AI in Action: Risk Prediction Using Wearable Technologies

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AMERICAN COLLEGE of CARDIOLOGY®
Advancing Heart Care Worldwide

Disclosures

- Employment: Biofourmis
- Consultant/ Advisory Board/ Ownership Interest: Avive, HealthTensor, HiLabs, Neuroglee, SwissRe

Overview / Learning Objectives

1. How does/can AI contribute to wearable technologies and physiological monitoring?

2. What roles does/will AI play in Hospital at Home?

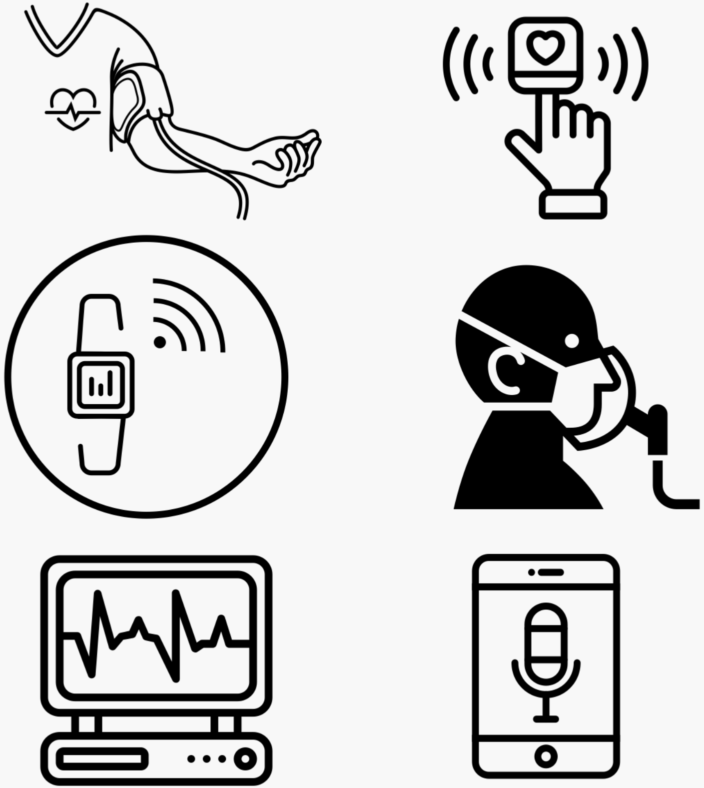
3. How can AI be used for optimizing medical therapeutics?

Role of AI for Wearable Technologies and Physiological Monitoring

Wearable Technologies and Physiological Monitoring

Increasing Amounts of Health Care-related Data

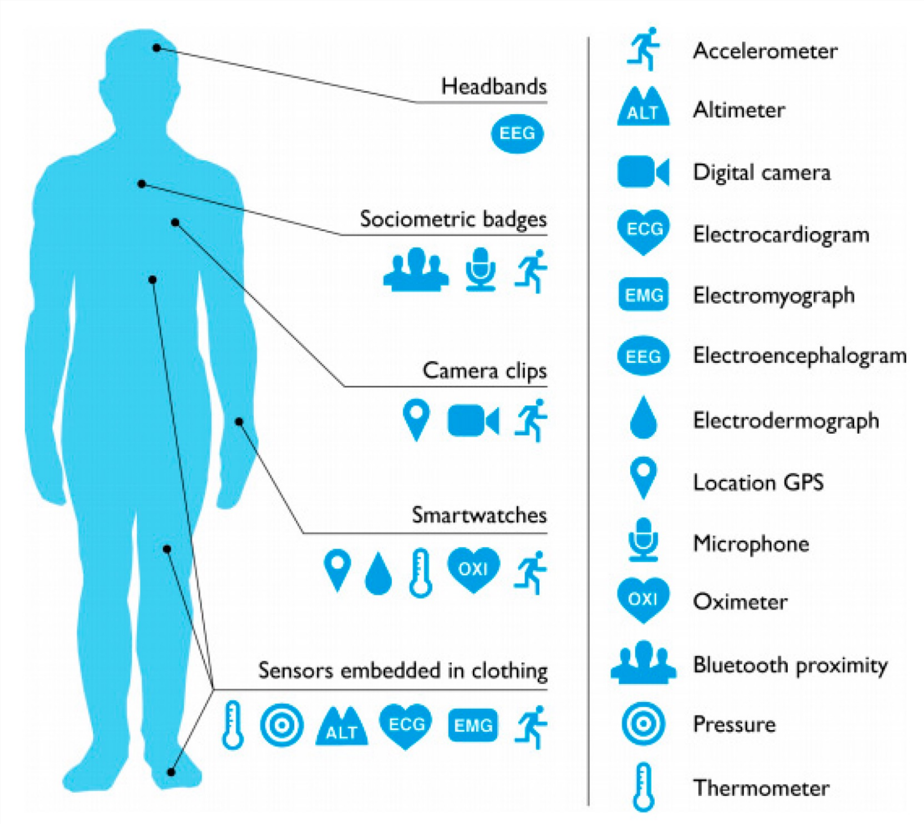
- Over 23% of the U.S. population wore a smart wearable in 2021 according to eMarketer
- Wireless clinical grade wearables
    - Eases monitoring in H@H and acute care settings



Credit: https://thenounproject.com/

https://www.pewresearch.org/internet/fact-sheet/mobile/
https://www.insiderintelligence.com/insights/wearable-technology-healthcare-medical-devices/

Wearable Health Systems Overview



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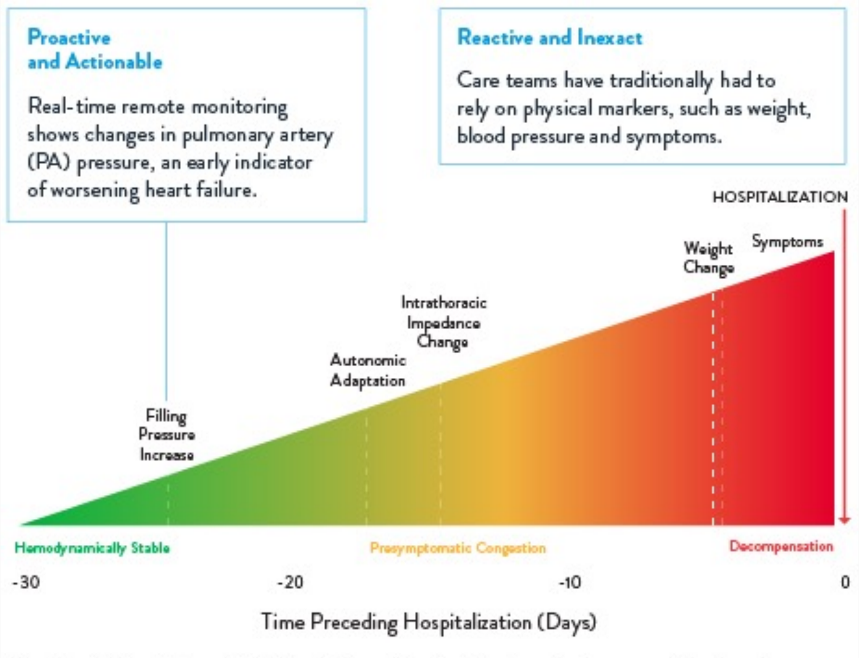
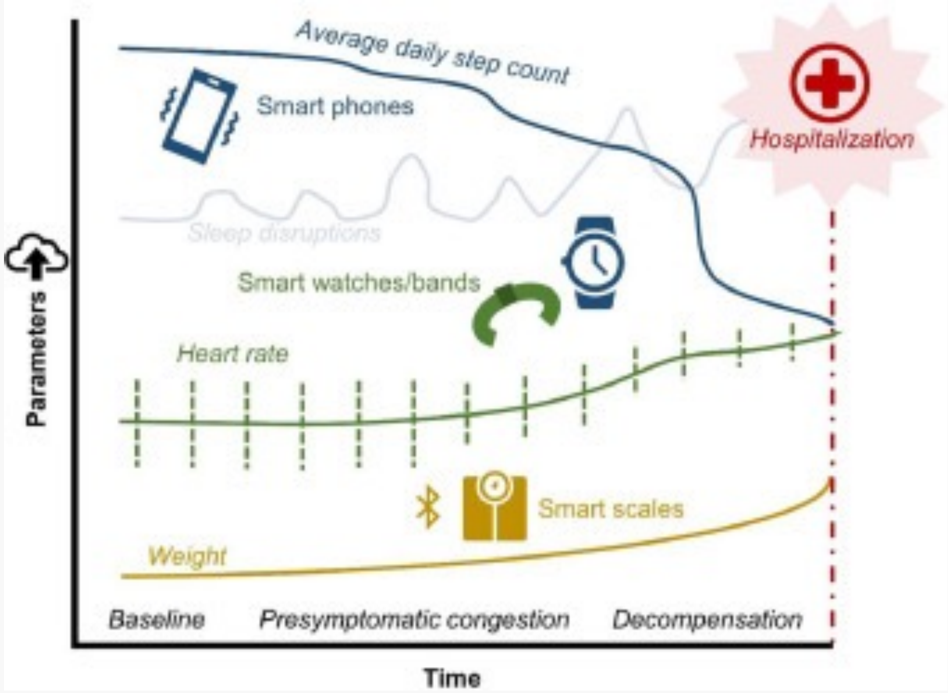
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6111409/pdf/sensors-18-02414.pdf
https://www.mdpi.com/1235214

//////////OUTFRONT ON EDUCATION

Intermittent vs. Continuous monitoring



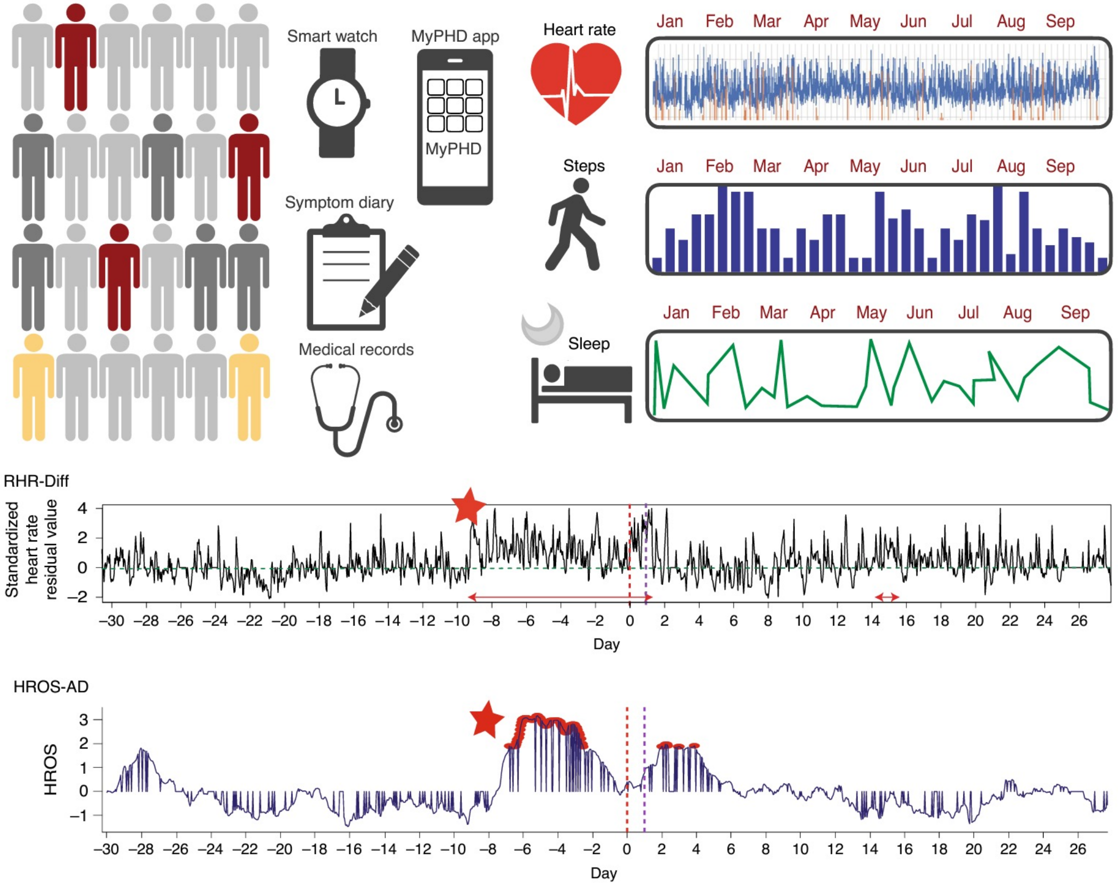
Graph adapted from Adamson PB. Pathophysiology of the transition from chronic compensated and acute decompensated heart failure: new insights from continuous monitoring devices. Current Heart Failure Reports. 2009;6:287-292.



https://www.jhltonline.org/article/S1053-2498(20)31870-2/fulltext; https://www.cardiovascular.abbott/us/en/hcp/products/heart-failure/pulmonary-pressure-monitors/cardiomems/about.html

Article | Published: 18 November 2020

Pre-symptomatic detection of COVID-19 from smartwatch data



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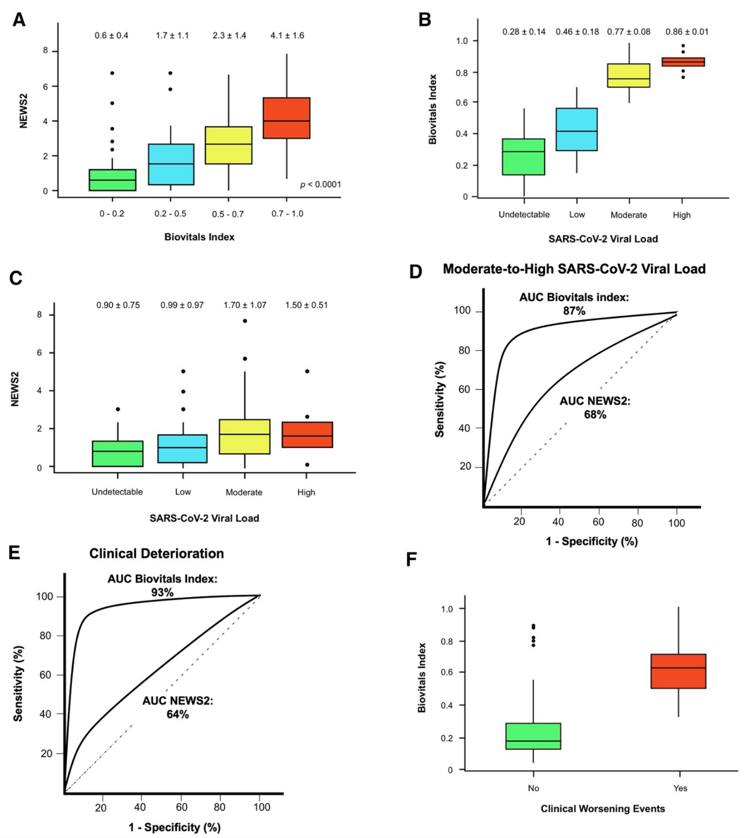
Article | Open Access | Published: 23 February 2021

Observational study on wearable biosensors and machine learning-based remote monitoring of COVID-19 patients



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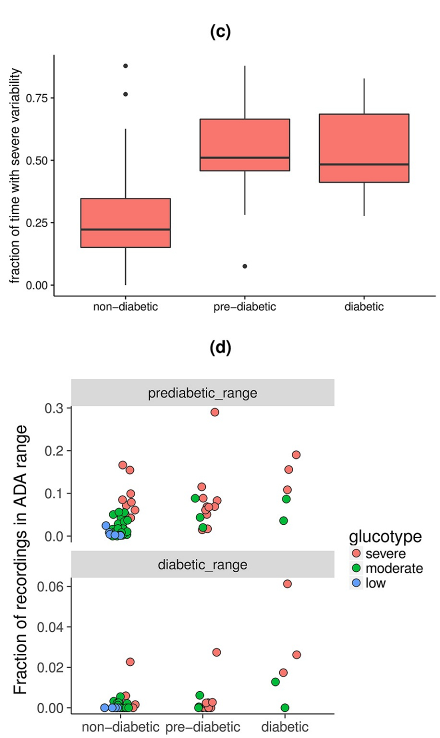
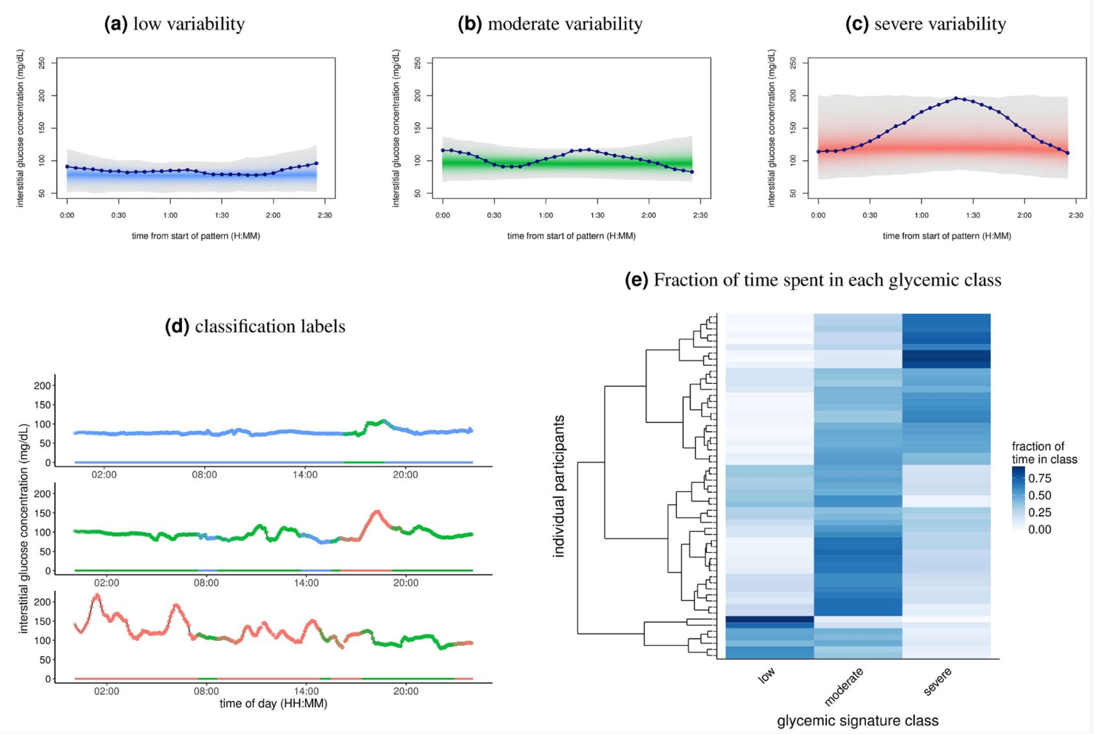
- Collects real time data, **continuously and non-invasively**
- Easy to **disinfect**
- Data communication via BLE or GSM
- Up to 7 days of battery run time

RESEARCH ARTICLE

Glucotypes reveal new patterns of glucose dysregulation

Heather Hall[1,2], Dalia Perelman[2], Alessandra Breschi[2], Patricia Limcaoco[2], Ryan Kellogg[2], Tracey McLaughlin[3], Michael Snyder[2]*





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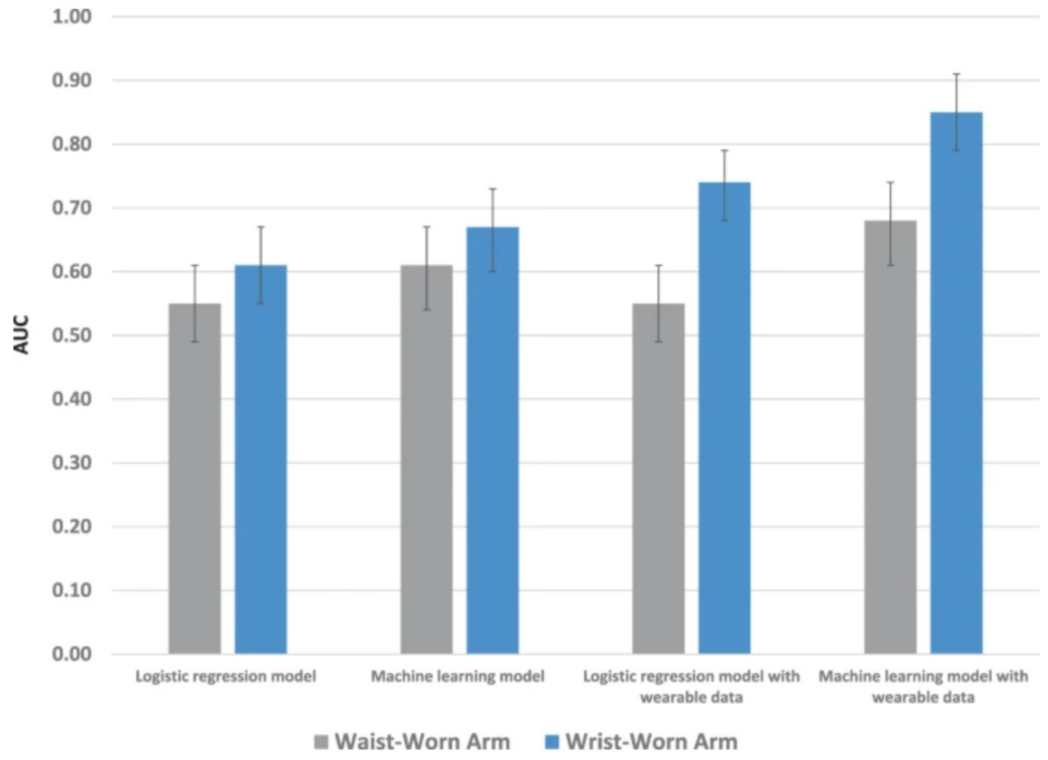
Article | Open Access | Published: 21 December 2021

Predicting changes in glycemic control among adults with prediabetes from activity patterns collected by wearable devices

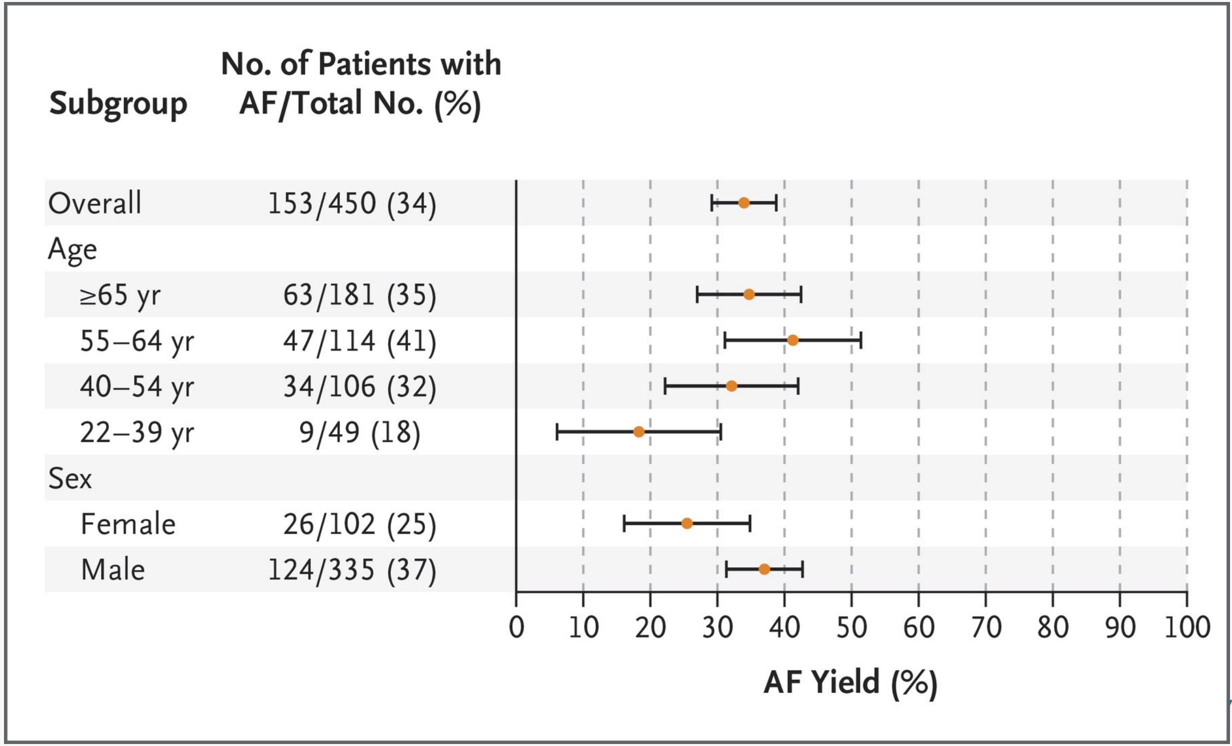
Fig. 3: Prediction of hemoglobin A1c worsening.



ORIGINAL ARTICLE

Large-Scale Assessment of a Smartwatch to Identify Atrial Fibrillation

Marco V. Perez, M.D., Kenneth W. Mahaffey, M.D., Haley Hedlin, Ph.D., John S. Rumsfeld, M.D., Ph.D., Ariadna Garcia, M.S., Todd Ferris, M.D., Vidhya Balasubramanian, M.S., Andrea M. Russo, M.D., Amol Rajmane, M.D., Lauren Cheung, M.D., Grace Hung, M.S., Justin Lee, M.P.H., et al., for the Apple Heart Study Investigators*



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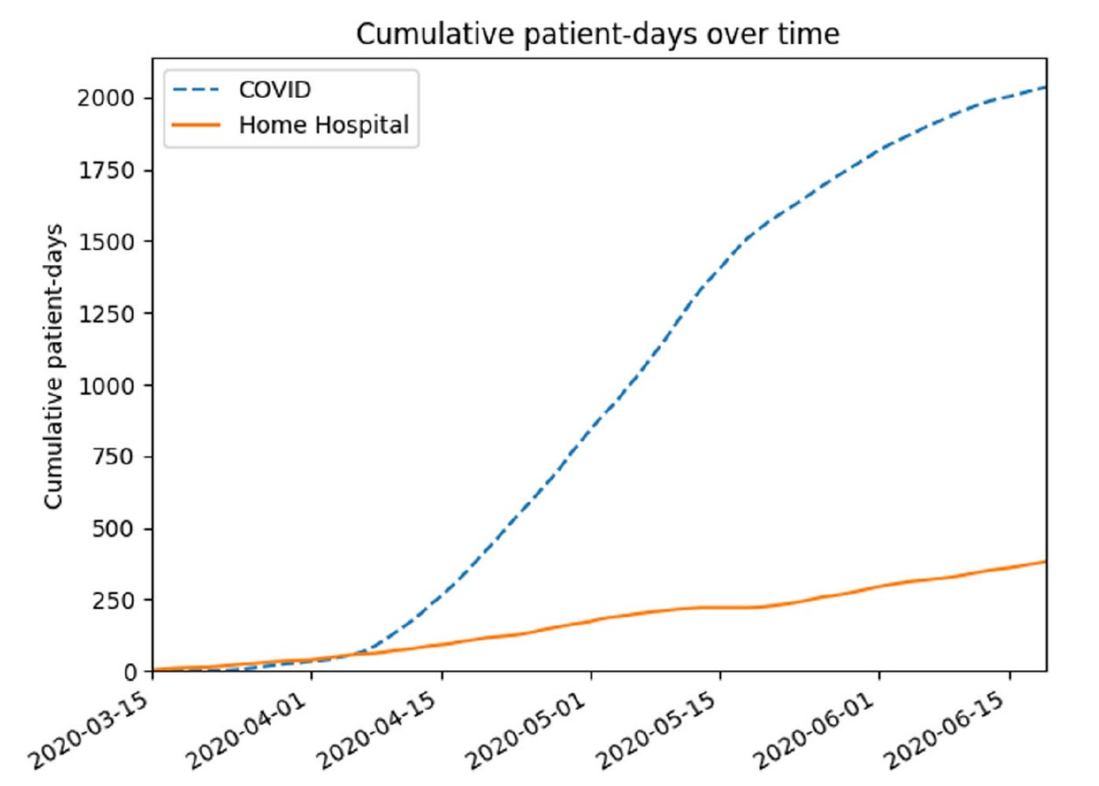
OUTFRONT ON EDUCATION

Role of AI for Hospital at Home

Hospital at Home Care During COVID-19 Pandemic

- Increase available hospital staff and resources for critical acute care (e.g. COVID-19 patients during surges in the pandemic)
  - Figure from pilot study, now available at hundreds of hospitals
- Cost of care significantly reduced compared to in-hospital costs
- Quality of patient outcomes better or similar to traditional hospital care
- Increased mobility of patients at home compared to in hospital setting



Acute Care at Home During the COVID-19 Pandemic Surge in Boston, Levine et al., 2021

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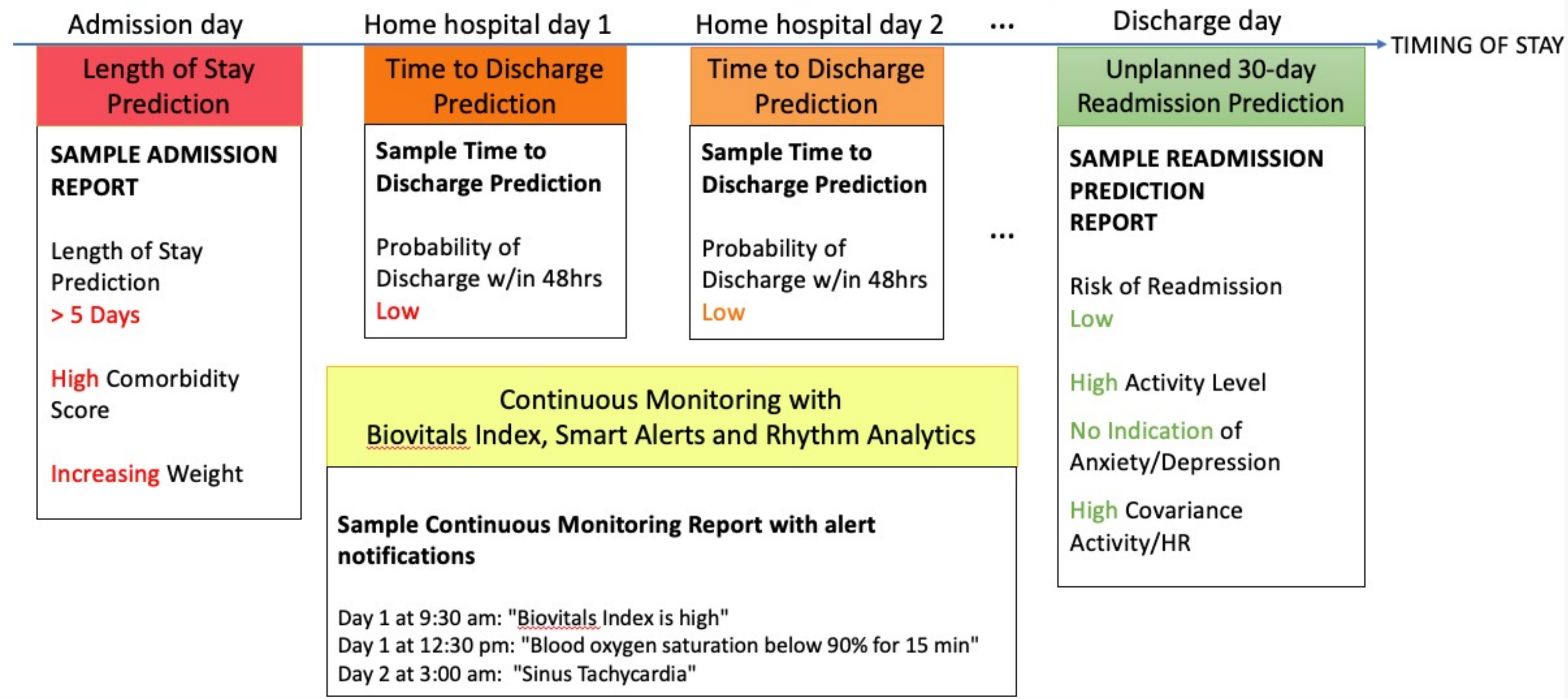
Sample Hospital at Home Patient Journey



Application of Machine Learning Techniques in Hospital at Home

Model Types	Sample Techniques	Sample Use Cases
Classification	CNN Logistic regression SVM	Arrhythmia interpretation Heart failure subtype classification COPD severity classification Sleep apnea severity estimation
Time series forecasting	LSTM Neural networks Time-series regression	Disease severity and disease progression prediction
Clustering / Pattern recognition	Gaussian mixture models K-means	Activity and vitals pattern learning
Anomaly detection	K-nearest neighbors One-class SVM	Continuous risk score generation Clinical decompensation prediction
Natural language processing	Latent Dirichlet Allocation RNN LSTM	Clinician note interpretation Depression/anxiety detection EHR parsing

Role of AI for Hospital at Home (Example: ECG)

Rapid ECG arrhythmia interpretation

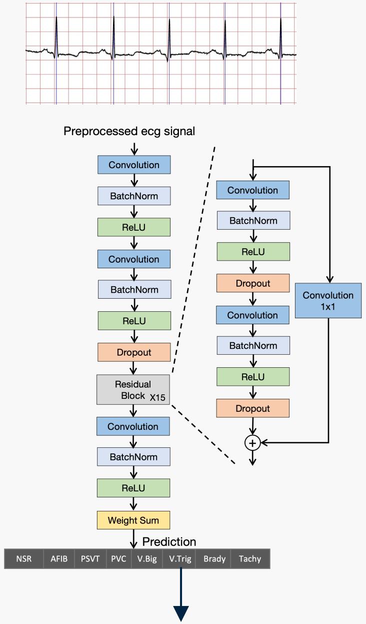
- Assisting clinician in interpreting long term ECG
- Reduce workload of clinician by deprioritise noise and focus only on important arrhythmia only
- Beneficial to patient because it allows to capture real time arrhythmia instead of single spot check

Auto measurement of QTc interval

- Allowing detection of sudden QTc prolongation from patient.
- Allowing new biomarker research of how QTc interval changes throughout patient journey
- Assisting clinician to diagnose patient with new real time event

Estimation of electrolyte abnormalities (K+ estimation from ECG)

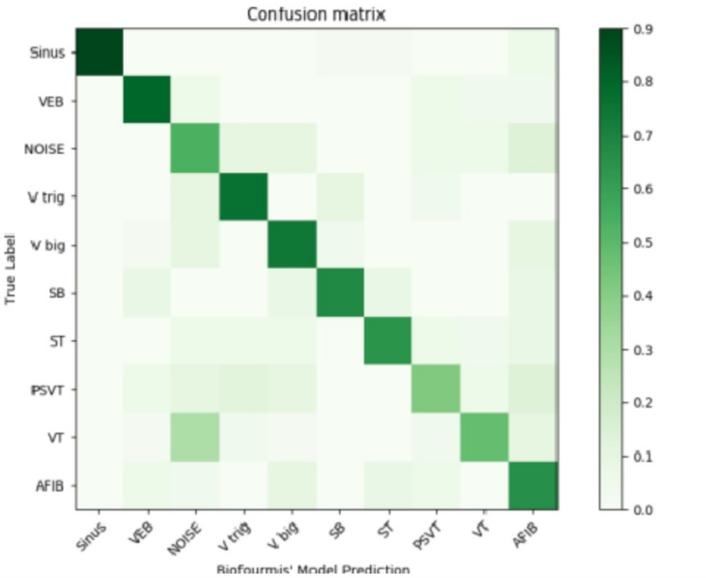
- Allowing real time alert of abnormal lab value
- Assisting clinician by providing extra evidence of lab value
- Alert hyperkalaemia / hypokalaemia



Auto interpretation, HR/HRV, QTc, K+

On Arrhythmia Detection by Deep Learning and Multidimensional Representation

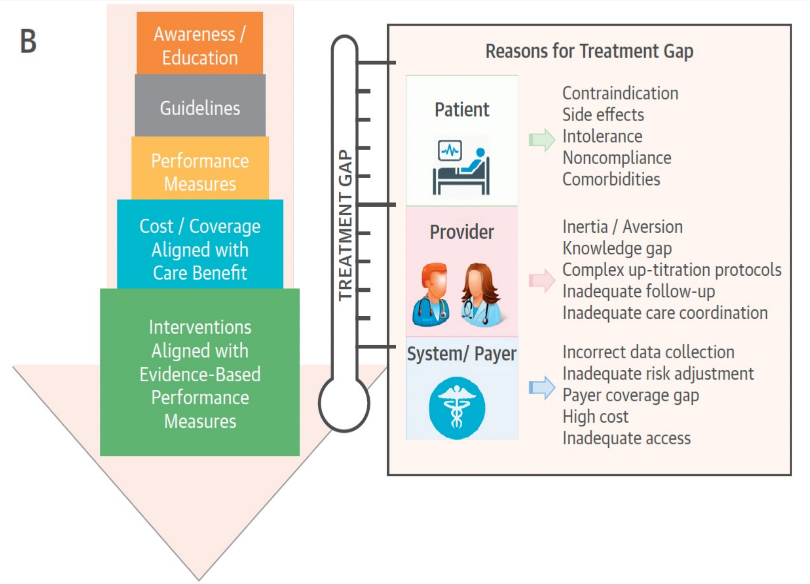
	F1 scores			
	Biofourmis' Model	Model(49)	Model(50)	Cardiologists
Normal Sinus Rhythm	0.924	0.932	**0.951**	0.911
Atrial Fibrillation	**0.838**	0.697	0.752	0.724
Sinus Tachycardia	**0.824**	0.794	0.741	0.806
Sinus Bradycardia	0.847	**0.853**	0.818	0.827
Ventricular Bigeminy	0.872	**0.882**	0.759	0.803
Ventricular Trigeminy	**0.880**	0.855	0.731	0.780
Ventricular Tachycardia	0.746	0.713	0.689	**0.784**
PSVT	**0.716**	0.618	0.602	0.654
Noise	**0.779**	0.707	0.632	0.713
VEB	**0.909**	0.872	0.824	0.834
Summary Results				
Specificity	**0.982**	0.973	0.935	0.952
Sensitivity	**0.908**	0.887	0.842	0.860
F1	**0.834**	0.792	0.749	0.784



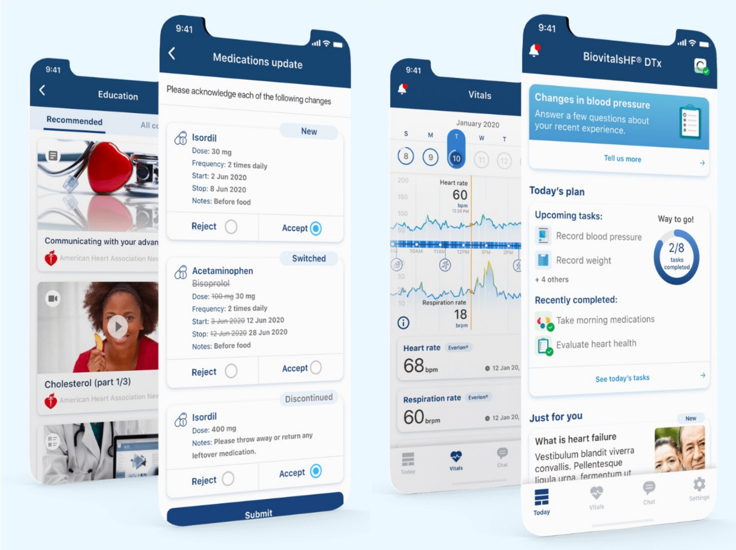
Role of AI for Optimizing Medical Therapeutics

AI for Optimizing Medical Therapeutics

Existing Gap between Therapeutics Guidelines and Clinical Practice



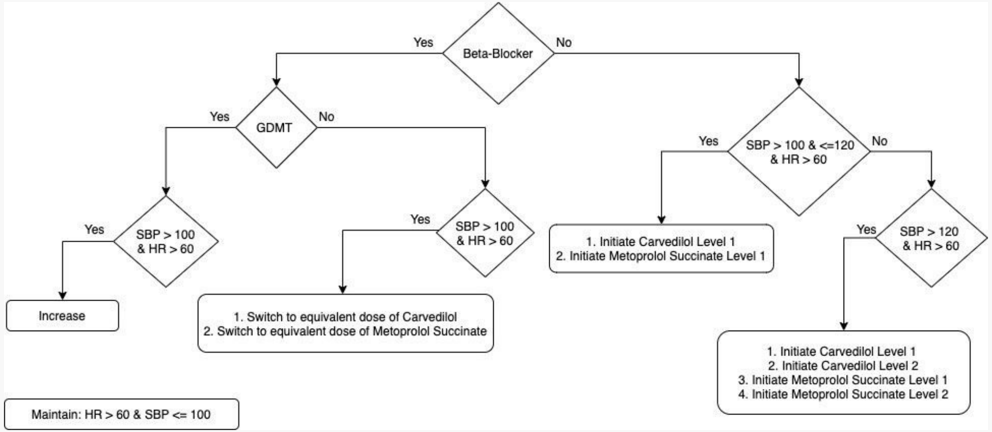
AI Optimized Therapeutics: Reduce the Gap and Optimize Outcome (Engagement, Tailored & Specific titration recommendations)

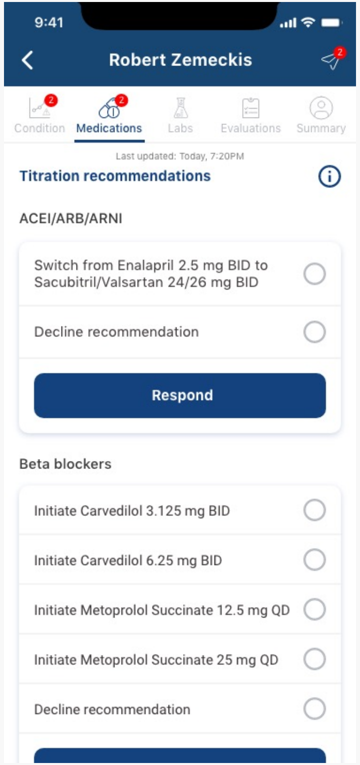


AI for Optimizing Medical Therapeutics (Example)

- Limited to recommendations of initiations and up-titrations of GDMT
- Drug recommendations are based on AHA guidelines and expert inputs
- Decisions to increase the dosage of GDMT or start HF medications will ultimately be made by the treating cardiologist, or qualified designated HCP.

e.g., Titration Algorithm Example





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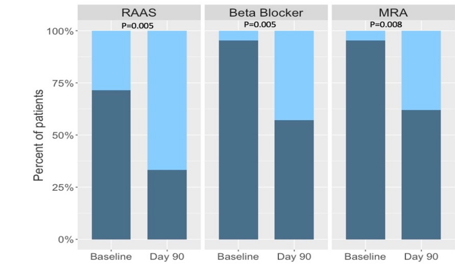
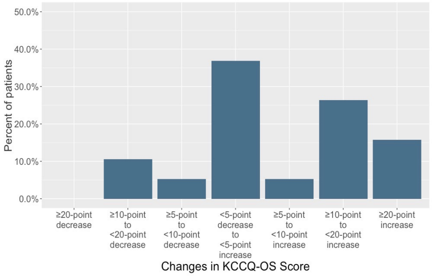
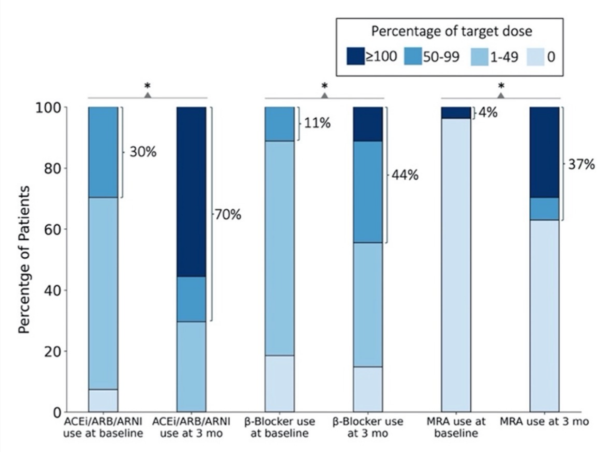
OUTFRONT ON EDUCATION

GDMT Optimization – Preliminary Evidence

- **N=~30** participated in a run-in phase of a larger RCT
- **Objective:** To determine whether a remote, software algorithm-driven, medication optimization program can enhance implementation of GDMT in HFrEF.
- Patients were onboarded to the BiovitalsHF platform with surveillance of laboratories, physiology, and symptoms and recommendations made to the clinical team **for approval of titration recommendation.**
- Results[1]:
  - At 3 months, patients on the BiovitalsHF platform experienced **significant increase from baseline in utilization of all categories of GDMT** ($p<0.05$).
  - The proportion of **patients advanced to target doses of GDMT was also higher** at 3 months as compared to historical controls/ registry data. ($p<0.05$)
  - At 3 months, patients on Biovitals-HF platform experience statistically significant and **clinically meaningful improvement in KCCQ-OS**.







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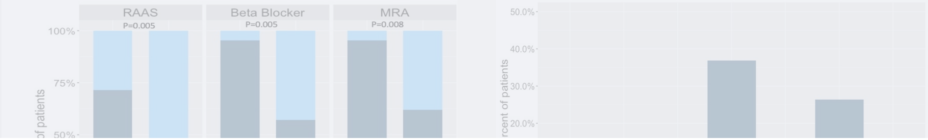

Biofourmis receives FDA breakthrough device designation for heart failure "digital therapy"

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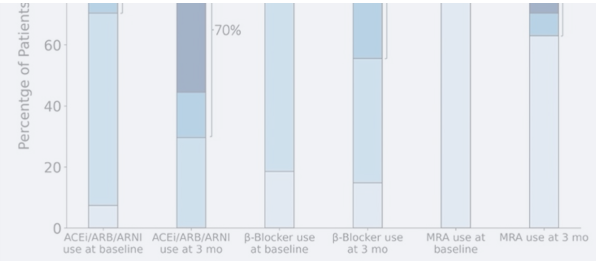

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