Stroke Performance Measures Do Not Predict Functional Outcome

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Abstract

Background and Purpose: Poststroke functional outcome is critical to stroke survivors. We sought to determine whether adherence to current stroke performance measures is associated with better functional outcome 90 days after an ischemic stroke. **Methods:** Utilizing the Brain Attack Surveillance in Corpus Christi cohort, we examined adherence to 7 ischemic stroke performance measures from February 2009 to June 2012. Adherence to the measures was analyzed in aggregate using a binary defect-free score and an opportunity score, representing the proportion of eligible measures met. The opportunity score ranges from 0 to 1, with values closer to 1 implying better adherence. Functional outcome, defined by an activities of daily living and instrumental activities of daily living (ADL/IADL) score (range 1-4, higher scores worse), was ascertained at 90 days poststroke. Tobit regression models were fitted to examine the associations between the performance measures and functional outcome, adjusting for demographic and clinical characteristics, including stroke severity. **Results:** There were 565 patients with ischemic stroke included in the analysis. The median ADL/IADL score was 2.32 (interquartile range [IQR]: 1.41-3.41). The median opportunity score was 1 (IQR: 0.8-1), and 58.4% of the patients received defect-free care. After adjustment, the opportunity score ($P = .67$) and defect-free care ($P = .92$) were not associated with functional outcome. **Conclusion:** In this population, adherence to a composite of current stroke performance measures was not associated with poststroke functional outcome after adjustment for other factors. Performance measures that are associated with improved functional outcome should be developed and incorporated into stroke quality measures.

Keywords

stroke, inpatient, quality, outcomes

Introduction

Improving the quality of care patients receive is a priority.¹ Performance measures evaluate the structure, process, and outcome of care and provide a metric that can be tracked and reported.² Recently, there has been tremendous growth in not only the number of performance measures tracked but also in the various ways these measures are reported.³ Performance measures are used to assess the quality of inpatient stroke care and have been defined since 2000.²

The Joint Commission (JC) is the largest accrediting organization in health care and has certified more than 1000 hospitals as primary stroke centers (PSCs).⁴ Primary stroke centers track performance on 8 process-based measures.⁵ These performance measures are also part of the Centers for Medicare and Medicaid Services (CMS) core measures, which

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are publicly reported. Although evaluating performance is associated with better scores on the measured metrics,⁶ there are a lack of data showing an association between adherence to performance measures and better functional outcomes.⁷ Since stroke mortality has decreased substantially⁸ and more patients are living with stroke-related disability,⁹ addressing patient-centered outcomes, such as poststroke functional status, is important.^{10,11}

Theoretically, adherence to current stroke performance measures may improve functional outcome by reducing or preventing in-hospital complications or reducing recurrent stroke; however, the link between process-based stroke performance measures and functional outcome is not well established. The goal of this study was to determine whether adherence to current stroke performance measures was associated with better functional outcome after ischemic stroke in a community-based setting. We hypothesized that better adherence to current performance measures would not be associated with improved functional outcome. If adherence to stroke performance measures is associated with better functional outcome, then compliance should be further incentivized; however, if, as we expect, there is no association, then other measures associated with improved functional outcome should be developed to achieve this important patient-centered goal.

Methods

Study Population

The Brain Attack Surveillance in Corpus Christi (BASIC) project is a population-based stroke surveillance study in Nueces County, Texas. The methods of the BASIC project have been reported previously.¹² Nueces County is a predominantly urban, biethnic community, and the majority of the 340 000 residents reside in the city of Corpus Christi. Sixty-two percent of Nueces County residents are Mexican American (MA), 32% are non-Hispanic white, and the remainder are of other race/ethnicities.¹³ The county is served by 6 acute care adult hospitals (median bed size: 154, range: 72-345). All hospitals have computed tomography, magnetic resonance imaging, and neurology services. Two of the hospitals have JC PSC certification—1 was certified in January 2009 and the other in December 2010. All stroke cases in Nueces County in patients older than 44 years were ascertained by both active and passive surveillance. Possible stroke events were validated by a neurologist or stroke fellowship-trained emergency medicine physician blinded to race/ethnicity and age using source documentation. As part of BASIC, all patients with a validated stroke were invited to participate in a baseline interview that included medical record abstraction, as well as an outcome interview conducted about 90 days after the stroke. This study includes patients with ischemic stroke identified from February 2009 through June 2012 who completed a baseline interview and a 90-day outcome interview. We excluded

patients who had their index stroke in hospital and those who had missing data or were lost to follow-up. Deaths in BASIC participants were verified by reports from family, the Texas Department of Health, and/or the Social Security Death Index. This study was approved by the institutional review board (IRB) of the University of Michigan as well as the IRBs of the 2 hospital systems in Nueces County. Participants (or proxies) who were interviewed provided written informed consent.

Variables and Outcome

Prestroke characteristics were obtained from a baseline interview and medical record abstraction. For patients unable to answer orientation questions, the interview was completed by a proxy (28.9%). Race/ethnicity, marital status, and education were self-reported. Prestroke functional status was measured using the modified Rankin scale (mRS) obtained through a structured interview.¹⁴ Sociodemographic and clinical data were abstracted from the medical record by trained personnel blinded to the patient's 90-day outcome and the study question. A comorbidity index was created by summing the number of comorbidities for each patient. Stroke severity, measured by the National Institutes of Health Stroke Scale (NIHSS), was abstracted directly from the chart or, if not present, retrospectively measured using a previously validated method.¹⁵

Performance measures were calculated based on the 2008 JC PSC definitions. Data needed to calculate the numerator, denominator, and exclusions for specific performance measures were abstracted from the medical record, including progress notes and the medication administration record. We collected information on the following measures adapted from the processes outlined by the JC: (1) deep vein thrombosis prophylaxis, (2) discharged on antithrombotic therapy, (3) patients with atrial fibrillation receiving anticoagulation therapy at discharge, (4) thrombolytic therapy administered, (5) antithrombotic therapy by the end of hospital day 2, (6) discharged on cholesterol-reducing medication, and (7) assessed for rehabilitation. Patients who were transferred ($n = 61$) had their performance measures attributed to the discharging hospital. To ensure measurement of the performance measures was reliable, a random sample of cases was reabstracted. The mean percentage agreement between the original and reabstracted cases was 97% (range: 88%-100%) for determination of inclusion/exclusion in the numerators of the performance measures and 92% (range: 83%-100%) for determination of inclusion/exclusion in the denominators.

A composite quality measure, termed opportunity score,¹⁶ was calculated by dividing the number of performance measures that a patient received by the number of measures a patient was eligible to receive. This score ranges between 0 and 1, with values closer to 1 implying better adherence to the performance measures. We also calculated a binary defect-free score, which was defined as a patient receiving *all* of the performance measures he or she was eligible to receive.

A structured outcome interview was conducted at 90 days after the stroke by trained personnel. In 20.2% of cases, the outcome interview was completed by a proxy. The primary outcome for this analysis was functional outcome at 90 days, as measured by activities of daily living and instrumental activities of daily living (ADL/IADL) score. Respondents reported the level of difficulty associated with 7 ADLs and 15 IADLs (scale ranging from 1 to 4), and these scores were summed and then divided by the number of items resulting in an average score ranging from 1 to 4. A score of 1 indicates that the patient can perform ADL/IADL without difficulty; a score of 2 indicates that these tasks can be done with some difficulty; a score of 3 indicates that a patient can perform these activities with a lot of difficulty; and a score of 4 indicates that the ADL/IADL can only be done with assistance from another person or equipment. The ADL/IADL score captures the aspects of functional status that lead to institutionalization or need for caregiving resources^{17,18} and includes cognitive domains that are not measured in other outcome measures, such as the mRS.¹⁹

Data Analysis

Descriptive statistics for the included variables were calculated for patients alive at 90 days. Covariates were preselected for inclusion in a multivariable model based on their plausible association with functional outcome and included age, sex, race/ethnicity, education, marital status, health insurance (yes/no), stroke severity (as measured by the NIHSS), pre-stroke disability (as measured by the mRS, dichotomized to 0-2 vs 3-5), and the comorbidity index. The same covariates were used in every multivariable model.

The primary analyses were examinations of the association between functional outcome, analyzed continuously, and adherence to performance measures as measured by the opportunity score or defect-free care. A Tobit regression model was fitted to minimize possible bias because the ADL/IADL score is constrained by lower and upper bounds (ie, the score ranges from 1 to 4).²⁰ Due to a small amount of variation among hospitals (intraclass correlation coefficient <.01) in the ADL/IADL score, a multilevel model was not pursued further (ie, the patient was the unit of analysis.) In the primary analyses, we excluded patients who died within 90 days but included these patients in secondary analyses. In our data, the distribution of the opportunity score was concentrated at the higher end of the scale, therefore, we report the estimated difference in the ADL/IADL score associated with an interquartile range (IQR; ie, the difference between the 25th and 75th percentile) difference in the continuous opportunity score. (Since a 1 unit change in the continuous opportunity score is not relevant in this analysis and the IQR was 0.2, the IQR comparison reflects comparing someone who got all the measures [100% that reflects the 75th percentile] with someone who got only 80% [25th percentile].) We also report

the ADL/IADL difference associated with the binary defect-free score (yes vs no).

Given the sample size available for this analysis and using variance estimates from the fitted model, we computed the difference in ADL/IADL score per IQR difference in the opportunity score that would be detectable with 80% power and found that we were able to detect a 0.12 or greater difference in the ADL/IADL score, after adjusting for other confounders. This suggests ample power to detect a clinically meaningful difference in the outcome.

To further investigate the relationship between the performance measures and functional outcome, as a secondary analysis, we dichotomized the ADL/IADL score to define patients with a good outcome (ADL/IADL score <3) and a poor outcome (ADL/IADL score ≥3) and examined the association between the performance measures and functional outcome with and without including patients who died within 90 days of their index stroke in the poor outcome group. Generalized estimating equations with the log link function were used to estimate the association between the performance measures and good outcome. Robust standard errors were used to account for clustering within hospitals.²¹

To evaluate for the possibility of selection bias, we compared the population in the primary analysis to patients who had a validated ischemic stroke and who were alive at 90 days, but not included in our analysis, due to exclusions listed in Figure 1, using χ^2 test for categorical variables and Kruskal-Wallis nonparametric test for continuous variables. Statistical analysis was performed using SAS version 9.3 and R software version 3.1.1.

Results

There were 1337 patients who had a validated ischemic stroke during the study period and 844 completed a baseline interview. There were 6 patients who were not eligible for any performance measures, leaving 838 potentially eligible patients for analysis. Of these 838 patients, we excluded patients who died ($n = 107$), were unable to be located for an outcome interview ($n = 77$), refused the outcome interview ($n = 55$), and had missing outcome or covariate data ($n = 34$), yielding 565 complete cases for the primary analysis. A flow diagram of study participants is shown in Figure 1.

Demographic information about the patients included in the analyses and alive at 90 days is shown in Table 1. The median opportunity score was 1 (IQR: 0.8-1.0), and 58% of the patients received defect-free care. The median ADL/IADL score was 2.32 (IQR: 1.41-3.41). When compared to patients who had an ischemic stroke and were alive at 90 days but were not included in our study (Table 1), the patients in our analyses were younger ($P = .02$) and more likely to be MA ($P < .001$). The number of patients who met each performance measure and the number of eligible patients for each measure are shown in Table 2.

Figure 1. Participant flow.

When the ADL/IADL score was examined continuously, in the unadjusted analysis, there was a nonsignificant trend toward an association between adherence to stroke performance measures and better functional outcome (0.10 lower ADL/IADL score per IQR increase in opportunity score: 95% confidence interval [CI]: -0.20 to 0.01 ; $P = .08$; 0.16 lower ADL/IADL score when comparing defect-free care: 95% CI: -0.37 to 0.04 ; $P = .11$). After adjustment, neither defect-free care ($P = .92$) nor the opportunity score ($P = .67$) was associated with better functional outcome. In the adjusted model (Table 3), worse functional outcome was associated with increasing age, female sex, MA ethnicity, prestroke disability, greater stroke severity, and higher comorbidity index.

When the ADL/IADL score was dichotomized, the unadjusted analyses showed a positive association between the performance measures and better functional outcome. When patients who died within 90 days were excluded, the relative risk (RR) for poor outcome was 0.89 (95% CI: 0.80-0.99) per IQR increase in the opportunity score ($P = .04$) and 0.80 (95% CI: 0.64-1.00) for the defect-free indicator ($P = .05$). Similarly, when patients who died were included, the respective RRs were 0.88 for opportunity score (95% CI: 0.83 to 0.94; $P < .001$) and 0.84 for defect-free care (95% CI: 0.71-1.00; $P = .05$). Table 4 shows that after adjustment, however, the opportunity score and defect-free care were no longer associated with better functional outcome. Worse functional

Table 1. Demographics and Clinical Information.^a

	Patients Alive at 90 Days After Ischemic Stroke (n = 565)		Patients Alive at 90 days After Ischemic Stroke and Not Included in the Primary Analyses (n = 531)		P Value
	N or median	% or Q1-Q3	N or median	% or Q1-Q3	
Age	67	57-78	69	59-80	.02
Female	294	52.0	257	48.4	.23
Ethnicity					
NHW	182	32.2	223	43.2	<.001
MA	341	60.4	256	49.6	
Other	42	7.4	37	7.2	
Marital status					
Married/living together	281	49.7			
Single	38	6.7			
Widowed	138	24.4			
Divorced/separated	108	19.1			
Greater than high school education	197	34.9			
Insured	500	88.5	459	88.3	.93
Prestroke mRS 0-2	450	79.7			
Comorbidity index	3	2-5	3	2-5	.82
NIH stroke scale	4	2-8	4	2-7	.57
Defect-free care	330	58.4			
Opportunity score	1	0.8-1			
ADL/IADL score	2.32	1.41-3.41			

Abbreviations: ADL, activities of daily living; HS, high school; IADL, instrumental activities of daily living; MA, Mexican American; mRS, modified Rankin scale; NIH, National Institutes of Health; NHW, non-Hispanic white.

^aFor patients not included in the analyses, we do not have data regarding their marital status, education, pre-stroke disability, adherence to performance measures, or functional outcome.

Table 2. Performance Measure Adherence.^a

Performance Measure	Patients With Adherence to the Measure (n)	Patients Eligible for the Measure (n)	Adherence Rate
DVT prophylaxis at 48 hours	287	363	79.1
Discharged on antithrombotic therapy	481	554	86.8
Anticoagulation for atrial fibrillation at discharge	79	104	76.0
Thrombolytic therapy	42	70	60.0
Antithrombotic therapy by the end of hospital day 2	471	501	94.0
Discharged on a cholesterol-reducing medication	335	418	80.1
Assessed for rehabilitation	485	502	96.6

Abbreviation: DVT, Deep vein thrombosis.

^aRate = numerator/denominator.

outcome was associated with older age, MA ethnicity, greater stroke severity, prestroke disability, and higher comorbidity index.

Discussion

In this population-based study, we did not find an association between current stroke performance measures and better functional outcomes after adjusting for important patient-level factors. As in prior work, differences in functional outcome were more attributable to individual patient characteristics than adherence to quality measures.²² Adherence to stroke performance measures is emphasized by the JC, and CMS

encourages patients to make decisions about where they receive their care based on how hospitals adhere to these measures.²³ Hospitals allocate significant resources to track and report these measures, and their performance is publicly reported. The lack of association with functional outcome, a critically important stroke end point, suggests the need to develop additional measures that are tied to functional outcome, a critically important patient-centered metric.

Although a clinically meaningful difference in the ADL/IADL score has not been specified in the literature, this study had 80% power to detect a 0.12 difference on the 4-point scale, which is a small difference when comparing individual patients. The difference we found, 0.03, was presumably far

Table 3. Adjusted Predictors of Functional Outcome With ADL/IADL Analyzed Continuously.

Variable	Analysis With Adherence to Performance Measures Represented by an Increase in the Opportunity Score by 0.2 (ie, IQR)				Analysis With Adherence to Performance Measures Represented by Defect-Free Care			
	Estimate	Lower CI	Upper CI	P Value	Estimate	Lower CI	Upper CI	P Value
Performance measure adherence	−0.02	−0.10	0.06	.67	0.01	−0.15	0.16	.92
Age	0.02	0.01	0.03	<.001	0.02	0.01	0.03	<.001
Female sex	0.33	0.17	0.49	<.001	0.33	0.18	0.49	<.001
Race/ethnicity (reference: NHW)								
MA	0.43	0.26	0.61	<.001	0.43	0.26	0.61	<.001
Other	0.14	−0.17	0.44	.38	0.14	−0.17	0.44	.38
Marital status (reference: married)								
Single	0.20	−0.12	0.51	.23	0.20	−0.12	0.51	.22
Widowed	0.05	−0.16	0.25	.66	0.04	−0.17	0.25	.70
Divorced/separated	−0.01	−0.22	0.20	.95	−0.01	−0.22	0.20	.93
Greater than high school education	−0.15	−0.32	0.02	.09	−0.15	−0.32	0.02	.09
Baseline mRS 0-2	−0.74	−0.95	−0.53	<.001	−0.74	−0.95	−0.53	<.001
NIH stroke scale	0.07	0.05	0.08	<.001	0.07	0.05	0.08	<.001
Insured	−0.04	−0.30	0.22	.75	−0.05	−0.31	0.21	.72
Comorbidity index	0.12	0.08	0.17	<.001	0.12	0.08	0.17	<.001

Abbreviations: CI, confidence interval; MA, Mexican American; mRS, modified Rankin scale; NHW, Non-Hispanic white; NIH, National Institutes of Health.

Table 4. Adjusted Predictors of Functional Outcome With ADL/IADL Dichotomized.

Variable	Patients Who Died Within 90 Days Excluded								Patients Who Died Within 90 Days Included in the Poor Outcome Group							
	Analysis With Performance Measure Adherence Represented by an Increase in the Opportunity Score by 0.2 (ie, IQR)				Analysis With Performance Measure Adherence Represented by Defect-Free Care				Analysis With Performance Measure Adherence Represented by an Increase in the Opportunity Score by 0.2 (ie, IQR)				Analysis With Performance Measure Adherence Represented by Defect-Free Care			
	RR	Lower CI	Upper CI	P Value	RR	Lower CI	Upper CI	P Value	RR	Lower CI	Upper CI	P Value	RR	Lower CI	Upper CI	P Value
Performance measure adherence	1.01	0.92	1.13	.78	1.02	0.83	1.27	.84	0.98	0.92	1.04	.52	0.99	0.85	1.15	.89
Age	1.02	1.01	1.04	<.001	1.02	1.01	1.03	<.001	1.02	1.01	1.03	<.001	1.02	1.01	1.03	<.001
Female sex	1.18	0.94	1.48	.15	1.17	0.94	2.07	.16	1.05	0.89	1.24	.57	1.05	0.90	1.24	.52
Race/ethnicity (reference: NHW)																
MA	1.66	1.29	2.15	<.001	1.66	1.29	2.15	<.001	1.32	1.10	1.57	<.001	1.32	1.11	1.58	<.001
Other	1.39	0.94	2.06	.10	1.40	0.94	2.07	.09	1.19	0.87	1.62	.27	1.19	0.87	1.62	.27
Marital status (reference: married)																
Single	1.16	0.71	1.90	.56	1.15	0.71	1.89	.57	1.09	0.77	1.54	.63	1.09	0.77	1.54	.62
Widowed	0.96	0.77	1.28	.94	0.99	0.77	1.28	.95	0.97	0.81	1.16	.76	0.97	0.81	1.16	.73
Divorced/separated	0.96	0.70	1.32	.80	0.96	0.70	1.32	.80	0.94	0.73	1.20	.60	0.93	0.73	1.20	.59
Greater than high school education	0.95	0.73	1.25	.73	0.96	0.73	1.25	.74	0.93	0.77	1.12	.42	0.93	0.77	1.12	.43
Baseline mRS 0-2	0.55	0.44	0.69	<.001	0.56	0.44	0.70	<.001	0.63	0.54	0.74	<.001	0.63	0.53	0.74	<.001
NIH stroke scale	1.04	1.03	1.06	<.001	1.04	1.03	1.06	<.001	1.03	1.02	1.04	<.001	1.03	1.02	1.04	<.001
Insured	1.00	0.56	1.79	.99	1.00	0.55	1.79	.99	0.99	0.63	1.53	.97	0.99	0.63	1.53	.97
Comorbidity index	1.12	1.06	1.19	<.001	1.12	1.06	1.19	<.001	1.10	1.06	1.14	<.001	1.10	1.06	1.14	<.001

Abbreviations: ADL, activities of daily living; IADL, instrumental activities of daily living; MA, Mexican American; mRS, modified Rankin scale; NHW, Non-Hispanic white; NIH, National Institutes of Health; RR, relative risk.

smaller than any clinically meaningful difference, suggesting that these performance measures are not associated with better functional outcome.

A focus on process measures, rather than outcomes, has been criticized because of concerns that the excess emphasis on measured processes could distract from other unmeasured processes that contribute to good outcomes.²⁴ Additionally, some process-based performance measures have not had the expected association with improved outcomes.²⁵ Regarding the current stroke performance measures, with the exception of thrombolytic therapy,²⁶ none of the other metrics we examined have been associated with improved functional outcomes. Although other measures could indirectly contribute to better functional outcomes by reducing the risk of recurrent stroke²⁷⁻²⁹ or stroke-related complications,³⁰ the direct evidence that links these measures to functional outcome is lacking. Our findings suggest that measures associated with functional outcome should be considered for inclusion as stroke quality measures.

Prior studies assessing the association between performance measurement in stroke and functional outcome have had conflicting results with studies finding evidence of a positive association³¹ or no association.³² A review identified 14 studies that examined the relationship between compliance with stroke performance measures and patient-centered outcomes and found that 9 reported a positive association.³³ Most of these studies looked at mortality, complications, or recurrent stroke rather than functional outcome and they rarely accounted for stroke severity, a major predictor of stroke outcomes.

A strength of this study is that it was population based and took place in a community without an academic medical center, thus reflecting a setting where most US patients with stroke are treated. The other major strength was the use of functional outcome as the primary end point, a measure that is important to patients with stroke.^{10,11} Differences in the ADL/IADL score represent clinically meaningful changes in patient-centered outcomes: physical and cognitive functioning. Additionally, increasing ADL/IADL scores are predictive of nursing home placement and additional caregiving needs.^{17,18} We evaluated functional outcome at 3 months. This is a time frame that is commonly used in acute stroke trials.³⁴ Beyond this point, outcomes are less likely related to the care provided in the acute inpatient setting. Our analysis found similar conclusions when adherence to performance measures was measured by the opportunity score and defect-free care, which strengthens our results. Unlike studies using administrative data, we analyzed validated stroke cases based on standardized criteria. We were also able to adjust for predictors of stroke outcome at the patient level by accounting for stroke severity and medical comorbidities, which are often unmeasured in analyses that seek to find associations between quality of care and outcomes. A recent scientific statement recommends that these patient-level factors be included in hospital-level risk adjustment models.³⁵ By adjusting for stroke severity and medical comorbidities, we were better able to

isolate the effects (or lack thereof) of the performance measures. Additionally, with the exception of age and ethnicity, the population included in our analyses was similar to the ischemic stroke population as a whole, suggesting that these results are generalizable to the ischemic stroke population in Corpus Christi.

This study has limitations. First, although evaluation of performance measures is typically done at the hospital level, we assumed that evaluating their impact at the individual patient level is also valid. Second, we analyzed the adherence to the performance measures in aggregate, rather than individually, which assigns equal importance to each measure. Despite this limitation, there are valuable reasons for using all-or-none assessments when measuring quality.³⁶ Third, our analysis was limited to 1 measure of functional outcome. Use of a more sensitive outcome measure, beyond the ADL/IADL score, could change the results. Fourth, utilization of postacute rehabilitation was not included in the models. Since there was good adherence to the “evaluated for rehabilitation” measure, the lack of adjustment for postacute rehabilitation is unlikely to confound the results. Fifth, most patients in this cohort had a high opportunity score, though a few had low scores. The narrow range of the opportunity score decreases the power to observe statistically significant effects because predictors with low variance tend to have higher standard errors—that is, even if the coefficient itself was large, low variance in the opportunity score results in a large standard error for the coefficient and thus a large *P* value. However, the regression coefficient was so small in our analysis that even if the variance of the opportunity score had been 2 or 5 times larger, the *P* value would still not reach significance.

Our findings suggest that current stroke performance measures are not associated with better functional outcome. Although adherence to current stroke performance measures is crucial to reduce recurrent stroke and mortality, future studies should identify additional measures that are associated with improved functional outcome to ensure these metrics encompass outcomes relevant to providers, patients, and their families.

Declaration of Conflicting Interests

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