NIH Toolbox

Technical Manual

Jerry Slotkin, PhD, Michael Kallen, PhD, James Griffith, PhD, Susan Magasi, PhD, John Salsman, PhD, Cindy Nowinski, MD, PhD, and Richard Gershon, PhD

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NIH Toolbox Technical Manual

Domain:

COGNITION

Subdomain:

EPISODIC MEMORY

Measure:

NIH Toolbox Auditory Verbal Learning Test (Rey)

(Supplemental Measure)

Expert Contributors-COGNITION

Patricia Bauer, PhD (Emory University), Noelle Carlozzi, PhD (University of Michigan), Kevin Conway, PhD (National Institute on Drug Abuse, NIH), Sureyya Dikmen, PhD (University of Washington), Emmeline Edwards, PhD (National Center for Complementary and Alternative Medicine, NIH), Nathan Fox, PhD (University of Maryland), Lisa Freund, PhD (National Institute of Child Health and Human Development, NIH), Richard Gershon, PhD (Northwestern University), Richard Havlik, MD (Westat, Inc.), Robert Heaton, PhD (University of California-San Diego), Jonathan King, PhD (National Institute on Aging, NIH), Jennifer Manly, PhD (Columbia University), Claudia Moy, PhD (National Institute of Neurological Disorders and Stroke, NIH), Dan Mungas, PhD (University of California-Davis), Jerry Slotkin, PhD (Northwestern University), David Tulsky, PhD (University of Michigan), Sandra Weintraub, PhD (Northwestern University), Ellen Witt, PhD (National Institute on Alcohol Abuse and Alcoholism, NIH), Philip Zelazo, PhD (University of Minnesota)

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This Technical Manual contains the following informational sections:

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Section 1: Introduction to NIH Toolbox

NIH Toolbox is a multidimensional set of brief measures assessing cognitive, emotional, motor, and sensory function from ages 3-85. This suite of on-line and royalty-free measures can be administered to study participants 3 to 85 years of age in two hours or less, across diverse study designs and settings.

What is the NIH Toolbox?

The NIH Toolbox provides a standard set of royalty-free, brief, and comprehensive assessment tools that can be used by researchers and clinicians in a variety of settings, with a particular emphasis on measuring outcomes in longitudinal epidemiologic studies and prevention or intervention trials across the lifespan (ages 3-85). The battery ensures that assessment methods and results can be used for comparisons across existing and future studies and provides a "common currency" for the study of neurological research that promotes economies of scale and enhanced efficiency in measurement. The NIH Toolbox can be used to monitor neurological and behavioral function over time and measure key constructs across developmental stages. This facilitates the study of functional changes across the lifespan, including evaluating intervention and treatment effectiveness.

The NIH Toolbox Batteries

The basic NIH Toolbox can be administered within two hours and divides tests into four domain batteries: Cognition, Emotion, Motor, and Sensation. In addition, within some domains, there are supplemental measures that are available to be administered.

Selection of the NIH Toolbox Domains and Subdomains

Four domains were selected for the NIH Toolbox: Cognition, Emotion, Motor, and Sensation. Subdomain selection was based upon literature reviews, expert interviews, and multiple formal Requests for Information (RFI) of NIH-funded researchers. Initial literature and database reviews and an RFI identified the subdomains for inclusion in the NIH Toolbox, existing measures relevant to the project goals, and criteria for instrument selection. NIH Project Team members, external content experts, and contract scientists met at a follow-up consensus meeting to discuss potential subdomains along with the criteria affecting instrument selection, creation, and norming. Additional expert interviews were undertaken to gather more detailed information from clinical and scientific experts to help further refine the list of possible subdomains. A second consensus group meeting was held and results directed the decision for the final NIH Toolbox to assess four core domain areas (cognitive, emotional, motor, and sensory health and function).

Selection of Measures for the NIH Toolbox

More than 1,400 existing measures were identified and evaluated for potential inclusion in the NIH Toolbox. The selection criteria included a measure's applicability across the life span,

psychometric soundness, brevity, ease of use, applicability in diverse settings and with different groups, and lack of intellectual property constraints. There was also a preference for instruments that were already validated and normed for use with individuals between 3 and 85 years old. Results of the instrument selection process yielded draft development plans established for the NIH Toolbox measures.

Early Childhood Use

NIH Toolbox measure development focused special attention on assessing young children, to ensure that all tests given are developmentally appropriate for ages 3-7. A special team of early childhood assessment consultants was engaged to provide testing guidelines for the very young, to offer input on measure development, and to review all NIH Toolbox measures to ensure they fit the needs of young children. Advanced statistical methods were used to emphasize continuity of measurement, allowing Toolbox users to confidently conduct longitudinal measurement from age 3 through the life span while assessing the same domain constructs.

Section 2: Validation

Validation studies were conducted for all NIH Toolbox Cognition domain measures, to assure that these important tools for research met rigorous psychometric standards. Studies were

conducted across the entire age range and were statistically compared against “gold standard” measures wherever available.

For specifics regarding Cognition domain measure validation, see Weintraub et al., Cognition Assessment Using the NIH Toolbox, *Neurology*, in press. This manuscript describes measure development studies undertaken (e.g., expert panels for content development and validation; cognitive interviews; small and large-scale pilot testing) and psychometric characteristics (e.g., internal consistency and test-retest reliability; convergent and divergent validity).

Section 3: Norming

NIH Toolbox conducted a large national standardization study in both English and Spanish languages to allow for normative comparisons on each assessment. A sample of 4,859 participants, ages 3-85 – representative of the U.S. population based on gender, ethnicity, race, and socioeconomic status – was administered all of the NIH Toolbox measures at sites around the country (n = 2,917 English-speaking children, ages 3-17; n = 496 Spanish-speaking children, ages 3-7; n = 1,038 English-speaking adults, ages 18-85; n = 408 Spanish-speaking adults, ages 18-85). NIH Toolbox normative scores are now available for each year of age from 3 through 17, as well as for age ranges 18-29, 30-39, 40-49, 50-59, 60-69, and 70-85, allowing for targeted and accurate comparisons to the U.S. population.

Specifics regarding NIH Toolbox norming sampling methods (e.g., stratification by age, gender, and language preference; sampling a minimum of 25-100 individuals per targeted demographic and language subgroup) and norming analytic methods (e.g., post-stratification adjustment using iterative proportional fitting, i.e., "raking") can be found in the following publication: Beaumont et al., Norming Plans for the NIH Toolbox, *Neurology*, in press.

Section 4: NIH Toolbox and the National Children's Study (NCS)

In collaboration with NIH Toolbox scientists, NCS investigators selected measures from PROMIS and NIH Toolbox for a Maternal Health Profile, the Maternal Self-Reported Health Battery. This profile assesses Physical Health (Physical function, Fatigue, Sleep disturbance, Sleep-related impairment), Mental Health (Anger, Anxiety, Depression, Positive affect, Perceived stress, Self-efficacy), and Social Health (Social support and companionship, Social isolation). The Maternal Self-Reported Health Battery was field tested in fall 2011, using an online sample of 1000 women (200 pre-conception, 150 pregnant women (50 per trimester), and 650 mothers with a child between 0-36 months of age). In addition, NIH Toolbox norming was jointly sponsored by the NCS and included: 3,413 children in single-year age bands (from 3-17 years); 1,446 adults in seven age bands, including the mothers of children also being tested; and 105 pregnant women. The NIH Toolbox sampling plan matched distributions of race/ethnicity and level of education for each age band.

Section 5: Domain Definition

Domain: COGNITION

Cognition refers to the mental processes involved in gaining knowledge and comprehension. It includes processes such as thinking, knowing, remembering, judging, and problem-solving. These higher-level functions of the brain encompass language, imagination, perception, and the planning and execution of complex behaviors. Measurement of cognition is essential to any study of health and well-being and should be included in large-scale epidemiologic studies and experimental studies of health and development, even when the target of the study is not cognition itself. The Cognition domain includes measures of:

EXECUTIVE FUNCTION

Measured by:

NIH Toolbox Flanker Inhibitory Control and Attention Test

NIH Toolbox Dimensional Change Card Sort Test

ATTENTION

Measured by:

NIH Toolbox Flanker Inhibitory Control and Attention Test

EPISODIC MEMORY

Measured by:

NIH Toolbox Picture Sequence Memory Test

NIH Toolbox Auditory Verbal Learning Test (Rey) (Supplemental Measure)

LANGUAGE

Measured by:

NIH Toolbox Picture Vocabulary Test

NIH Toolbox Oral Reading Recognition Test

PROCESSING SPEED

Measured by:

NIH Toolbox Pattern Comparison Processing Speed Test

NIH Toolbox Oral Symbol Digit Test (Supplemental Measure)

WORKING MEMORY

Measured by:

NIH Toolbox List Sorting Working Memory Test

Section 6: Subdomain Definition

Subdomain: EPISODIC MEMORY

Episodic Memory refers to cognitive processes involved in the acquisition, storage, and retrieval of new information. It involves conscious recollection of information learned within a context. The term "learning" refers to the acquisition of skills and knowledge, while the term "memory" refers to the persistence of this learning over time and/or the facility with which one is able to spontaneously recall the information following a delay. Episodic Memory can be verbal, as in remembering a conversation or a list of grocery items, or nonverbal, as in imagining a place one visited or a picture one saw a week ago. In NIH Toolbox, Episodic Memory is measured by:

NIH Toolbox Picture Sequence Memory Test

NIH Toolbox Auditory Verbal Learning Test (Rey) (Supplemental Measure)

Section 7: Measure Description

COGNITION Supplemental Measure

The NIH Toolbox Auditory Verbal Learning Test (Rey) is a word-list learning task in which 15 unrelated words are presented orally (via audio recording) over three consecutive learning trials (many other versions of this test are available, but this description applies to the NIH Toolbox version). After each presentation, the participant is asked to recall as many of the

words as he/she can. The Rey is one of the most widely studied measures of memory and has been used in different languages, cultures, and ethnic groups around the world. The test is administered to ages 8-85 and takes approximately three minutes to complete. It can be administered as a supplement to the NIH Toolbox Picture Sequence Memory Test (PSMT), for even more detailed study of Episodic Memory, or as an accommodation in place of PSMT for those with significant visual impairment. (The NIH Toolbox version of this test differs from some other available versions in that there are three rather than five learning trials and there is neither a delayed recall trial nor an interference trial.)

Section 8: Post-Validation/Post-Norming Changes to the Measure

No notable Post-Validation/Post-Norming changes were made to this measure.

Section 9: The Measure's Scoring Model

Measurement theory applied for scoring:

Classical Test Theory (CTT)

CTT scoring approach employed:

Sum (the number of words recalled across all trials)

Measure length:

Fixed (15 items per trial)

Response data:

Dichotomous (correct, incorrect)

Scores computed/available*:

Sum (range 0 to 45)

*Details on these scores and their interpretations are available in the NIH Toolbox Scoring and Interpretation Guide.

Section 10: Measure Norms

The following Table presents NIH Toolbox normative data associated with this measure:

Table 1. Measure Raw/Computed Score Statistics (N, Mean, Standard Deviation, Minimum/Maximum Observed, 25th/50th/75th Percentile) per Age Group (8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18-29, 30-39, 40-49, 50-59, 60-69, 70-85, All)

Table 1. NIH Toolbox Auditory Verbal Learning (Rey) Test (number correct) – Age 8		English			Spanish			Total		All
		Males	Females	Total	Males	Females	Total	Males	Females	
	N	26	31	57	0	0	0	26	31	57
	Mean	18.59	20.66	19.57				18.59	20.66	19.57
	Standard Deviation	3.07	3.55	3.36				3.07	3.55	3.36
	Minimum Observed	10.00	9.00	9.00				10.00	9.00	9.00
	25th Percentile	14.00	16.00	15.00				14.00	16.00	15.00
	50th Percentile (Median)	18.00	21.00	19.00				18.00	21.00	19.00
	75th Percentile	24.00	25.00	24.00				24.00	25.00	24.00
	Maximum Observed	27.00	38.00	38.00				27.00	38.00	38.00

Table 1. NIH Toolbox Auditory Verbal Learning (Rey) Test (number correct) – Age 9		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	29	27	56	0	0	0	29	27	56
	Mean	21.20	21.55	21.33				21.20	21.55	21.33
	Standard Deviation	3.53	2.48	3.04				3.53	2.48	3.04
	Minimum Observed	5.00	10.00	5.00				5.00	10.00	5.00
	25th Percentile	18.00	20.00	18.00				18.00	20.00	18.00
	50th Percentile (Median)	22.00	21.00	22.00				22.00	21.00	22.00
	75th Percentile	26.00	25.00	25.00				26.00	25.00	25.00
	Maximum Observed	30.00	33.00	33.00				30.00	33.00	33.00

Table 1. NIH Toolbox Auditory Verbal Learning (Rey) Test (number correct) – Age 10		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	30	27	57	0	0	0	30	27	57
	Mean	21.24	23.76	22.25				21.24	23.76	22.25
	Standard Deviation	4.27	2.72	3.65				4.27	2.72	3.65
	Minimum Observed	1.00	15.00	1.00				1.00	15.00	1.00
	25th Percentile	18.00	20.00	20.00				18.00	20.00	20.00
	50th Percentile (Median)	23.00	23.00	23.00				23.00	23.00	23.00
	75th Percentile	27.00	27.00	27.00				27.00	27.00	27.00
	Maximum Observed	30.00	37.00	37.00				30.00	37.00	37.00

Table 1. NIH Toolbox Auditory Verbal Learning (Rey) Test (number correct) – Age 11		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	34	22	56	0	0	0	34	22	56
	Mean	23.76	25.80	24.42				23.76	25.80	24.42
	Standard Deviation	3.14	2.33	2.88				3.14	2.33	2.88
	Minimum Observed	11.00	17.00	11.00				11.00	17.00	11.00
	25th Percentile	19.00	23.00	21.00				19.00	23.00	21.00
	50th Percentile (Median)	24.00	25.00	24.00				24.00	25.00	24.00
	75th Percentile	28.00	29.00	28.00				28.00	29.00	28.00
	Maximum Observed	31.00	34.00	34.00				31.00	34.00	34.00

Table 1. NIH Toolbox Auditory Verbal Learning (Rey) Test (number correct) – Age 12		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	28	32	60	0	0	0	28	32	60
	Mean	24.55	25.54	25.02				24.55	25.54	25.02
	Standard Deviation	3.11	3.40	3.25				3.11	3.40	3.25
	Minimum Observed	15.00	13.00	13.00				15.00	13.00	13.00
	25th Percentile	21.00	21.00	21.00				21.00	21.00	21.00
	50th Percentile (Median)	25.00	27.00	25.00				25.00	27.00	25.00
	75th Percentile	27.00	29.00	29.00				27.00	29.00	29.00
	Maximum Observed	36.00	43.00	43.00				36.00	43.00	43.00

Table 1. NIH Toolbox Auditory Verbal Learning (Rey) Test (number correct) – Age 13		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	28	34	62	0	0	0	28	34	62
	Mean	25.17	24.29	24.82				25.17	24.29	24.82
	Standard Deviation	4.12	2.90	3.48				4.12	2.90	3.48
	Minimum Observed	13.00	8.00	8.00				13.00	8.00	8.00
	25th Percentile	21.00	22.00	21.00				21.00	22.00	21.00
	50th Percentile (Median)	25.00	25.00	25.00				25.00	25.00	25.00
	75th Percentile	31.00	28.00	29.00				31.00	28.00	29.00
	Maximum Observed	37.00	37.00	37.00				37.00	37.00	37.00

Table 1. NIH Toolbox Auditory Verbal Learning (Rey) Test (number correct) – Age 14		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	35	30	65	0	0	0	35	30	65
	Mean	25.90	23.81	25.14				25.90	23.81	25.14
	Standard Deviation	3.10	3.12	3.13				3.10	3.12	3.13
	Minimum Observed	15.00	11.00	11.00				15.00	11.00	11.00
	25th Percentile	23.00	20.00	22.00				23.00	20.00	22.00
	50th Percentile (Median)	26.00	23.00	25.00				26.00	23.00	25.00
	75th Percentile	30.00	27.00	29.00				30.00	27.00	29.00
	Maximum Observed	37.00	40.00	40.00				37.00	40.00	40.00

Table 1. NIH Toolbox Auditory Verbal Learning (Rey) Test (number correct) – Age 15		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	28	27	55	0	0	0	28	27	55
	Mean	25.45	23.75	24.78				25.45	23.75	24.78
	Standard Deviation	2.81	3.00	2.92				2.81	3.00	2.92
	Minimum Observed	13.00	16.00	13.00				13.00	16.00	13.00
	25th Percentile	23.00	20.00	21.00				23.00	20.00	21.00
	50th Percentile (Median)	26.00	22.00	25.00				26.00	22.00	25.00
	75th Percentile	28.00	26.00	27.00				28.00	26.00	27.00
	Maximum Observed	34.00	37.00	37.00				34.00	37.00	37.00

Table 1. NIH Toolbox Auditory Verbal Learning (Rey) Test (number correct) – Age 16		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	34	32	66	0	0	0	34	32	66
	Mean	25.25	26.01	25.57				25.25	26.01	25.57
	Standard Deviation	3.54	2.39	3.02				3.54	2.39	3.02
	Minimum Observed	13.00	18.00	13.00				13.00	18.00	13.00
	25th Percentile	22.00	24.00	22.00				22.00	24.00	22.00
	50th Percentile (Median)	24.00	26.00	25.00				24.00	26.00	25.00
	75th Percentile	29.00	29.00	29.00				29.00	29.00	29.00
	Maximum Observed	39.00	38.00	39.00				39.00	38.00	39.00

Table 1. NIH Toolbox Auditory Verbal Learning (Rey) Test (number correct) – Age 17		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	28	35	63	0	0	0	28	35	63
	Mean	23.55	25.78	24.56				23.55	25.78	24.56
	Standard Deviation	3.68	2.93	3.32				3.68	2.93	3.32
	Minimum Observed	11.00	12.00	11.00				11.00	12.00	11.00
	25th Percentile	18.00	23.00	21.00				18.00	23.00	21.00
	50th Percentile (Median)	24.00	27.00	26.00				24.00	27.00	26.00
	75th Percentile	27.00	29.00	28.00				27.00	29.00	28.00
	Maximum Observed	33.00	36.00	36.00				33.00	36.00	36.00

Table 1. NIH Toolbox Auditory Verbal Learning (Rey) Test (number correct) – Age 18-29		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	15	34	49	7	20	27	22	54	76
	Mean	24.08	25.90	25.15	22.94	23.59	23.36	23.95	25.57	24.92
	Standard Deviation	13.45	7.19	9.58	6.76	5.52	5.73	11.59	6.70	8.45
	Minimum Observed	17.00	18.00	17.00	15.00	16.00	15.00	15.00	16.00	15.00
	25th Percentile	20.00	23.00	21.00	18.00	19.00	18.00	20.00	23.00	21.00
	50th Percentile (Median)	22.00	26.00	25.00	23.00	23.00	23.00	23.00	26.00	25.00
	75th Percentile	29.00	29.00	29.00	27.00	29.00	28.00	27.00	29.00	29.00
	Maximum Observed	34.00	35.00	35.00	30.00	32.00	32.00	34.00	35.00	35.00

Table 1. NIH Toolbox Auditory Verbal Learning (Rey) Test (number correct) – Age 30-39		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	13	46	59	6	18	24	19	64	83
	Mean	23.86	25.42	24.99	22.85	22.12	22.39	23.71	25.11	24.71
	Standard Deviation	8.38	7.81	7.95	6.82	3.77	4.55	7.75	7.02	7.21
	Minimum Observed	14.00	12.00	12.00	15.00	17.00	15.00	14.00	12.00	12.00
	25th Percentile	21.00	22.00	22.00	15.00	19.00	19.00	21.00	22.00	22.00
	50th Percentile (Median)	27.00	26.00	26.00	25.00	21.00	22.00	25.00	26.00	26.00
	75th Percentile	27.00	29.00	28.00	26.00	25.00	26.00	27.00	28.00	28.00
	Maximum Observed	28.00	34.00	34.00	30.00	34.00	34.00	30.00	34.00	34.00

Table 1. NIH Toolbox Auditory Verbal Learning (Rey) Test (number correct) – Age 40-49		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	16	27	43	10	10	20	26	37	63
	Mean	24.32	25.48	24.92	19.71	20.94	20.17	23.67	25.10	24.39
	Standard Deviation	11.32	11.29	11.22	4.45	1.82	3.37	9.68	9.85	9.78
	Minimum Observed	17.00	10.00	10.00	15.00	17.00	15.00	15.00	10.00	10.00
	25th Percentile	20.00	20.00	20.00	17.00	20.00	18.00	20.00	20.00	20.00
	50th Percentile (Median)	24.00	27.00	25.00	19.00	21.00	20.00	23.00	26.00	24.00
	75th Percentile	28.00	30.00	29.00	21.00	22.00	22.00	28.00	30.00	28.00
	Maximum Observed	38.00	34.00	38.00	26.00	24.00	26.00	38.00	34.00	38.00

Table 1. NIH Toolbox Auditory Verbal Learning (Rey) Test (number correct) – Age 50-59		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	14	17	31	5	7	12	19	24	43
	Mean	19.97	22.10	20.83	18.06	18.59	18.30	19.82	21.75	20.61
	Standard Deviation	9.46	5.68	7.83	3.66	3.96	3.67	8.31	5.45	7.03
	Minimum Observed	15.00	15.00	15.00	15.00	12.00	12.00	15.00	12.00	12.00
	25th Percentile	18.00	20.00	18.00	16.00	15.00	16.00	17.00	20.00	18.00
	50th Percentile (Median)	20.00	22.00	21.00	17.00	18.00	17.00	20.00	22.00	21.00
	75th Percentile	22.00	24.00	22.00	20.00	23.00	22.00	22.00	24.00	22.00
	Maximum Observed	29.00	28.00	29.00	22.00	23.00	23.00	29.00	28.00	29.00

Table 1. NIH Toolbox Auditory Verbal Learning (Rey) Test (number correct) – Age 60-69		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	13	20	33	10	5	15	23	25	48
	Mean	18.08	20.33	19.14	14.85	17.89	15.58	17.59	20.18	18.75
	Standard Deviation	9.94	8.27	9.08	4.20	1.74	3.74	8.11	7.45	8.00
	Minimum Observed	12.00	11.00	11.00	6.00	15.00	6.00	6.00	11.00	6.00
	25th Percentile	15.00	17.00	16.00	12.00	17.00	13.00	13.00	17.00	15.00
	50th Percentile (Median)	18.00	21.00	19.00	16.00	18.00	17.00	18.00	20.00	18.00
	75th Percentile	20.00	24.00	24.00	17.00	20.00	18.00	20.00	24.00	23.00
	Maximum Observed	25.00	29.00	29.00	20.00	20.00	20.00	25.00	29.00	29.00

Table 1. NIH Toolbox Auditory Verbal Learning (Rey) Test (number correct) – Age 70-85		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	28	28	56	12	6	18	40	34	74
	Mean	13.69	17.24	15.14	12.58	15.09	13.24	13.59	17.13	15.00
	Standard Deviation	5.95	5.46	6.14	2.86	0.89	2.47	5.19	4.98	5.49
	Minimum Observed	2.00	12.00	2.00	3.00	13.00	3.00	2.00	12.00	2.00
	25th Percentile	11.00	14.00	12.00	12.00	14.00	13.00	11.00	14.00	12.00
	50th Percentile (Median)	14.00	16.00	15.00	14.00	15.00	14.00	14.00	16.00	15.00
	75th Percentile	16.00	21.00	17.00	15.00	17.00	15.00	16.00	21.00	17.00
	Maximum Observed	21.00	27.00	27.00	17.00	17.00	17.00	21.00	27.00	27.00