

***In Vitro* Diagnostics Certification for Creatinine Assays in Korea over 7 Years:  
Achievements and Future Outlook**

Eun-Jung Cho, M.D., Ph.D.<sup>1</sup>, Joonsang Yu, M.D., M.S.<sup>2</sup>, Jeayeon Ryu, M.D., M.S.<sup>2</sup>,  
Jiwoo Seo, M.S.<sup>3</sup>, Hyunae Lee, A.S.<sup>3</sup>, Chan-Ik Cho, MPH<sup>3</sup>, Tae-Dong Jeong, M.D., Ph.D.<sup>4</sup>,  
Sollip Kim, M.D., Ph.D.<sup>2</sup>, Woochang Lee, M.D., Ph.D.<sup>2</sup>, Sail Chun, M.D., Ph.D.<sup>2</sup>, and Won-  
Ki Min, M.D., Ph.D.<sup>5</sup>

<sup>1</sup>Department of Laboratory Medicine, Hallym University Dongtan Sacred Heart Hospital,

Hallym University College of Medicine, Hwaseong, Korea; <sup>2</sup>Department of Laboratory  
Medicine, Asan Medical Center, University of Ulsan College of Medicine, Seoul, Korea;

<sup>3</sup>Division of Chronic Disease Prevention, Korea Disease Control and Prevention Agency,  
Cheongju, Korea; <sup>4</sup>Department of Laboratory Medicine, Ewha Womans University College

of Medicine, Seoul, Korea; <sup>5</sup>Future Strategy Division, SD Biosensor, Seoul, Korea

**Supplemental Data Text S1.** Acceptance criteria for the IVD certification program.

The absolute percentage bias (absBias%) was calculated as  $([\text{measured result} - \text{target value}] / \text{target value}) \times 100$ . Analytical imprecision was assessed by calculating the intra-run CV (%), and total error (TE) was defined as  $\text{bias} (\%) + 1.96 \times \text{CV} (\%)$ . To evaluate linearity, the results were compared to a fitted straight line and assessed based on the average deviations from the line, as per the College of American Pathologists LN24 Creatinine Accuracy Calibration Verification/Linearity Survey. The limit for linearity is  $>1/4$ th the goal for TE (15%) when the average value of the results for the same concentration includes their best-fit line.

**Supplemental Data Table S1.** Concentration ranges and number of specimens for each range used for IVD certification of Cr assays

Year	Samples (N)					
	0–1.0 mg/dL	1.0–1.5 mg/dL	1.5–2.0 mg/dL	2.0–3.0 mg/dL	3.0–4.0 mg/dL	4.0–5.0 mg/dL
2017	4	8		8	2	2
2018	8	8		4	2	2
2019	4	6	4	4	2	4
2020-1 <sup>st</sup>	4	2	2	4	6	6
2020-2 <sup>nd</sup>	4	2	4	4	6	4
2021-1 <sup>st</sup>	4	4	6	2	4	4
2022-2 <sup>nd</sup>	4	4	6	2	4	4
2022-1 <sup>st</sup>	4	6	4	4	4	2
2022-2 <sup>nd</sup>	4	6	4	4	4	2
2023-1 <sup>st</sup>	4	4	4	4	4	4
2023-2 <sup>nd</sup>	4	4	4	4	4	4

Abbreviations: IVD, *in vitro* diagnostics; Cr, creatinine.

**Supplemental Data Table S2.** absBias%, CV, and TE for all manufacturers based on the Cr assay type and target value ranges for each year

Year	Method Target range	KJ-C					KJ-NC					KJ-RB					ENZ				
		0.0≤ Cr< 1.0	1.0≤ Cr< 2.0	2.0≤ Cr< 3.0	3.0≤ Cr< 4.0	4.0≤ Cr	0.0≤ Cr< 1.0	1.0≤ Cr< 2.0	2.0≤ Cr< 3.0	3.0≤ Cr< 4.0	4.0≤ Cr	0.0≤ Cr< 1.0	1.0≤ Cr< 2.0	2.0≤ Cr< 3.0	3.0≤ Cr< 4.0	4.0≤ Cr	0.0≤ Cr< 1.0	1.0≤ Cr< 2.0	2.0≤ Cr< 3.0	3.0≤ Cr< 4.0	4.0≤ Cr
2017	absBias%	5.8	5.1	2.8	3.9	2.7	21.7	10.6	3.9	5.8	6.0	3.4	3.1	4.0	4.8	6.0	2.5	2.5	2.2	2.0	2.0
	CV(%)	1.5	1.4	1.5	1.5	1.5	3.1	3.1	3.1	3.1	3.1	1.3	1.3	1.3	1.3	1.3	0.6	0.6	0.6	0.6	0.6
	TE(%)	8.0	7.8	8.0	8.0	8.0	15.4	15.4	15.4	15.4	15.4	6.5	6.5	6.5	6.5	6.5	3.5	3.5	3.5	3.5	3.5
2018	absBias%	4.3	3.6	3.6	3.9	4.5	22.7	9.1	5.6	4.9	4.4	5.5	2.9	2.6	3.9	4.5	4.4	3.4	2.2	2.5	1.9
	CV(%)	1.7	1.9	1.9	1.9	1.9	2.4	2.4	2.4	2.4	2.4	1.5	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.6
	TE(%)	7.5	8.2	8.2	8.2	8.2	17.1	17.1	17.1	17.1	17.1	6.8	6.8	6.8	6.8	6.8	6.4	6.4	6.4	6.4	6.4
2019	absBias%	7.1	4.7	4.2	3.4	2.9	15.7	6.3	5.1	5.4	5.7	6.2	4.2	2.9	4.5	4.6	7.8	4.7	3.7	3.2	2.8
	CV(%)	1.1	1.1	1.1	1.1	1.1	0.9	0.9	0.9	0.9	0.9	1.1	1.1	1.0	1.1	1.1	0.8	0.8	0.8	0.8	0.8
	TE(%)	6.7	6.8	6.6	6.6	6.6	9.4	9.4	9.0	9.4	9.4	6.7	6.7	6.2	6.7	6.7	6.3	6.1	6.3	6.2	6.2
2020	absBias%	5.8	2.6	2.0	1.6	2.0	10.8	3.6	4.0	3.9	5.0	2.8	2.4	3.5	3.5	4.1	5.7	2.8	2.3	2.1	2.2
	CV(%)	1.0	1.0	1.0	1.0	1.0	0.8	0.8	0.8	0.9	0.9	0.7	0.7	0.7	0.8	0.7	0.8	0.8	0.8	0.8	0.8
	TE(%)	4.7	4.7	4.7	4.6	4.8	6.9	6.7	6.8	6.9	7.1	4.7	4.5	4.7	4.8	4.7	4.4	4.3	4.4	4.6	4.4
2021	absBias%	3.7	2.5	3.4	3.0	3.4	8.7	6.0	5.1	3.6	4.5	4.1	2.4	2.5	2.6	3.3	5.1	3.0	3.0	2.6	3.0
	CV(%)	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.6	1.5	1.5	1.5	1.5	1.7	1.7	1.7	1.7	1.7
	TE(%)	5.5	5.4	5.4	5.3	5.4	7.9	7.8	7.8	7.8	7.8	5.9	5.9	5.9	5.9	5.9	6.6	6.6	6.6	6.6	6.6
2022	absBias%	3.6	2.7	2.8	3.2	3.5	10.3	4.2	3.6	3.7	4.2	4.8	3.2	3.1	3.2	3.3	5.8	3.4	2.8	2.9	2.6
	CV(%)	1.4	1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.5	1.5	1.3	1.3	1.2	1.2	1.3	1.4	1.4	1.4	1.4	1.4
	TE(%)	5.8	5.9	5.7	5.8	5.8	8.0	8.0	8.1	8.0	7.8	5.9	6.0	5.8	5.8	5.9	6.2	6.2	6.3	6.3	6.2
2023	absBias%	6.7	3.6	3.6	2.3	2.3	9.7	3.9	3.1	4.0	4.3	3.3	3.4	4.1	4.7	4.7	6.0	2.5	1.9	1.7	1.5
	CV(%)	1.7	1.7	1.7	1.7	1.6	1.4	1.4	1.4	1.4	1.3	1.1	1.2	1.1	1.1	1.1	1.5	1.5	1.5	1.5	1.3
	TE(%)	7.0	6.9	7.0	7.0	7.1	7.6	7.6	7.6	7.6	7.4	6.1	6.1	6.1	6.1	6.1	5.6	5.7	5.6	5.6	5.3

Abbreviations: absBias%, absolute percentage bias; TE, total error; KJ-C, kinetic Jaffe method with compensation; KJ-NC, kinetic Jaffe method without compensation; KJ-RB, rate-blanked compensated kinetic Jaffe method; ENZ, enzymatic method.

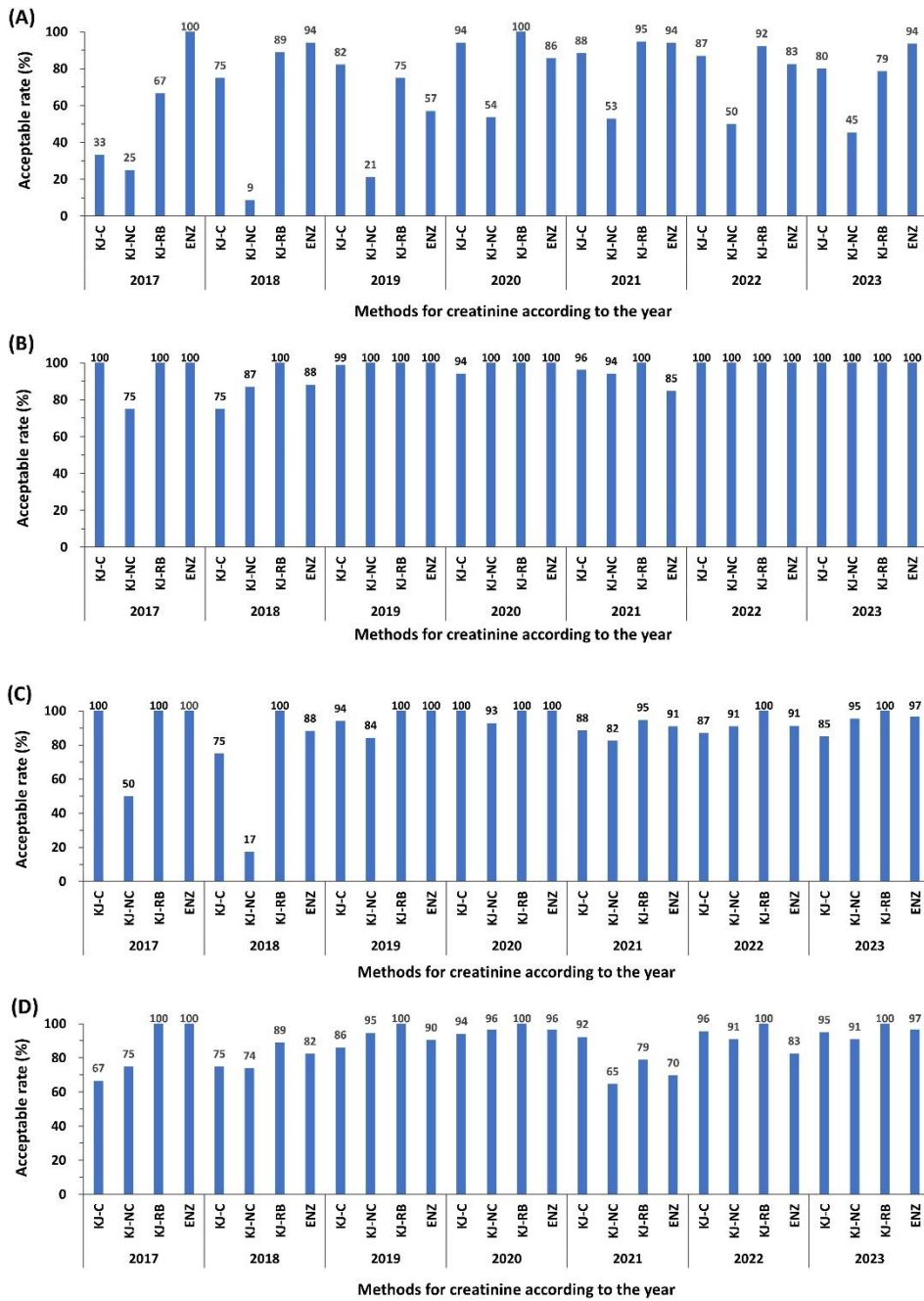
**Supplemental Data Table S3.** One-way ANOVA results on bias differences for the target value range according to the Cr assay type

Method	Range of target value (mg/dL)	Source of variation	Sum of squares	Degrees of freedom	Mean square	F-ratio	<i>P</i>
KJ-C	0.0≤Cr<1.0	Between groups	1,613.44	6	268.91	4.66	<0.001
		Within groups	42,690.73	739	57.77		
		Total	44,304.17	745			
	1.0≤Cr<2.0	Between groups	1,670.86	6	278.48	17.43	<0.001
		Within groups	26,890.63	1,683	15.98		
		Total	28,561.49	1,689			
	2.0≤Cr<3.0	Between groups	368.22	6	61.37	5.58	<0.001
		Within groups	7,620.04	693	11		
		Total	7,988.25	699			
	3.0≤Cr<4.0	Between groups	255.11	6	42.52	5.75	<0.001
		Within groups	4,252.91	575	7.4		
		Total	4,508.02	581			
	4.0≤Cr	Between groups	163.04	6	27.17	3.02	0.006
		Within groups	6,581.64	731	9		
		Total	6,744.68	737			
KJ-NC	0.0≤Cr<1.0	Between groups	20,577.5	6	3,429.58	37	<0.001
		Within groups	57,748.83	623	92.69		
		Total	78,326.33	629			
	1.0≤Cr<2.0	Between groups	4,765.07	6	794.18	34.72	<0.001
		Within groups	26,052.27	1,139	22.87		
		Total	30,817.34	1,145			
	2.0≤Cr<3.0	Between groups	410.07	6	68.35	6.81	<0.001
		Within groups	5,016.78	500	10.03		
		Total	5,426.85	506			
	3.0≤Cr<4.0	Between groups	154.91	6	25.82	2.25	0.038

		Within groups	5,460.91	475	11.5		
		Total	5,615.82	481			
		Between groups	118.44	6	19.74		
	4.0≤Cr	Within groups	6,912.84	451	15.33	1.29	0.261
		Total	7,031.29	457			
		Between groups	303.76	6	50.63		
	0.0≤Cr<1.0	Within groups	3,645.1	302	12.07	4.19	<0.001
		Total	3,948.85	308			
		Between groups	170.7	6	28.45		
	1.0≤Cr<2.0	Within groups	2,659.1	601	4.42	6.43	<0.001
		Total	2,829.8	607			
		Between groups	90.7	6	15.12		
KJ-RB	2.0≤Cr<3.0	Within groups	980.05	229	4.28	3.53	0.002
		Total	1,070.75	235			
		Between groups	169.79	6	28.3		
	3.0≤Cr<4.0	Within groups	1,164.2	251	4.64	6.1	<0.001
		Total	1,333.99	257			
		Between groups	111.97	6	18.66		
	4.0≤Cr	Within groups	1,392.86	225	6.19	3.02	0.007
		Total	1,504.83	231			
		Between groups	1,168.9	6	194.82		
	0.0≤Cr<1.0	Within groups	25,240.83	761	33.17	5.87	<0.001
		Total	26,409.74	767			
		Between groups	1,003.65	6	167.27		
ENZ	1.0≤Cr<2.0	Within groups	14,479.79	1526	9.49	17.63	<0.001
		Total	15,483.43	1532			
		Between groups	292.78	6	48.8		
	2.0≤Cr<3.0	Within groups	3,068.7	625	4.91	9.94	<0.001

	Total	3,361.48	631			
3.0≤Cr<4.0	Between groups	170.48	6	28.41		
	Within groups	2,890.77	621	4.66	6.1	<0.001
	Total	3,061.25	627			
4.0≤Cr	Between groups	163.69	6	27.28		
	Within groups	2,628.55	631	4.17	6.55	<0.001
	Total	2,792.24	637			

Abbreviations: KJ-C, kinetic Jaffe method with compensation; KJ-NC, kinetic Jaffe method without compensation; KJ-RB, rate-blanked compensated kinetic Jaffe method; ENZ, enzymatic method.



**Supplemental Data Fig. S1.** Percentage of IVDs meeting the analytical performance specifications for bias (A), imprecision (B), TE (C), and linearity (D) based on the Cr assay type from 2017 to 2023.

Abbreviations: IVDs, *in vitro* diagnostics; TE, total error; Cr, creatinine; KJ-C, kinetic Jaffe method with compensation; KJ-NC, kinetic Jaffe method without compensation; KJ-RB, rate-blanked compensated kinetic Jaffe method; ENZ, enzymatic method.