



# Quantitative At-Home Test for Kidney Function

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## Objective

Problem: Early detection of chronic kidney disease is limited by lack of accessible, quantitative at-home testing.

Solution: We develop a low-cost, paper-based device to quantitatively assess kidney health.

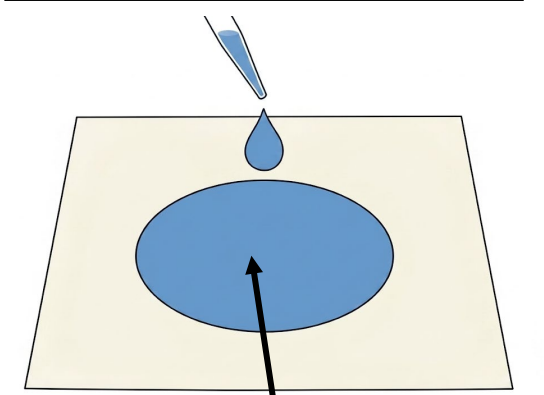
## Background

- Chronic kidney disease (CKD) affects over 1 in 7 U.S. adults and often goes undetected until advanced stages<sup>1</sup>.
- Kidney disease contributes to about one-quarter of annual Medicare spending<sup>2</sup>.
- Proteinuria, measured via the urine albumin-to-creatinine ratio ( $\mu$ ACR), is the gold standard for detecting early-stage kidney dysfunction.
- Standard testing relies on centralized labs, while existing at-home options are only semi-quantitative, limiting early detection and monitoring<sup>3</sup>.

## Methods

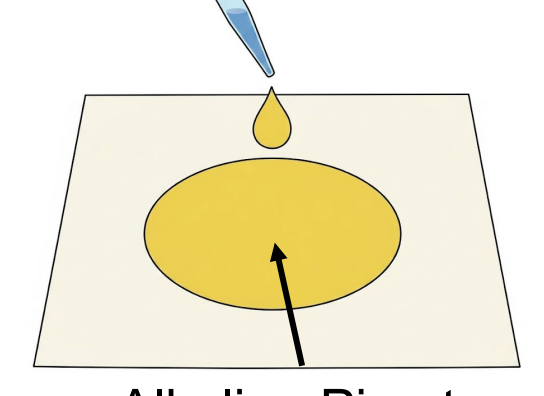
### 1. Prepare PAD

#### Albumin Detection



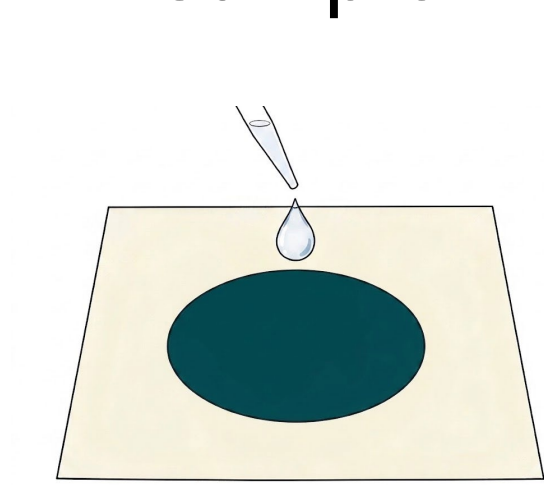
Tetrabromophenol Blue

#### Creatinine Detection

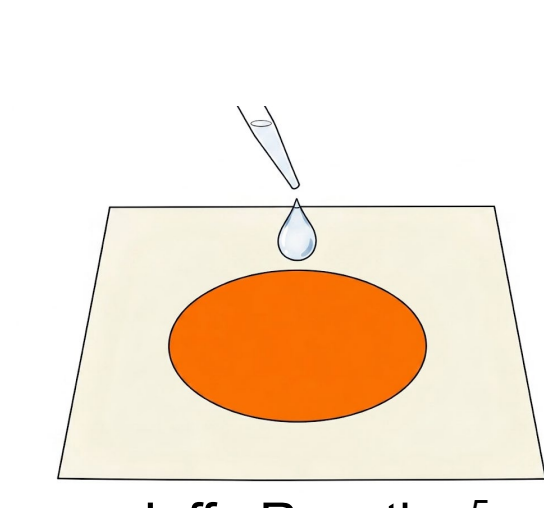


Alkaline Picrate

### 2. Apply Urine Sample

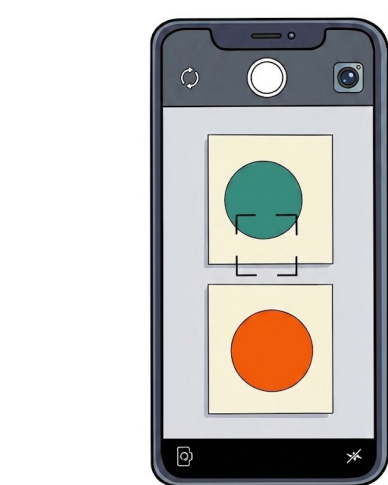


Dye-Binding Reaction<sup>4</sup>



Jaffe Reaction<sup>5</sup>

### 3. Capture & Analyze



## References

[1] "Chronic Kidney Disease in the United States," 2023.  
 [2] U.S. Department of Health and Human Services, "Healthcare Expenditures for Persons with CKD," 2022.  
 [3] T. Konta, "The health-economic impact of urine albumin-to-creatinine ratio testing for chronic kidney disease in Japanese non-diabetic patients," 2024.  
 [4] K. K. L. T. Izabela Lewinska, "Smartphone-Assisted Protein to Creatinine Ratio Determination on a Single Paper-Based Analytical Device," *Molecules*, 2021.  
 [5] T. T. e. al, "A user-friendly dip-function paper-based analytical device for creatinine analysis in clinical urine samples," *Microchemical Journal*

## Results

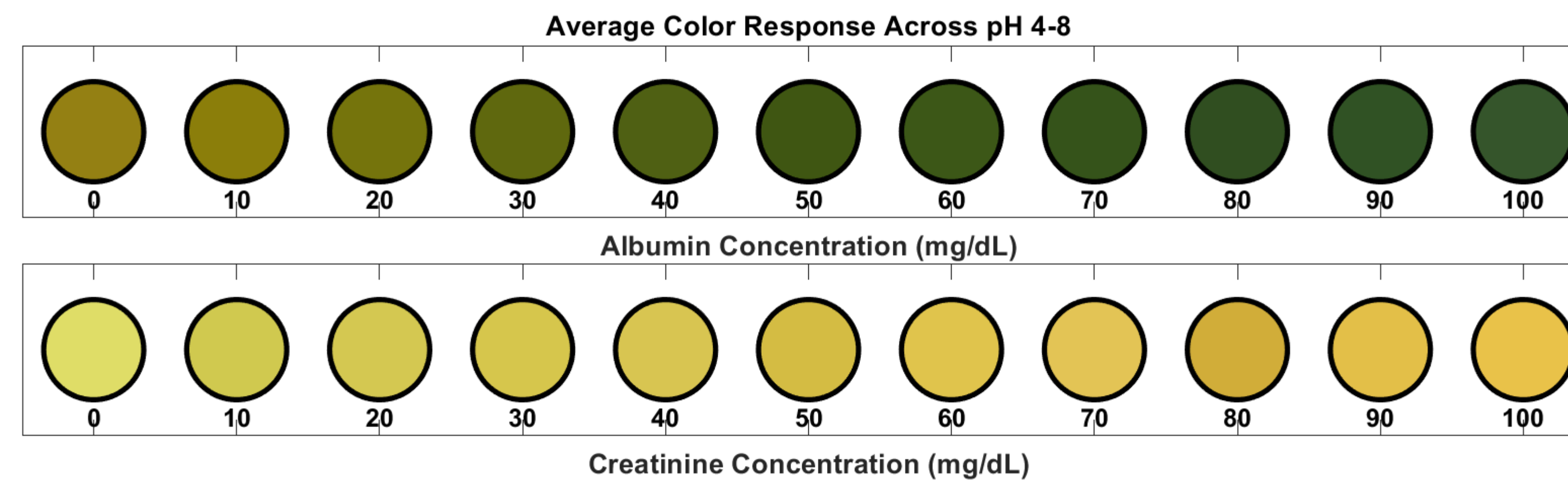


Figure 1. Color response across albumin (top) and creatinine (bottom) concentrations (0-100 mg/dL).

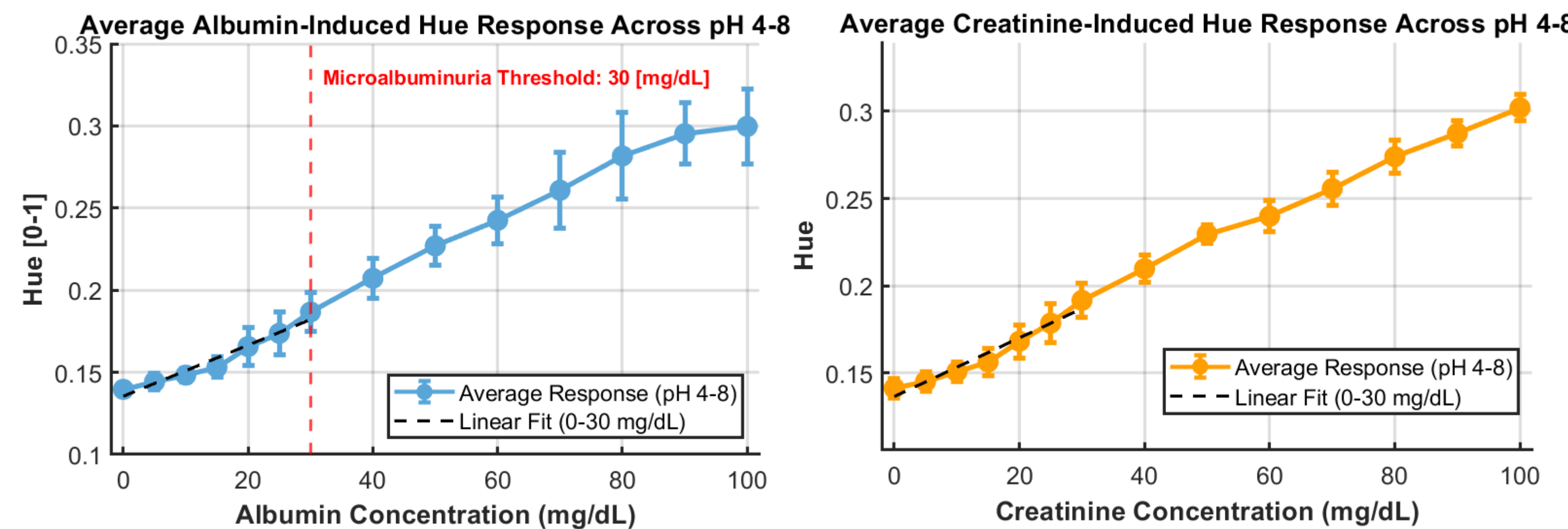


Figure 2. Hue response across albumin and creatinine concentrations (0-100 mg/dL), with linear behavior at low concentrations.

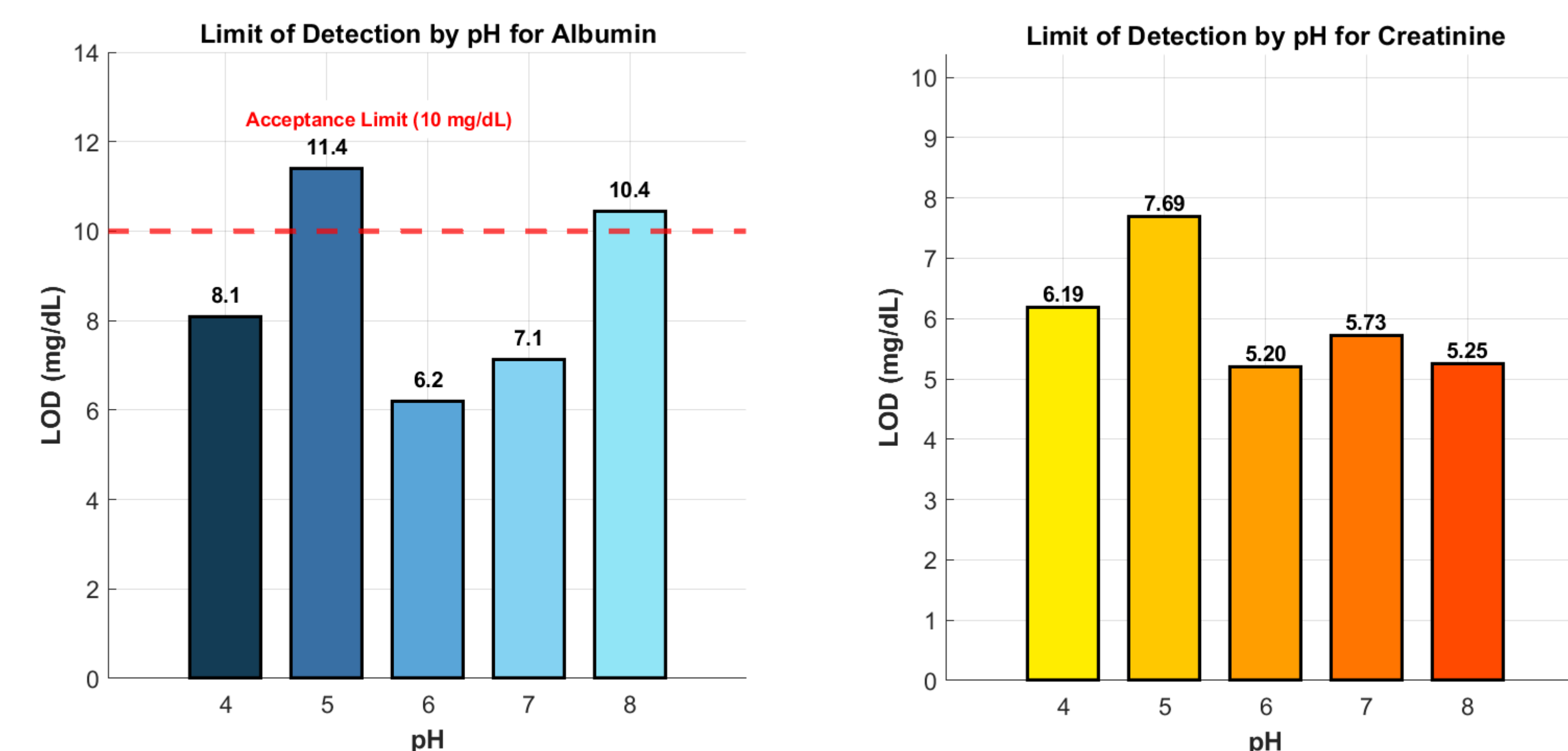


Figure 3. Limit of Detection for albumin (left) and creatinine (right) demonstrates strong sensitivity.

## Conclusion

- Achieved better sensitivity compared to commercially available test.
- Developed a predictive model capable of estimating biomarker concentrations for  $\mu$ ACR measurement with >83% accuracy.
- Future work includes advancing toward FDA approval and clinical implementation.

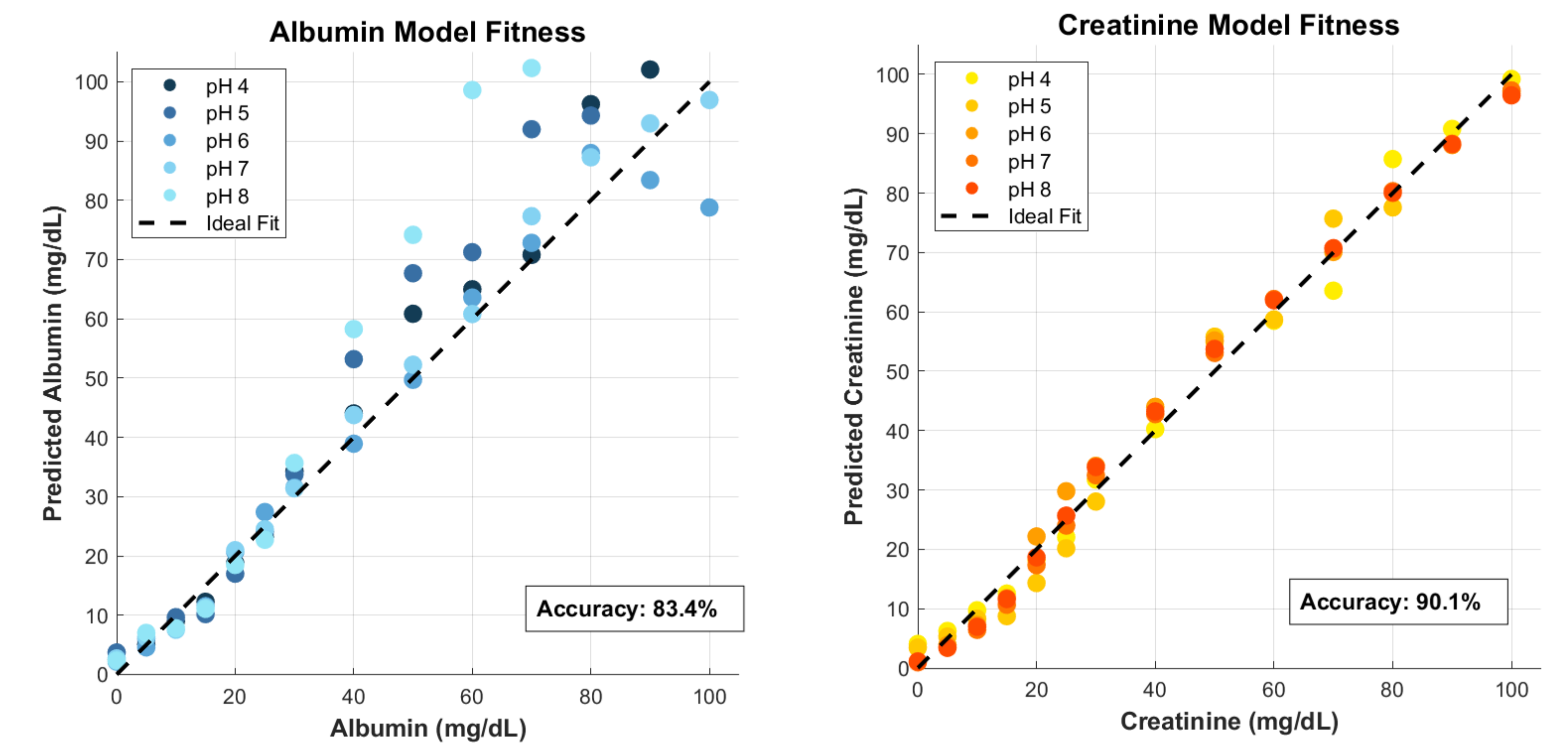


Figure 4. Predicted vs. true concentrations for albumin (left) and creatinine (right) across pH 4-8 show strong agreement with the predictive model (dashed line), with accuracies of 83.4% and 90.1% respectively.

## Device Design

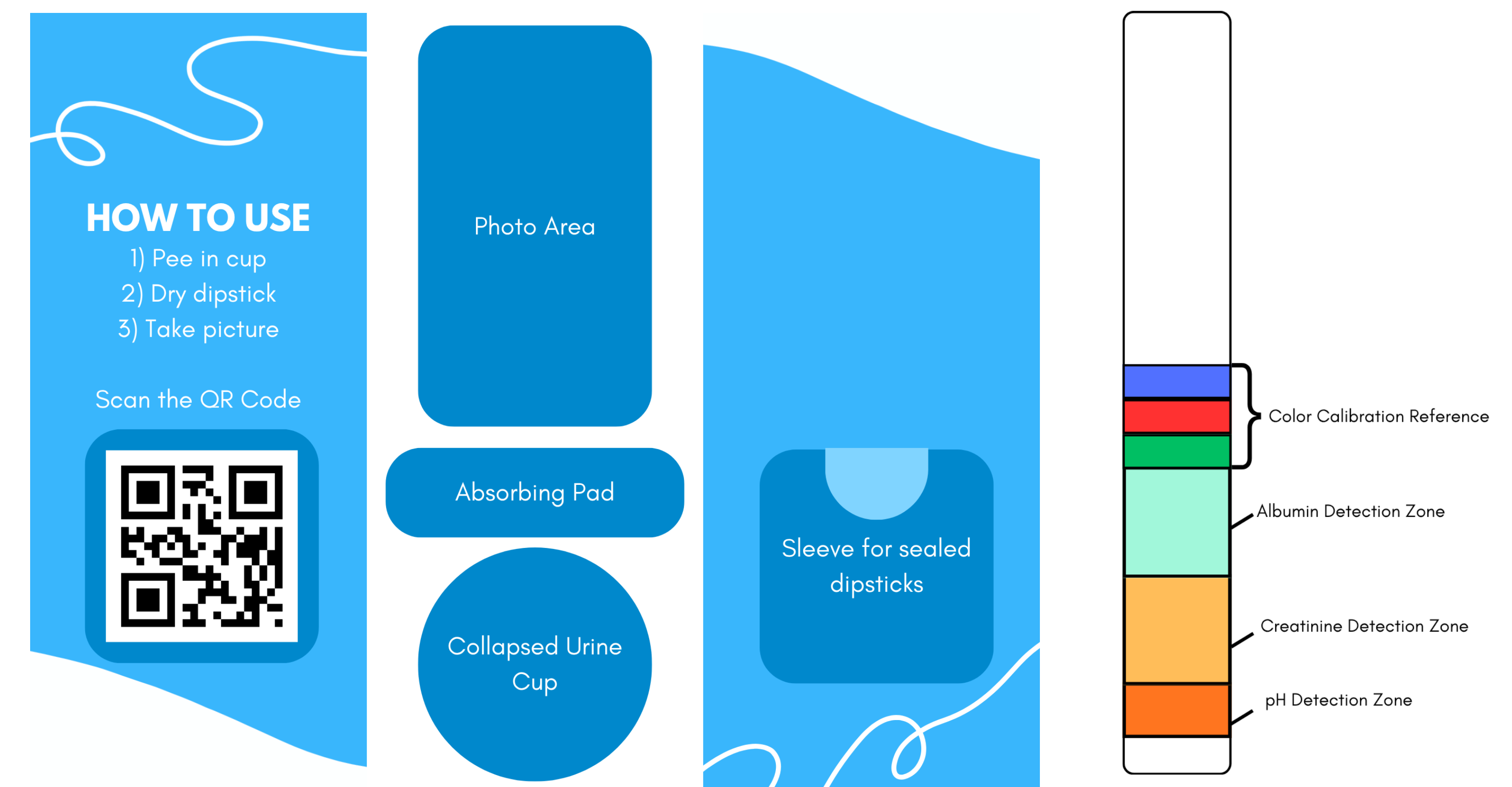


Figure 5. Device workflow and dipstick design showing sample collection, smartphone-based analysis, and labeled detection zones for albumin, creatinine, and pH with color calibration reference.

## Acknowledgments

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