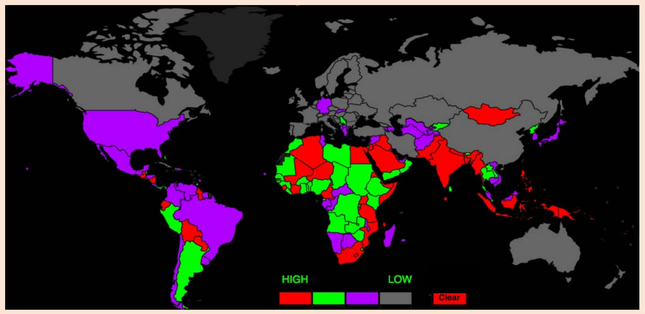
Patient Friendly Kidney Function Screening

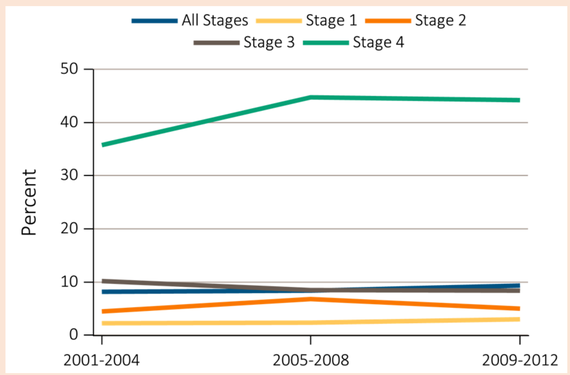
Ragwa M. El Sayed[1], Rathna Ramesh[2]
[1]Department of Biomedical Engineering, San Jose State University
[2]Department of Computer Engineering, University, San Jose State University
Academic Advisors: Dr. Alessandro Bellofiore, Dr. David Anastasiu, Dr. Melinda Simon
[1]Email: elsayed.ragwa@gmail.com

Chronic Kidney Disease

CKD was ranked the 13th leading cause of **Death** in 2013.

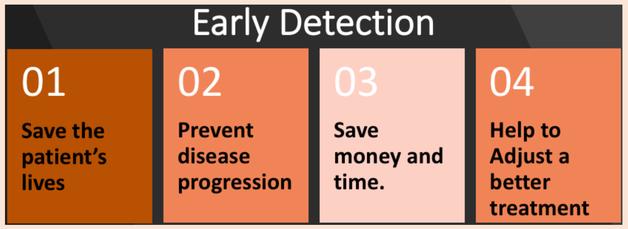


The major **Problem** associated with the disease is the Awareness.



The **Solution** is Early Detection.

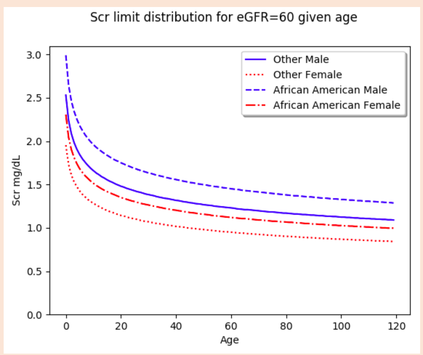
Creatinine is a chemical waste generated from muscle metabolism.



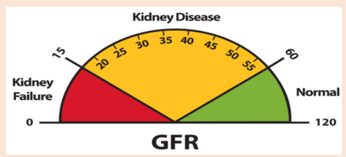
Creatinine level in blood is an indicator for kidney performance.

	CKD patients	Normal people
Blood	3.9-21.9	0.7-1.7
Salivary	0.2-6.6	0.1-1.2

Glomerular Filtration Rate



$$GFR = 175 \times [(S_{cr} \times 0.0113)^{-1.154}] \times (age)^{-0.203} \times (0.742 \text{ if female}) \times (1.212 \text{ if African-American})$$



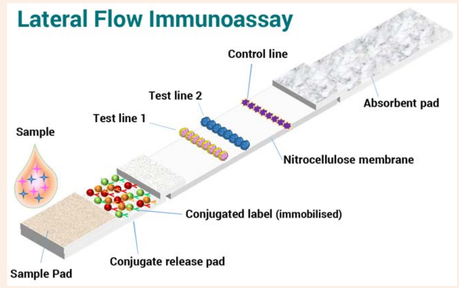
Objective: Kidney Function Monitoring

1. Provide a diagnostic method **Deliverable** to end-user.
2. Used in **Limited-resource Healthcare** settings.
3. An **Affordable** way for early detection of kidney failure disease.

Current Creatinine detection test cost	Proposed method cost
35-60 $ US dollar	0.3 – 1 $ US dollar

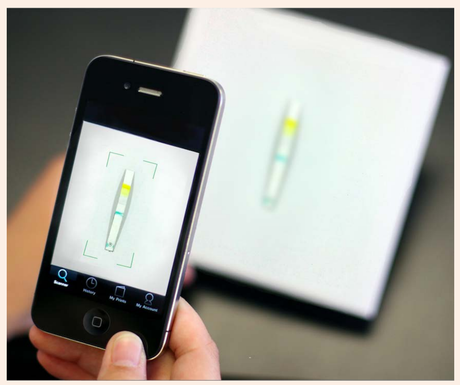
4. Imagine…. **Saving lives** by early detecting kidney failure.

Merging the idea of urine test strip and Immunoassay. Detection method is strip's **Colorimetry** changes with Jaffe's reaction.



Integrating **Machine Learning** techniques to measure colorimetry changes.

Using a **Smartphone** camera for detecting colorimetry changes by capturing the strip image.



Materials and Methods

- Lateral flow biosensor designed using Blood Separator pad.
- Operating principle is chemical biosensor based on Jaffe's Reaction.
- Images captured inside light box.
- We computed the levels of creatinine (Scr) that lead to different eGFR values, using the MDRD equation.
- Four categories (Other male, Other female, African American male, and African American female) for age between 1 and 120 years of age.

Creatinine reacts with picric acid in alkaline solution → red-orange chromogen

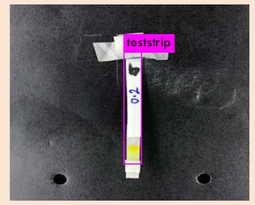
Results

- Total **65** different creatinine conc. tested.
- Total **2340** images were conducted.
- Test strip detected and localized by using **YOLO** Deep Learning regression model.
- Features are extracted using an **Overlapping** sliding window that scans the detection area of the test strips.
- Feature extraction techniques applied are:

1. Raw RGB pixels
2. Histogram of Gradients
3. Histogram of Colors

- Features extracted were used to train machine learning models:

1. Linear regression
2. logistic regression
3. Nearest neighbor regression
4. Support vector regression



Prediction root mean square error for creatinine concentration 0 - 4 mg/dL.

	Linear Regression	Logistic Regression	Nearest Neighbor Reg.	Support Vector Machine
RGB pixels	0.51	0.81	0.39	0.44
Histogram of Gradients	0.77	0.92	0.75	0.79
Histogram of colors	0.27	0.38	0.23	0.27

Conclusion

Developing an easy method to detect kidney disease is possible by using lateral flow paper microfluidics. Integrating smartphones in healthcare applications introduces an easy way to detect and monitor various diseases.

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Future Work
Plan is to extend the biosensor ability to detect potassium levels from blood drop and creatinine/albumin and protein level from urine as well to evaluate kidney disease prediction.

References

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2. M.D.S. Shephard, "Point-of-Care Testing and Creatinine Measurement," Clinical Chemistry and Laboratory Medicine CCLM, (2011).
3. T.J. Lasisi, "Salivary creatinine and urea analysis in patients with chronic kidney disease: a case control study," BioMed Neph (2016).