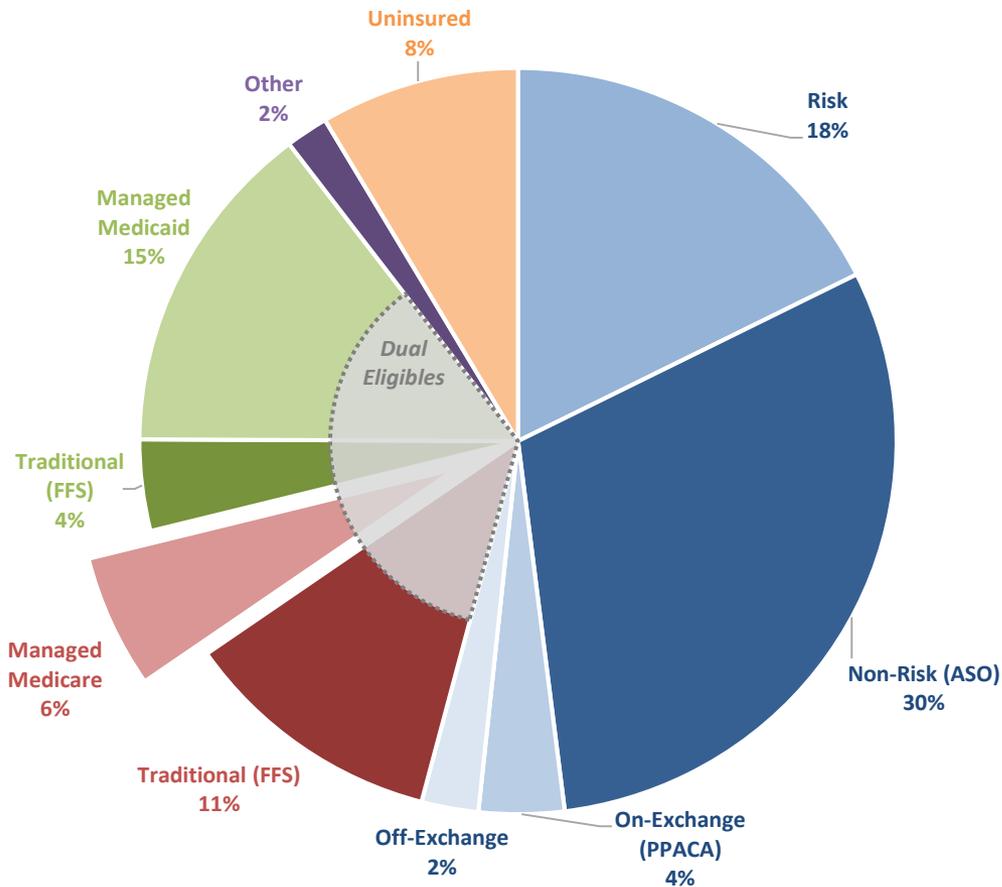




Using AI/Predictive Modeling to Address Suboptimal Care in Medicine

US HEALTH COVERAGE



Market Segment	Enrollment (2016 in millions)
Commercial (i.e., under-65)	179
<i>Group (e.g., Employer, Union)</i>	
Risk (Insured)	58
Non-Risk (Admin. Services Only)	100
<i>Individual</i>	
On-Exchange (ACA)	12
Off-Exchange	8
Medicare (i.e., 65+ or disability)	56
Traditional (Fee For Service)	37
Managed Medicare	19
Medicaid / CHIP (i.e., low income)	61
Traditional (Fee For Service)	13
Managed Medicaid	48
Other (e.g., TRICARE)	6
Uninsured	28
Subtotal	329
<i>Less Dual Eligibles (Medicare & Medicaid)</i>	<i>10.5</i>
Total US Population	319

Source: Kaiser Family Foundation, Barclays Managed Care 2016 Outlook

Note: Minor discrepancies due to rounding



MANAGED CARE PRODUCT OVERVIEW

Managed care organizations (MCOs) provide and administer health insurance through risk-based and administrative services only (ASO) products.

MA is one of the fastest growing and most profitable business lines.

	Commercial Risk	Commercial Non-Risk (ASO)	Medicare Advantage (MA)	Medicare Part D	Managed Medicaid
Description	Insurance for employers and individuals	Administrative services for large, self-insured employers	Insurance for Seniors	Stand-alone prescription drug plans for Seniors	Insurance for people with low incomes
Customer	Groups / Individuals	Large Groups	Seniors (funded by Federal Govt)	Seniors (funded by Federal Govt)	Low Income Individuals (jointly funded by Fed/States, administered by States)
Market Size*	\$350 B	\$30 B	\$195 B	\$30 B	\$210 B
2015 Enrollment	79 m	100 m	19 m	24 m	48 m
Revenue PMPM*	\$375	\$25	\$900	\$100	\$150-2,000
Pre-Tax Margin*	4-7%	15%	5%	3%	3%
Profit PMPM*	\$15-26	\$4	\$45	\$3	\$5-60

PMPM = Per Member Per Month

* Estimated value for 2015

Source: B of A Merrill Lynch Managed Care Primer 2016



HEART FAILURE

Ejection fraction important

- For patients with heart failure, their hearts' ability to push blood can be impaired, leading to "reduced ejection fraction"
 - >55% normal
 - ≤40% poor, imminent adverse events, need treatment
- Treatment modalities depend critically on knowing the left ventricular ejection fraction
- Common drug treatments: ACEI, ARB, MRA, ARNI

ACEI Angiotensin-converting-enzyme inhibitor

ARB Angiotensin II receptor blockers

MRA Mineralocorticoid Receptor Antagonists

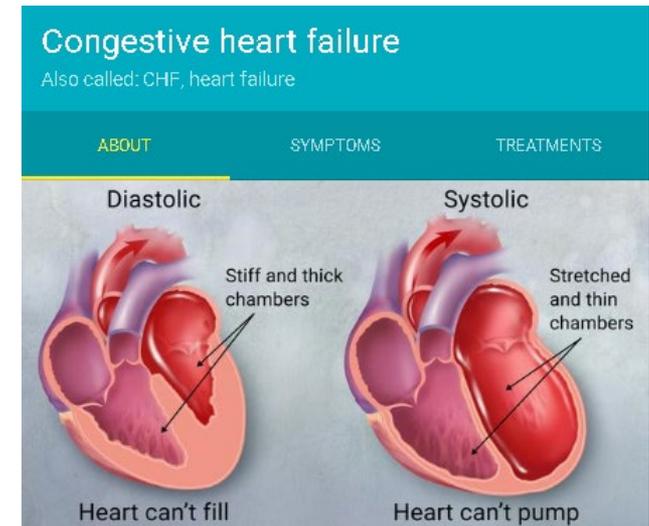
ARNI Angiotensin Receptor-Nepilysin Inhibitors



Reduce
blood
pressure



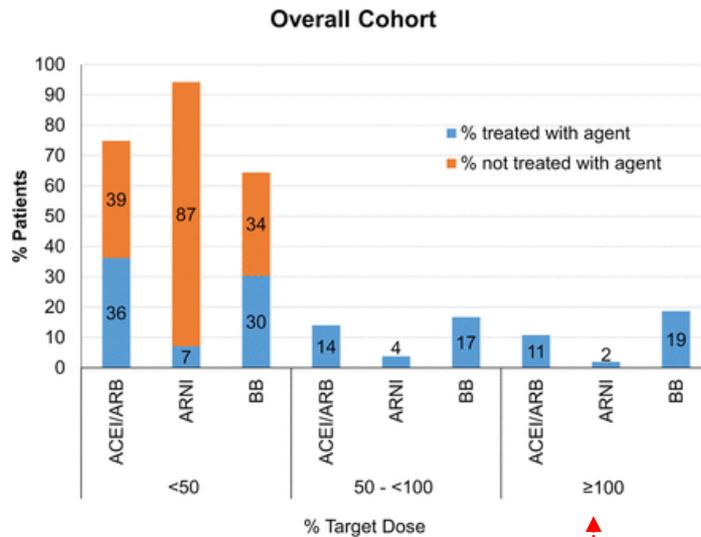
Why does reducing blood pressure help alleviate effects of heart failure?



Affects 5.7m Americans, \$30bn per annum, 1/9 deaths, 50% 5-year mortality rate from first diagnosis



PATIENTS RECEIVE LOW RATES OF GUIDELINE-DIRECTED THERAPY



ACEI = angiotensin converting enzyme inhibitor; ARNI = angiotensin receptor- neprilysin inhibitor; ARB = angiotensin receptor blocker; BB = beta blockers, SBP = systolic blood pressure

Receiving
Target Doses

JACC: Heart Failure

Volume 7, Issue 4, April 2019
DOI: 10.1016/j.jchf.2018.11.011

Target Doses of Heart Failure Medical Therapy and Blood Pressure Insights From the CHAMP-HF Registry

Conclusions In a large, contemporary registry of outpatients with chronic HFrEF eligible for treatment with BBs and ACEI/ARB/ARNI, **<20% of patients were receiving target doses**, even among those with SBP ≥ 110 mm Hg.



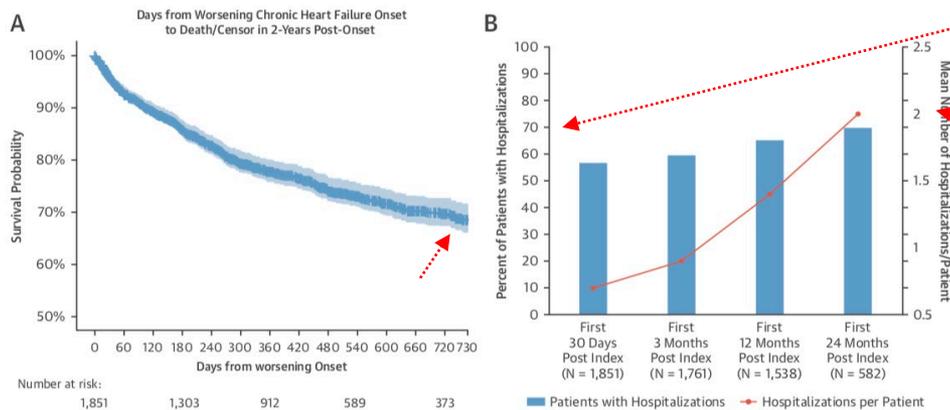
FAILURE TO CARE FOR HIGHEST-RISK PATIENTS IN TIMES OF GREATEST NEED

Clinical Course of Patients With Worsening Heart Failure With Reduced Ejection Fraction



Javed Butler, MD, MPH, MBA,¹ Mei Yang, PhD,² Massimiliano Alfonso Manzi, MBA,³ Gregory P. Hess, MD, MBA, MS,^{1,2} Mahesh J. Patel, MD,³ Thomas Rhodes, PhD,⁴ Michael M. Givertz, MD⁵

FIGURE 4 Outcomes for Patients With Worsening Heart Failure



2 year readmission risk = 70%

2 year number of readmissions = 2

2 year mortality risk = 30%



COST IMPACT

Adherence to guideline-directed therapy yields substantial value quickly.

TABLE 5 Costs

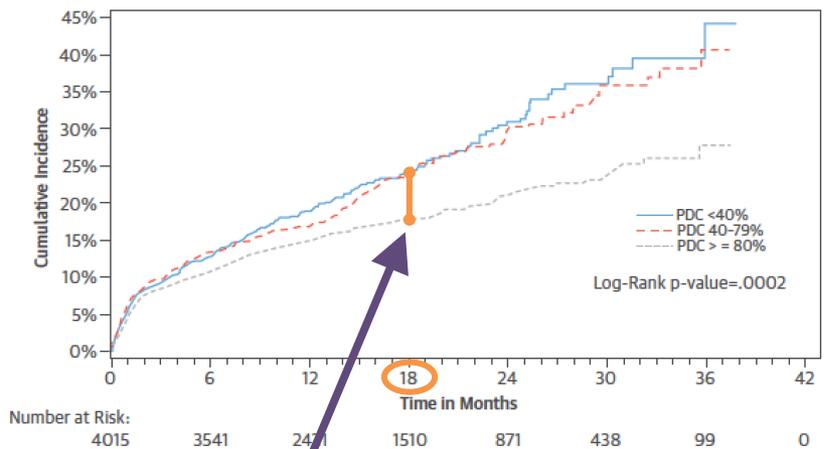
	Post-MI Cohort (Per Patient Per Year)			ATH Cohort (Per Patient Per Year)		
	Nonadherent	Partially Adherent	Fully Adherent	Nonadherent	Partially Adherent	Fully Adherent
MI (ACEI + Statins)	\$844.46	\$774.09	\$404.64	\$396.03	\$297.02	\$181.51
Stroke	\$178.49	\$133.87	\$89.24	\$168.62	\$116.74	\$77.82
Revascularization	\$3,375.21	\$3,000.00				
Angina and CV atherosclerosis	\$1,432.86	\$1,100.00				
All-cause ED visits	\$256.97	\$150.00				
Cardiac-related ED visits	\$14.77	\$10.00				
Outpatient visits to cardiologist	\$639.38	\$400.00				
Outpatient visits to cardiologist with CV testing	\$558.76	\$350.00				

+ \$439.82 PPPY

Abbreviations as in Tables 1 and 4.



FIGURE 2 Post-MI Primary Outcome Kaplan-Meier Curves



Kaplan-Meier curves for major adverse cardiovascular events (MACE) according to adherence categories in the post-MI cohort. Abbreviations as in Figure 1.

What is achievable with optimal adherence?

Bansilal S, et al. Assessing the Impact of Medication Adherence on Long-Term Cardiovascular Outcomes. J Am Coll Cardiol. 2016; 68(8): 789-801.



THE COMPLEXITY OF MEDICINE NOW EXCEEDS THE CAPACITY OF THE HUMAN MIND

The NEW ENGLAND JOURNAL of MEDICINE

Perspective
SEPTEMBER 28, 2017

Lost in Thought -- The Limits of the Human Mind and the Future of Medicine

In the good old days, clinicians thought in groups; [Rounding] was a chance for colleagues to work together on **problems too difficult for any single mind**... Today, thinking looks very different: we do it alone, bathed in the blue light of computer screens. **Our knee-jerk reaction is to blame the computer**, but the roots of this shift run far deeper.

The complexity of medicine now exceeds the capacity of the human mind.

Computers, far from being the problem, are the solution.

If a root cause of our challenge is complexity, the solutions are unlikely to be simple. **Asking doctors to work harder or get smarter won't help**. But there is hope. The same computers that today torment us with never-ending checkboxes and forms will tomorrow be able to process and synthesize medical data in ways we could never do ourselves.



Source: Lost in Thought – The Limits of the Human Mind and the Future of Medicine | NEJM, September 28, 2017



PROBLEM WE'RE SOLVING

Poor medical care is prevalent and health inequities are pervasive

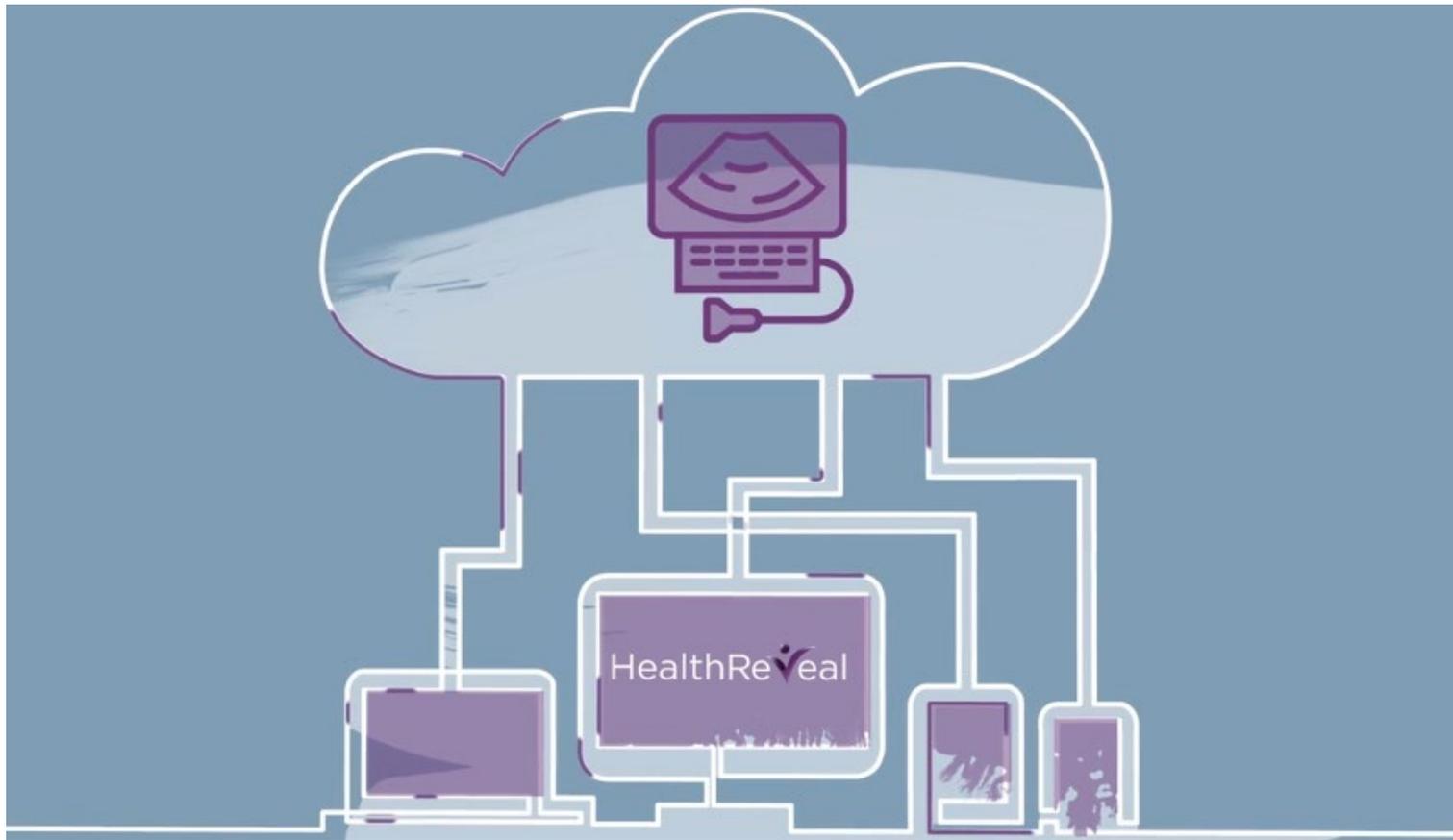
**HEALTHREVEAL'S CLINICAL AI SOLUTION IDENTIFIES SUBOPTIMAL CARE,
PREEMPTS THE AVOIDABLE CONSEQUENCES OF CHRONIC DISEASE**

SAMPLE CLIENTS & INVESTORS



HEALTHREVEAL GUIDES THE WAY

<https://vimeo.com/287445081>



CLIENT FEEDBACK HAS BEEN POSITIVE!



EmblemHealth and its Partner AdvantageCare Physicians Join Forces with HealthReveal

New technology equips ACPNY clinical teams with the latest medical research and best practices in real time to save lives, improve care and reduce medical costs

NEW YORK (March 28, 2019) – EmblemHealth, one of the nation's largest non-profit health insurers, and its partner, AdvantageCare Physicians (ACPNY), one of New York's largest primary and specialty care practices, announced today they are joining forces with HealthReveal, a clinical AI company dedicated to curating and deploying the latest in scientific medical evidence to improve patient outcomes and quality of life. ACPNY has integrated HealthReveal's clinical tool into its care model to improve patients' health by harvesting the latest research-backed clinical recommendations that are actionable and personalized. HealthReveal's technology was piloted in partnership with physician leaders at three ACPNY medical offices beginning in 2018 and will be deployed across all of ACPNY's sites by May 2019.

“I trained with the Washington Manual, then I had UpToDate, and now I have HealthReveal”

*“This is a truly **proactive** tool to identify problems before they happen”*

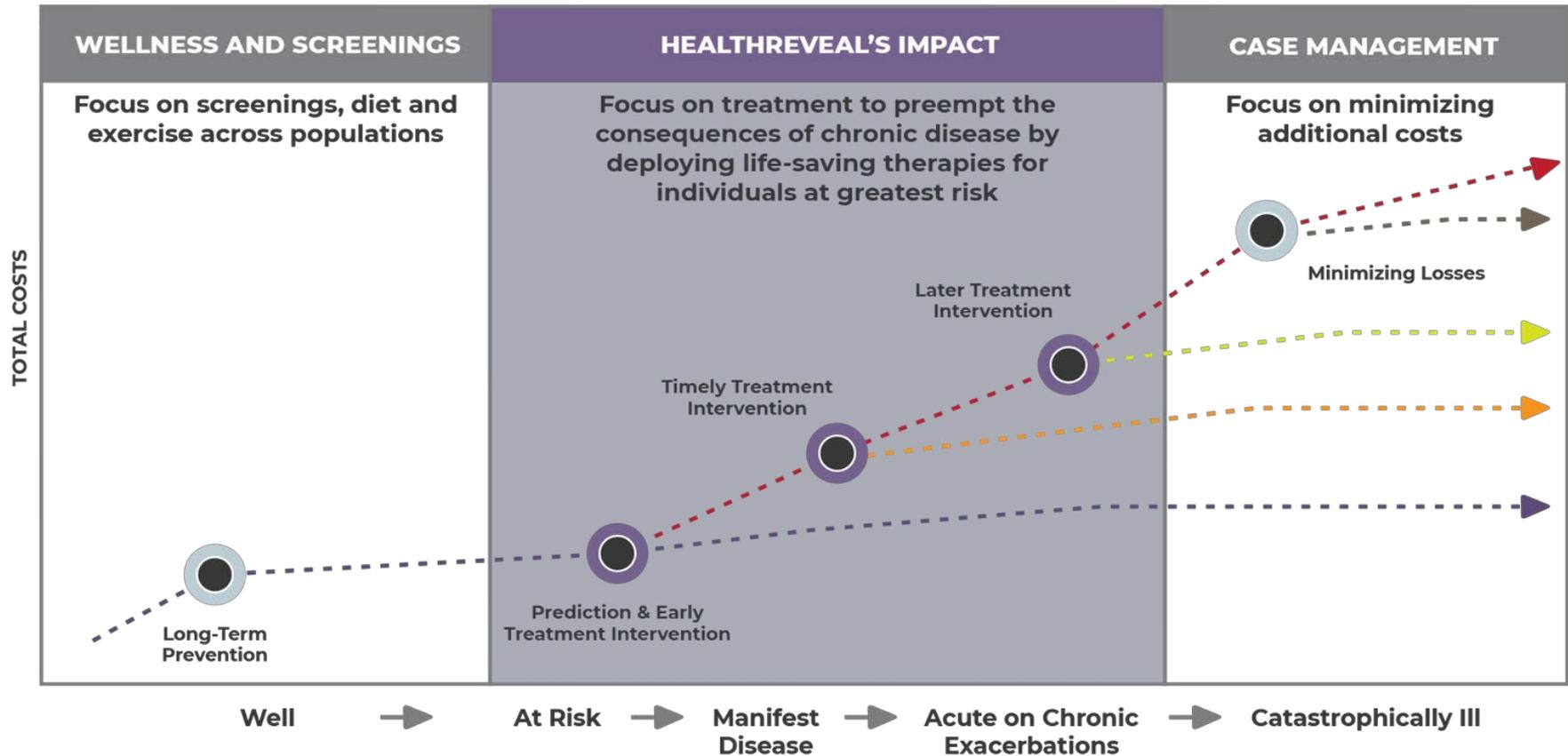
*“HealthReveal helps us do for our patients what we strive to do at every encounter; **the right thing**”*

*“HealthReveal fits **seamlessly** into our care model and EMR workflow”*



IMPACT ON TARGET POPULATIONS

Significant cost avoided by early detection and clinically optimal intervention that changes the trajectory of the patient.



ANALYTICS AT HEALTHREVEAL

Some 'fun' examples

1. Data processing lessons learnt
2. Tools we develop
3. ML to impute missing data
4. Predictive modeling to enhance risk stratification tools
5. Towards value based medicine



AUTOMATION IN MEDICINE

- Clinical AI software must be sufficiently accurate, **sensitive AND specific** to run independently
- Apart from isolated specific use of image processing AI, e.g. retinopathy, adoption of general AI in healthcare has been slow
- Input data **completeness/accuracy** need to be part of clinical AI pipeline
- Clinical findings generated through clinical AI must also be **explainable** for end user



DATA IS NOT ALL CREATED EQUAL

- Health data from different entities exist in **different formats**, of varying **completeness/quality**
- The **data ingest pipeline** needs to address variations in data structure and identify the level of completeness and accuracy of the data to inform subsequent use
- **Structured vs unstructured** require different tools



HEMODYNAMIC REPORT PARSING

Unstructured data processing

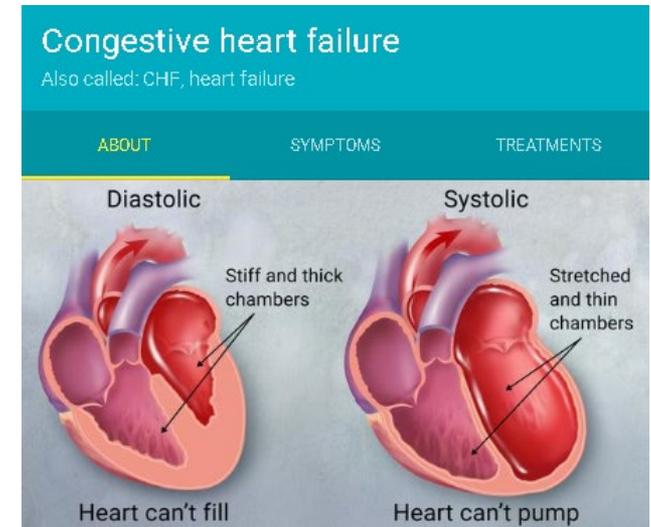
- Hemodynamic report contains a multitude of cardiovascular function measurements for a patient,
e.g. left ventricular ejection fraction, aortic valve max velocity
- Critical in diagnosing and treatment



“IMPUTING” MISSING DATA

Ejection fraction for heart failure

- “reduced ejection fraction”
 - >55% normal
 - $\leq 40\%$ poor, with imminent adverse events, requiring treatment
- Treatment modalities depend critically on knowing the left ventricular ejection fraction
- But **ejection fraction often missing**



Affects 5.7m Americans, \$30bn per annum, 1/9 deaths, 50% 5-year mortality rate from first diagnosis



“TRADITIONAL” RISK METRICS

CHADS-VASc score & stroke risk

Criteria		Poss. Point
Congestive heart failure Signs/symptoms of heart failure confirmed with objective evidence of cardiac dysfunction	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	+1
Hypertension Resting BP > 140/90 mmHg on at least 2 occasions or current antihypertensive pharmacologic treatment	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	+1
Age 75 years or older	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	+2
Diabetes mellitus Fasting glucose > 125 mg/dL or treatment with oral hypoglycemic agent and/or insulin	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	+1
Stroke, TIA, or TE Includes any history of cerebral ischemia	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	+2
Vascular disease Prior MI, peripheral arterial disease, or aortic plaque	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	+1
Age 65 to 74 years	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	+1
Sex Category (female) Female gender confers higher risk	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	+1
<input type="button" value="Reset"/> <input type="button" value="Calculate"/>		

The score is “blunt”

What are the CHADS-VASc scores for:

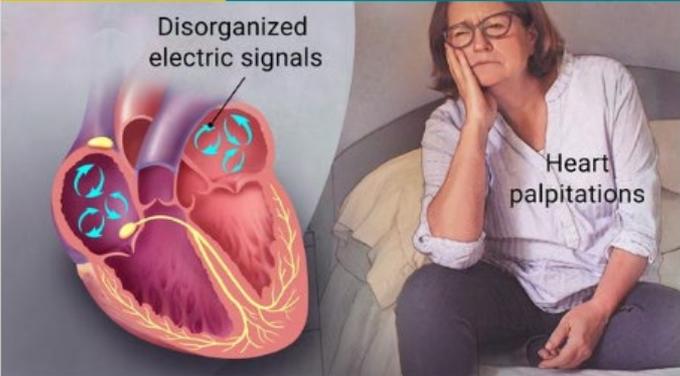
- 75 year old female = ?
- 55 year old male patient with prior stroke and myocardial infarction = ?



ATRIAL FIBRILLATION

Atrial fibrillation
Also called: AF, a-fib

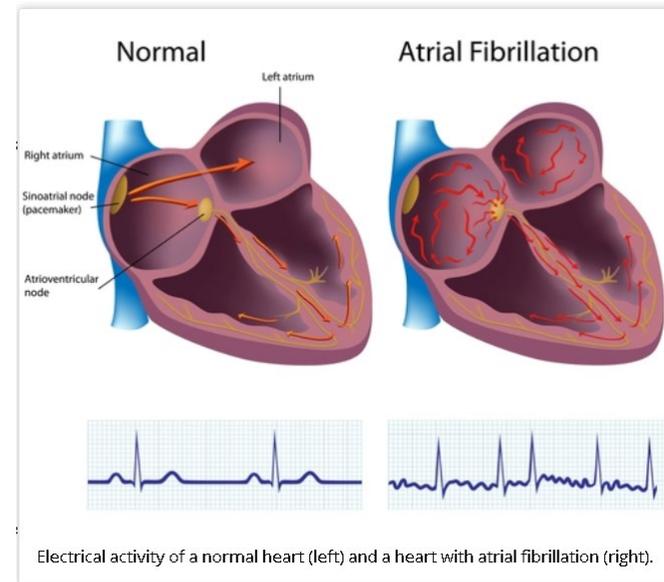
ABOUT SYMPTOMS TREATMENTS



Disorganized electric signals

Heart palpitations

An irregular, often rapid heart rate that commonly causes poor blood flow.



Treatment modalities:

- **Warfarin** – cheap, generic med, but requires regular monitoring, adherence problems
- **DOAC** – direct oral anticoagulants, “new” med, less half life, requires less monitoring, but more expensive
- **LAAC** – left atrial appendage closure device “plugs” and reduces the likelihood of large clots forming

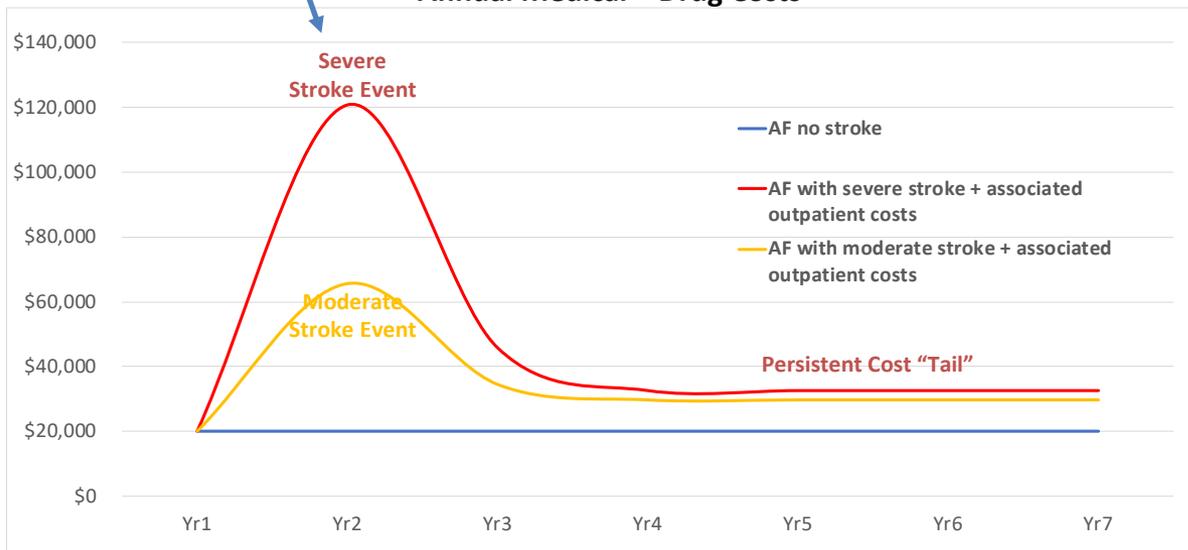


POOR MANAGEMENT OF AF PATIENTS IS COSTLY FOR MA PLAN

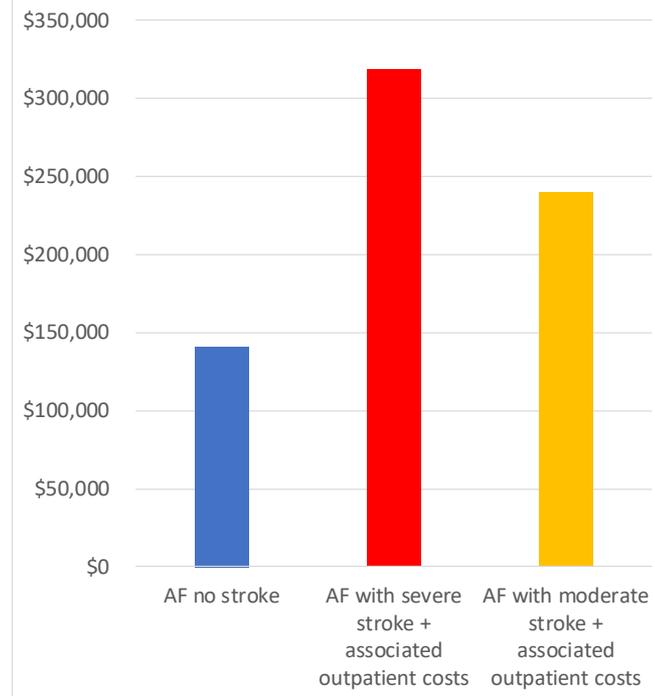
Projected medical costs for one NVAF patient by stroke severity*

NVAF patients tend to have more severe strokes than stroke due to atherosclerosis of aorta

Annual Medical + Drug Costs



7yr cumulative cost



*References:

Estimation of Total Incremental Health Care Costs in Patients With Atrial Fibrillation in the United States; Michael H. Kim
 Real-world costs of ischemic stroke by discharge status; F. Mu
 Long-Term Costs of Ischemic Stroke and Major Bleeding Events among Medicare Patients with Nonvalvular Atrial Fibrillation; Catherine J. Mercaldi

RISK ADJUSTMENT FACTOR (RAF) DRIVES REVENUE

Risk-Adjusted Revenue Gain

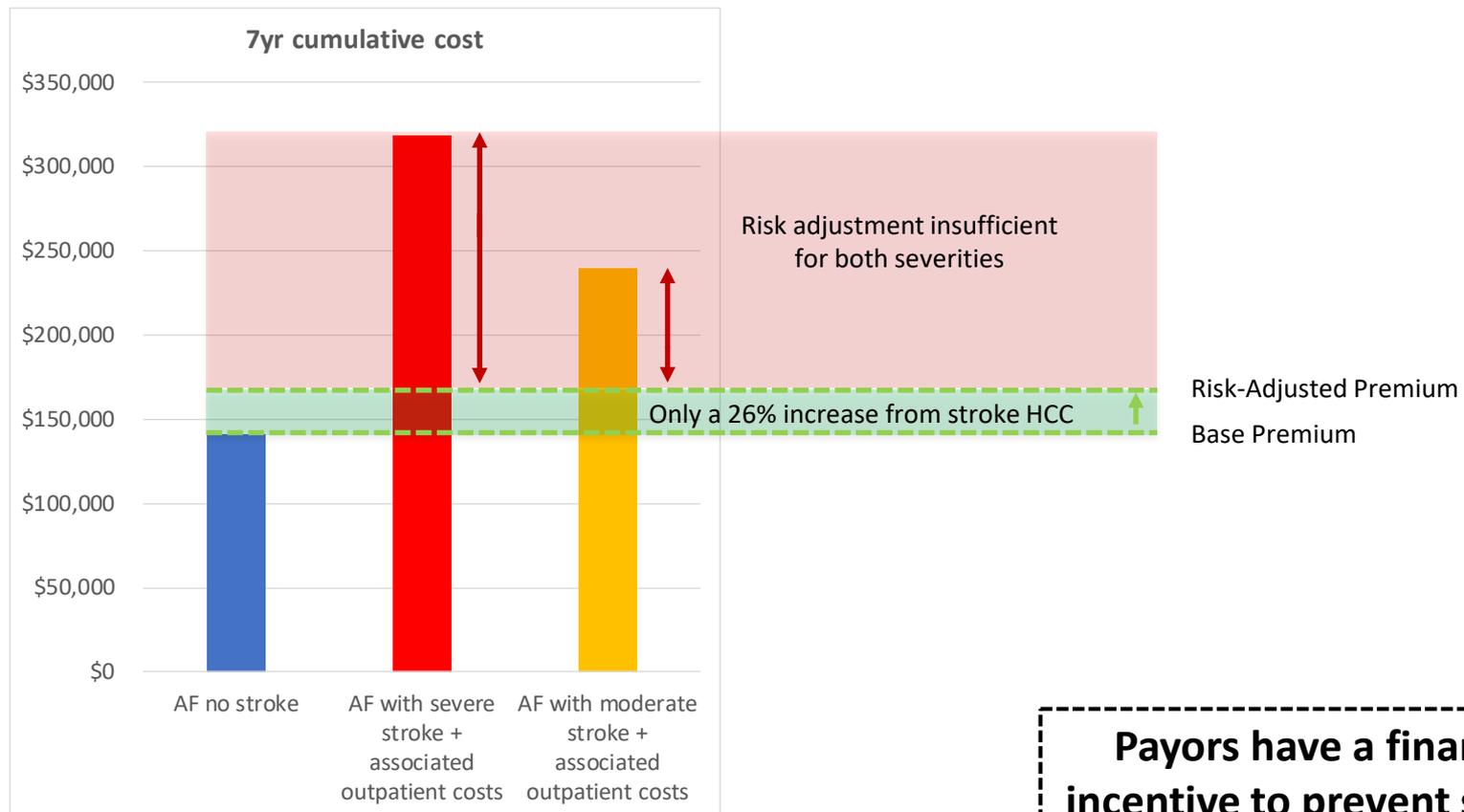
2019 HCC risk factors

Female 70-74 year-old	0.388	} Additive HCCs
HCC96 Specified Heart Arrhythmia	0.269	
HCC100 Ischemic or Unspecified Stroke	0.258	
HCC19 Diabetes with Chronic Complications	0.305	
HCC85 Congestive Heart Disease	0.337	+ Disease interactions
Diabetes + CHF	0.119	
Total HCC score	1.676	



RISK-ADJUSTED PREMIUMS ARE INSUFFICIENT TO COVER STROKE RELATED COSTS

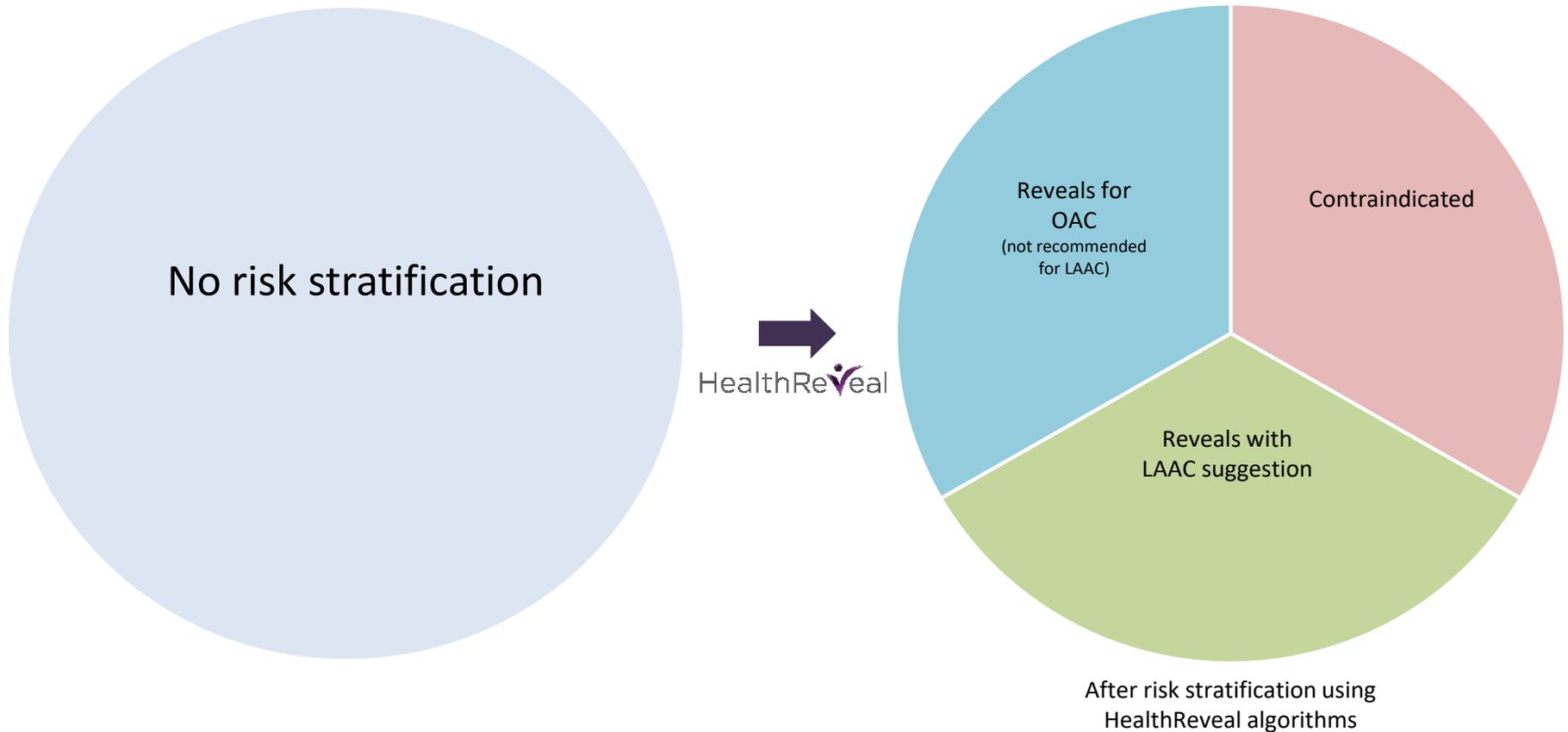
For one NVAF patient by stroke severity



HEALTHREVEAL IDENTIFIES COHORTS (E.G., NON-ADHERENT, HIGHEST-RISK)

Population segmentation has to be done for each cohort of NVAF patients

AF Patient Cohort



HEALTHREVEAL SOLUTION

- <https://vimeo.com/287444515>



ANALYTICS AT HEALTHREVEAL

Useful lessons

1. Data ingest pipeline important
2. Use the right tools for the right kind of data
3. ML can be used to impute missing data
4. Predictive modeling can enhance risk stratification tools
5. AI and enable and enhance value based medicine



