)	3.1	2.22 (1.35, 3.65)**	3.05 (1.58, 5.92)***
White	65.2	64.6	70.6	*reference*	*reference*	66.8	*reference*	*reference*
Missing	0.1	0.1	0.1	0.69 (0.16, 2.99)	1.01 (0.22,4.62)	0.2	1.88 (0.56, 6.36)	2.98 (1.02, 8.68)*
English language proficiency								
Very well	88.5	88.8	88.5	*reference*	*reference*	83.3	*reference*	*reference*
Well	5.8	5.7	5.5	0.96 (0.76, 1.21)	1.04 (0.79, 1.38)	7.1	1.32 (1.06, 1.64)*	1.23 (0.93, 1.61)
Not well	3.7	3.6	3.7	1.03 (0.79, 1.35)	1.01 (0.73, 1.41)	4.2	1.25 (0.95, 1.64)	1.06 (0.74, 1.54)
Not at all	2.1	1.9	2.3	1.24 (0.87, 1.76)	0.85 (0.57, 1.27)	5.4	3.12 (2.35, 4.15)***	1.70 (1.09, 2.67)*

	U.S. Population [n=33,424; 100%]	Least Limited (z-score> -1) [n=28,241; 87%] *reference group*	Somewhat Limited (z-score> -2 to -1) [n=2,974; 8%]			Most Limited (z-score≤ -2) [n=2,209; 5%]		
	Weighted %	**Weighted %**	**Weighted %**	**Bivariate Odds Ratios[a]**	**Multivariate Odds Ratios[b]**	**Weighted %**	**Bivariate Odds Ratios[a]**	**Multivariate Odds Ratios[b]**
Missing	0.0	0.0	0.0	1.40 (0.14, 13.99)	2.35 (0.17,32.76)	0.0	0.00 (0.00, 0.00)***	0.00 (0.00, 0.00)***
Marital status								
Separated	2.1	1.9	2.5	2.46 (1.78, 3.40)***	1.18 (0.84, 1.64)	3.9	3.76 (2.72, 5.19)***	1.52 (1.02, 2.26)*
Divorced	11.3	10.6	16.8	2.99 (2.49, 3.59)***	1.19 (0.97, 1.46)	16.1	2.81 (2.27, 3.47)***	0.92 (0.72, 1.19)
Married	53.1	54.0	49.7	1.73 (1.47, 2.04)***	0.95 (0.79, 1.14)	43.0	1.47 (1.2, 1.79)***	0.82 (0.65, 1.04)
Single	27.2	29.0	15.4	*reference*	*reference*	15.7	*reference*	*reference*
Widowed	6.2	4.4	15.6	6.64 (5.51, 8.00)***	1.08 (0.86, 1.36)	21.2	8.86 (7.16, 10.97)***	0.96 (0.73, 1.26)
Missing	0.1	0.1	0.0	0.53 (0.13, 2.17)	0.21 (0.05, 0.93)*	0.2	2.09 (0.76, 5.79)	0.62 (0.16, 2.39)
Insurance status								
Private	54.2	59.2	26.1	*reference*	*reference*	37.0	*reference*	*reference*
Dually-eligibility	2.3	1.1	6.6	13.04 (10.30, 6.52)***	5.16 (3.74, 7.11)***	14.9	59.59 (45.68, 77.74)***	13.01 (8.94, 18.92)***
Medicaid	8.8	8.2	12.2	3.37 (2.78, 4.08)***	2.60 (2.06, 3.29)***	13.3	7.47 (5.81,9.59) ***	3.42 (2.47, 4.73)***
Medicare	18.6	14.6	43.0	6.67 (5.84, 7.62)***	3.05 (2.34, 3.98)***	48.1	15.17 (12.32,18.69) ***	4.89 (3.47, 6.89)***

	U.S. Population [n=33,424; 100%]	Least Limited (z-score> -1) [n=28,241; 87%] *reference group*	Somewhat Limited (z-score> -2 to -1) [n=2,974; 8%]			Most Limited (z-score≤ -2) [n=2,209; 5%]		
	Weighted %	**Weighted %**	**Weighted %**	**Bivariate Odds Ratios[a]**	**Multivariate Odds Ratios[b]**	**Weighted %**	**Bivariate Odds Ratios[a]**	**Multivariate Odds Ratios[b]**
Other public insurance	3.6	3.6	3.7	2.37 (1.73, 3.25)***	1.69 (1.22, 2.33)**	3.4	4.31 (2.93,6.34) ***	2.37 (1.58, 3.55)***
Uninsured	12.0	12.7	8.1	1.45 (1.14, 1.83)**	1.30 (1.00, 1.69)	6.5	2.37 (1.75,3.22) ***	1.40 (0.99, 1.99)
Missing	0.6	0.6	0.3	1.19 (0.48, 2.97)	1.27 (0.51, 3.20)	1.0	8.01 (3.48, 18.42)***	6.05 (2.31, 15.86)***
Education								
Less than high school	12.9	11.4	18.9	1.33 (1.13, 1.56)***	1.23 (1.02, 1.50)*	28.8	1.99 (1.69, 2.34)***	1.54 (1.26,1.9)*** 1.98)***
High school or GED	25.1	24.3	30.4	*reference*	*reference*	30.9	*reference*	*reference*
Some college or associates	30.7	31.0	30.7	0.79 (0.69, 0.91)***	1.01 (0.87, 1.17)	26.3	0.67 (0.57, 0.79) ***	0.95 (0.79, 1.13)
Bachelor's degree or more	30.8	32.9	19.6	0.48 (0.41, 0.56)***	0.68 (0.57, 0.80)***	12.7	0.30 (0.25, 0.37)***	0.54 (0.44, 0.67)***
Missing	0.5	0.4	0.3	0.53 (0.23, 1.24)	0.45 (0.20, 1.01)	1.2	2.28 (1.27, 4.12)**	1.59 (0.74, 3.41)
Census region								
Northeast	17.6	18.1	15.2	*reference*	*reference*	14.4	*reference*	*reference*
Midwest	22.3	22.2	22.7	1.22 (1.02, 1.45)*	1.32 (1.09, 1.59)**	25.0	1.41 (1.14, 1.74)**	1.71 (1.35, 2.17)***
South	37.3	36.8	41.0	1.32 (1.13, 1.55)***	1.42 (1.20, 1.69)***	39.6	1.34 (1.11, 1.62)**	1.51 (1.22, 1.87)***
West	22.7	23.0	21.1	1.09 (0.92, 1.30)	1.34 (1.11, 1.61)**	20.9	1.14 (0.93, 1.40)	1.46 (1.16, 1.85)**

	U.S. Population [n=33,424; 100%]	Least Limited (z-score> -1) [n=28,241; 87%] *reference group*	Somewhat Limited (z-score> -2 to -1) [n=2,974; 8%]			Most Limited (z-score≤ -2) [n=2,209; 5%]		
	Weighted %	**Weighted %**	**Weighted %**	**Bivariate Odds Ratios[a]**	**Multivariate Odds Ratios[b]**	**Weighted %**	**Bivariate Odds Ratios[a]**	**Multivariate Odds Ratios[b]**
Personal Earnings								
$0–14,999	12.2	13.0	8.7	1.44 (1.11, 1.85)**	1.39 (1.07, 1.81)*	5.2	1.85 (1.23, 2.77)**	1.62 (1.07, 2.45)*
$15,000–34,999	16.0	17.5	7.7	*reference*	*reference*	3.6	*reference*	*reference*
$35,000–54,999	11.4	12.4	5.9	1.03 (0.76, 1.40)	1.13 (0.82, 1.54)	2.1	0.78 (0.48, 1.27)	0.93 (0.57, 1.51)
$55,000–74,999	6.6	7.3	2.3	0.73 (0.51, 1.06)	0.8 (0.55, 1.17)	1.0	0.59 (0.28, 1.24)	0.74 (0.34, 1.59)
$75,000 +	9.5	10.5	3.9	0.8 (0.56, 1.13)	0.93 (0.64, 1.35)	0.6	0.27 (0.13, 0.54)***	0.37 (0.18, 0.77)**
Missing	44.3	39.3	71.4	5.33 (4.34, 6.53)***	2.6 (2.07, 3.27)***	87.5	13.8 (10.26, 18.57)***	5.34 (3.85, 7.4)***

Note: Data are from the 2014-2015 NHIS (*N*=33,424). 1,818 respondents were removed from the model due to missing functional limitation responses. AI/AN = American Indian or Alaska Native. Model outcomes included binary (1/0) indicators for inclusion in the *somewhat limited* and *most limited* groups with the *least limited* group as the referent. All results are weighted according to NHIS documentation to be representative of the noninstitutionalized U.S. adult population. Significance levels are represented as follows: * $0.01 \leq p < 0.05$, ** $0.001 \leq p < 0.01$, *** $p < 0.001$.

[a] Bivariate models were run for each characteristic set one at a time.
[b] A multivariate model was run including all characteristics.
[c] Linear age was included with age indicators but is not shown here.