Smart phones and remote monitoring in preventive cardiology
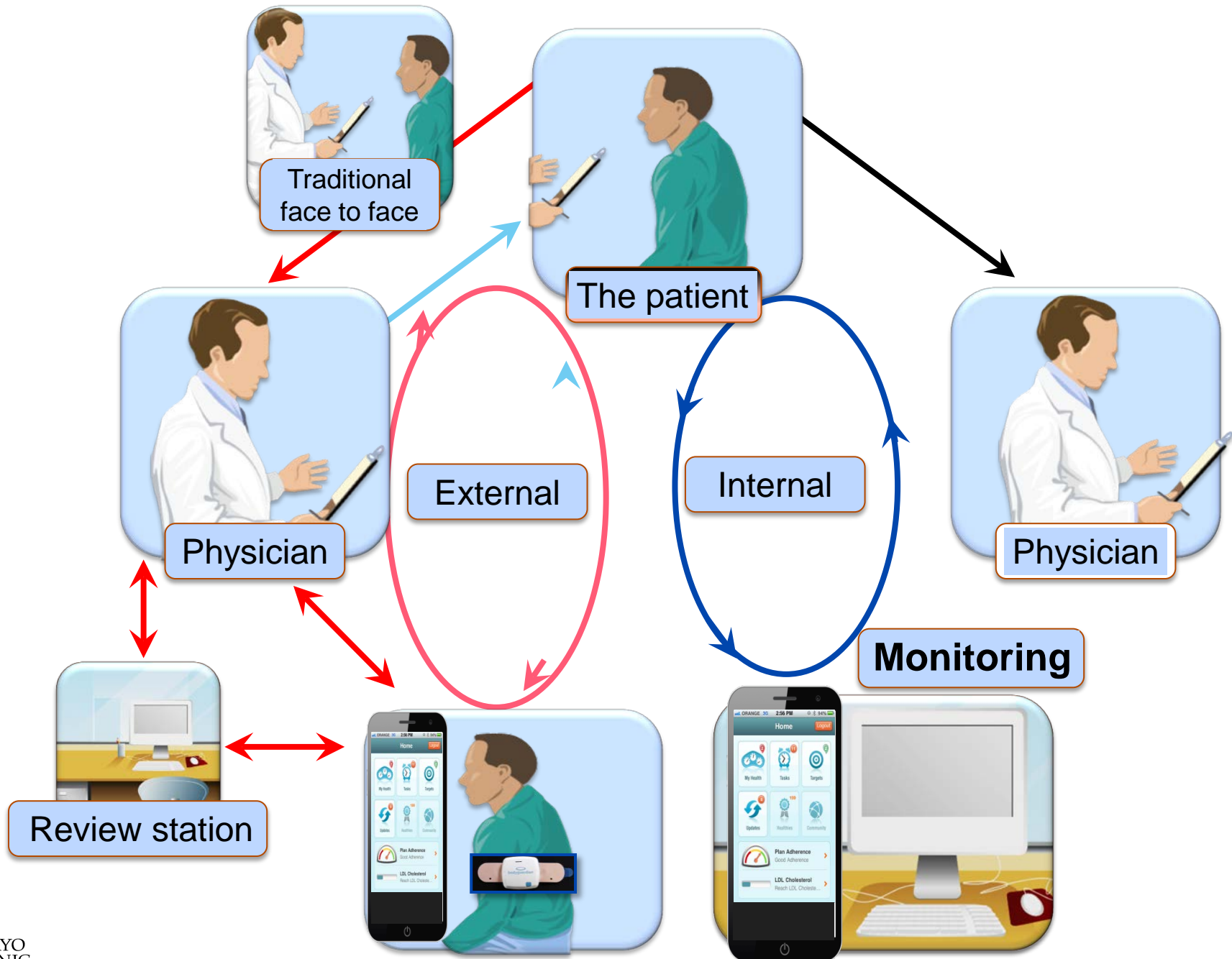
Amir Lerman, MD
Professor of Medicine
Chair for Research
Cardiovascular Division
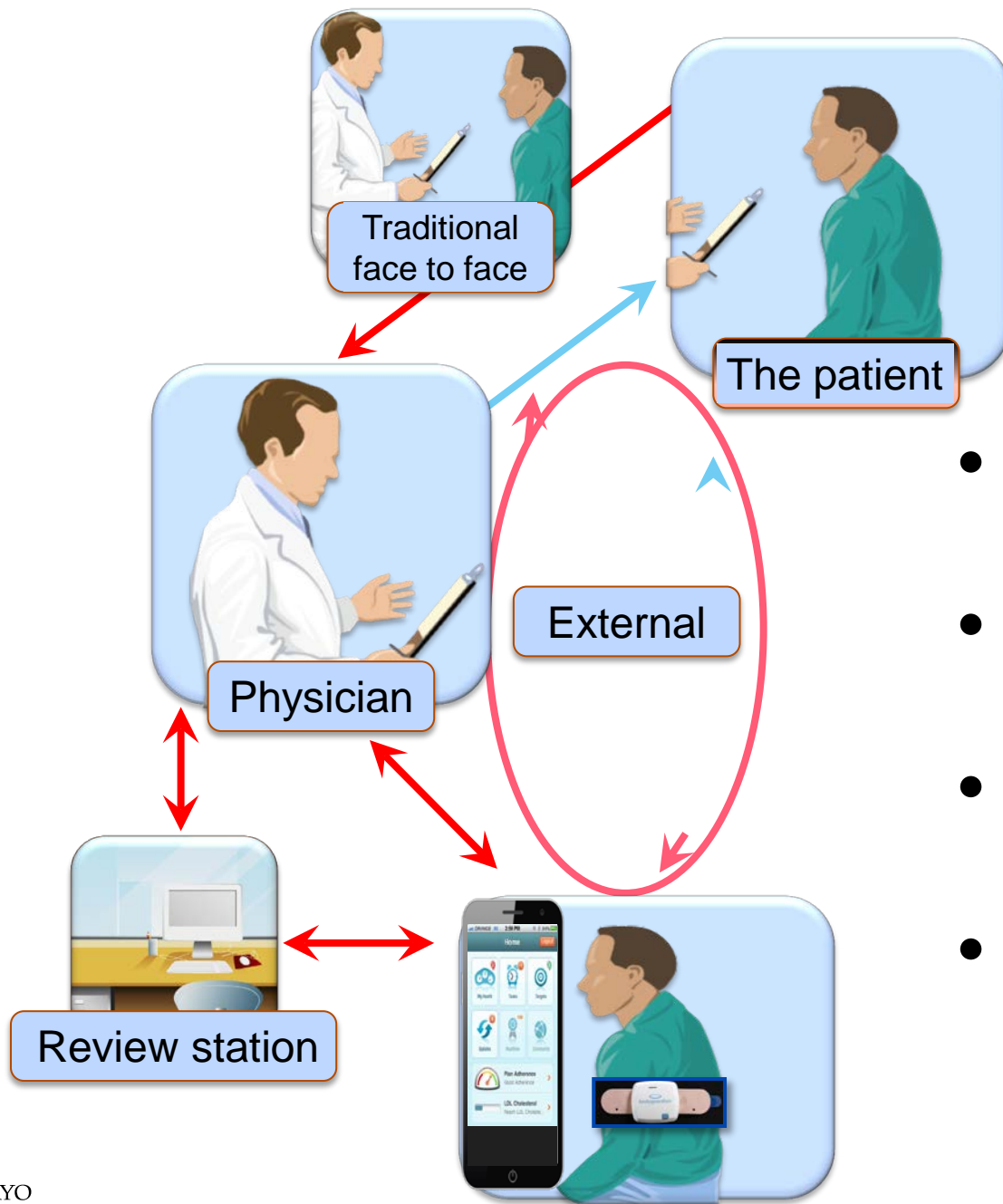Mayo Clinic, Rochester, MN

Future Vision

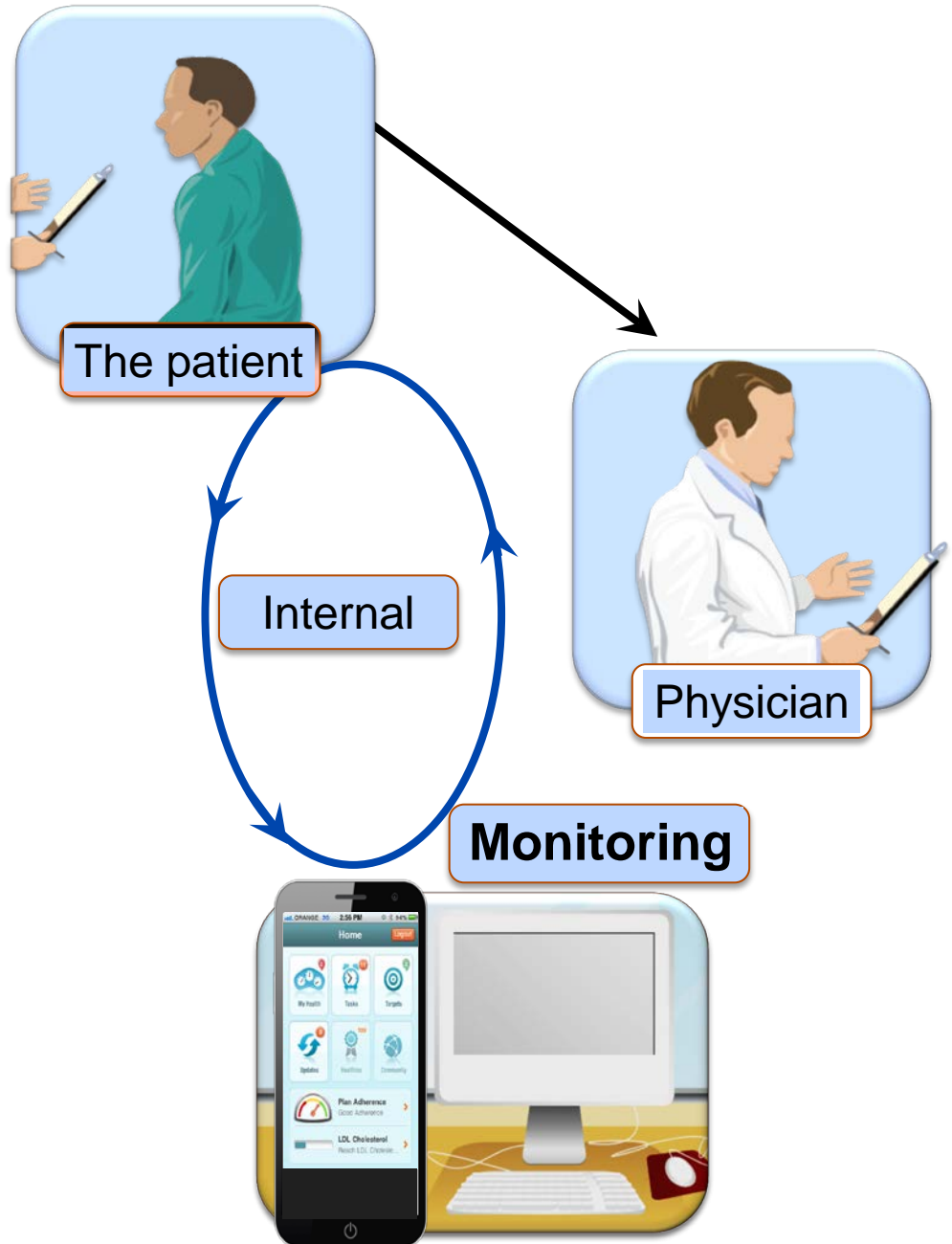- Improve patients' care and global health
- Increase the number of the patients in the Mayo network
- Retain the patients in the system
- Reduce re hospitalization
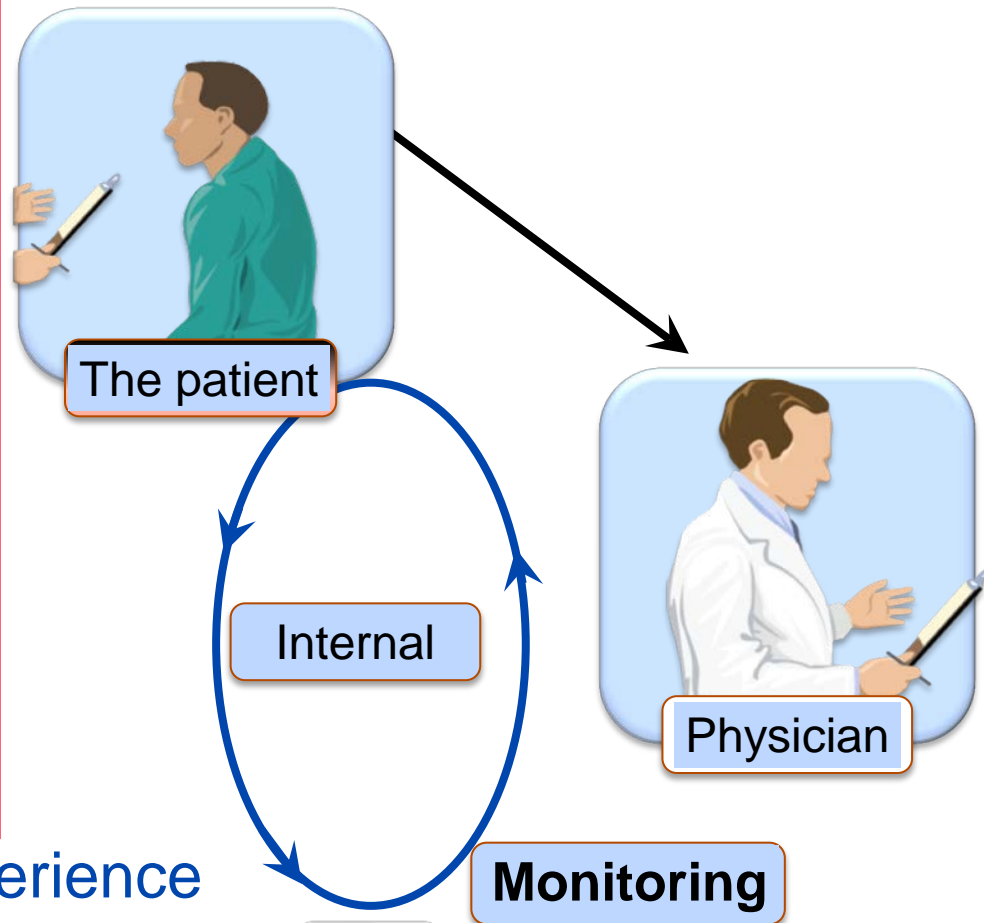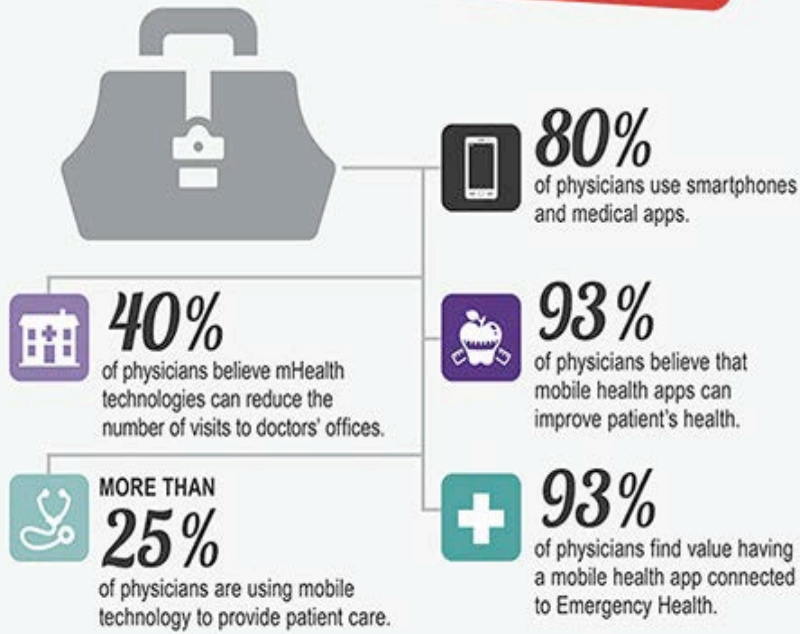
Traditional face to face

The patient

Physician

External

Internal

Physician

Monitoring

Review station

MAYO CLINIC

- Myocardial ischemia

- Arrhythmias

- Heart failure

- FDA apporval

The patient

Internal

Physician

Monitoring

Do Doctors Recommend mHealth Apps?

80% of physicians use smartphones and medical apps.

40% of physicians believe mHealth technologies can reduce the number of visits to doctors' offices.

93% of physicians believe that mobile health apps can improve patient's health.

MORE THAN 25% of physicians are using mobile technology to provide patient care.

93% of physicians find value having a mobile health app connected to Emergency Health.

The patient

Internal

Physician

Monitoring

Digital Impact on Customer Experience

70%

Comfortable communicating with doctors via texting, email, video instead of seeing them in person
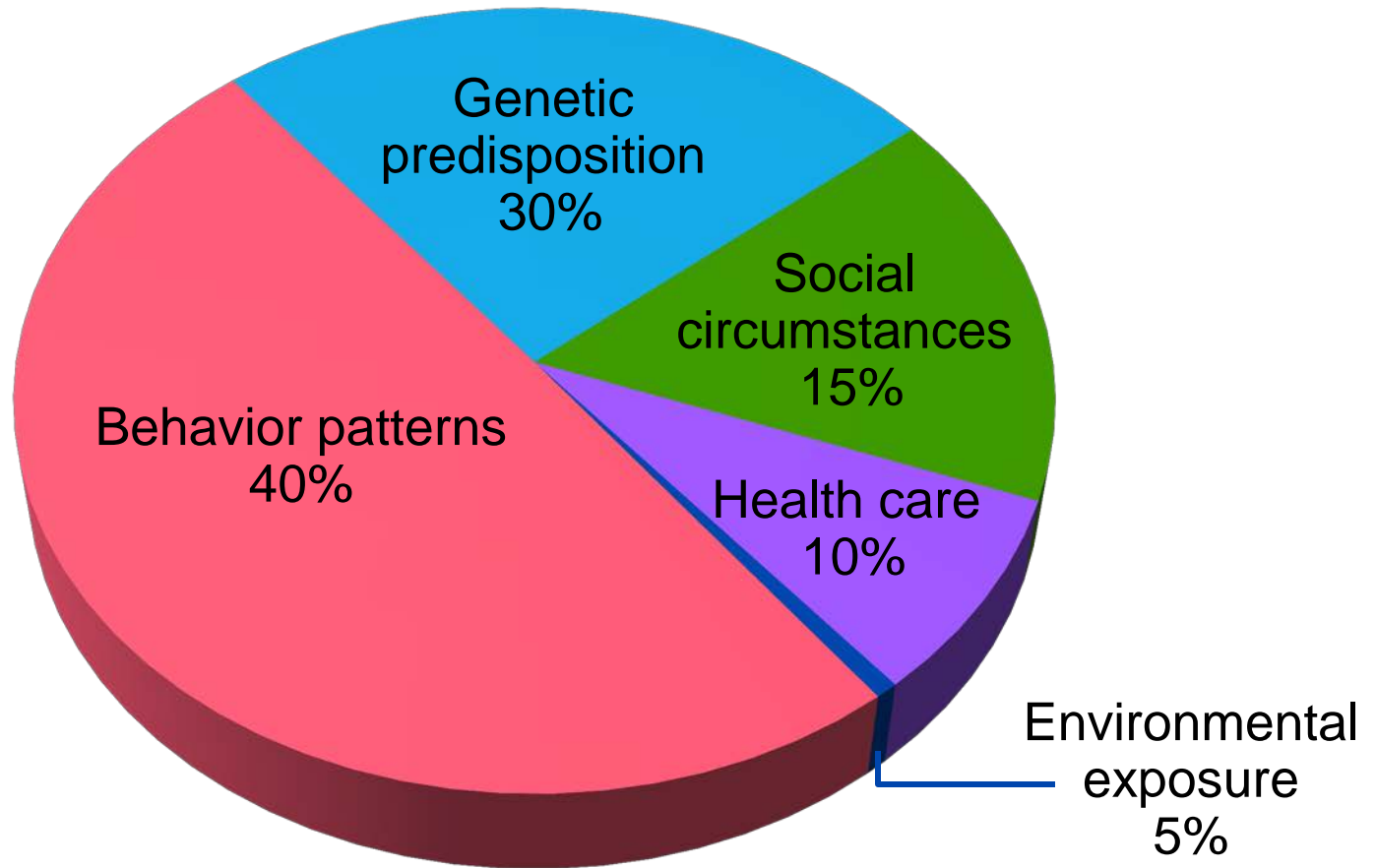
Background Information

- In 2012, 785,000 Americans will have a new acute coronary syndrome, and 470,000 will have a recurrent coronary attack

- Patients who survive acute stage of an MI have a chance of illness and death 1.5 to 15 times higher than that of general population
  - Among these people, risk of another MI, sudden death, AF, HF and stroke – for both men and women – is substantial (FHS, NHLBI)

- Estimated cost of CHD in 2010 - $177.1 billion

- Re-hospitalization rates are 20-50% (PREMIER registry; Can J Cardiol. 2003)
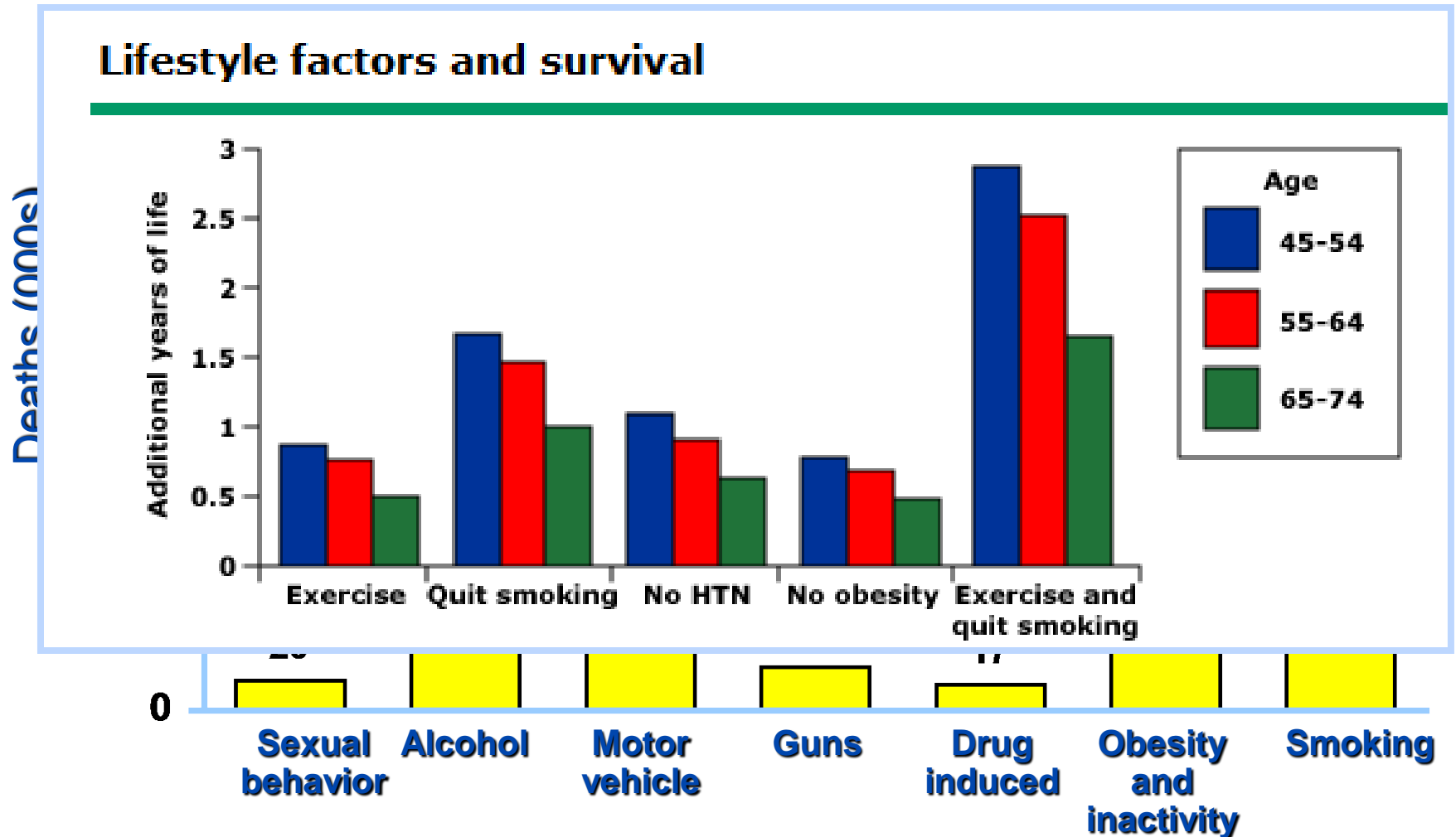 - 24-26% readmission rate at 30 days (JAMA, 2011)

MAYO
CLINIC

Determinants of Health and Their Contribution to Premature Death
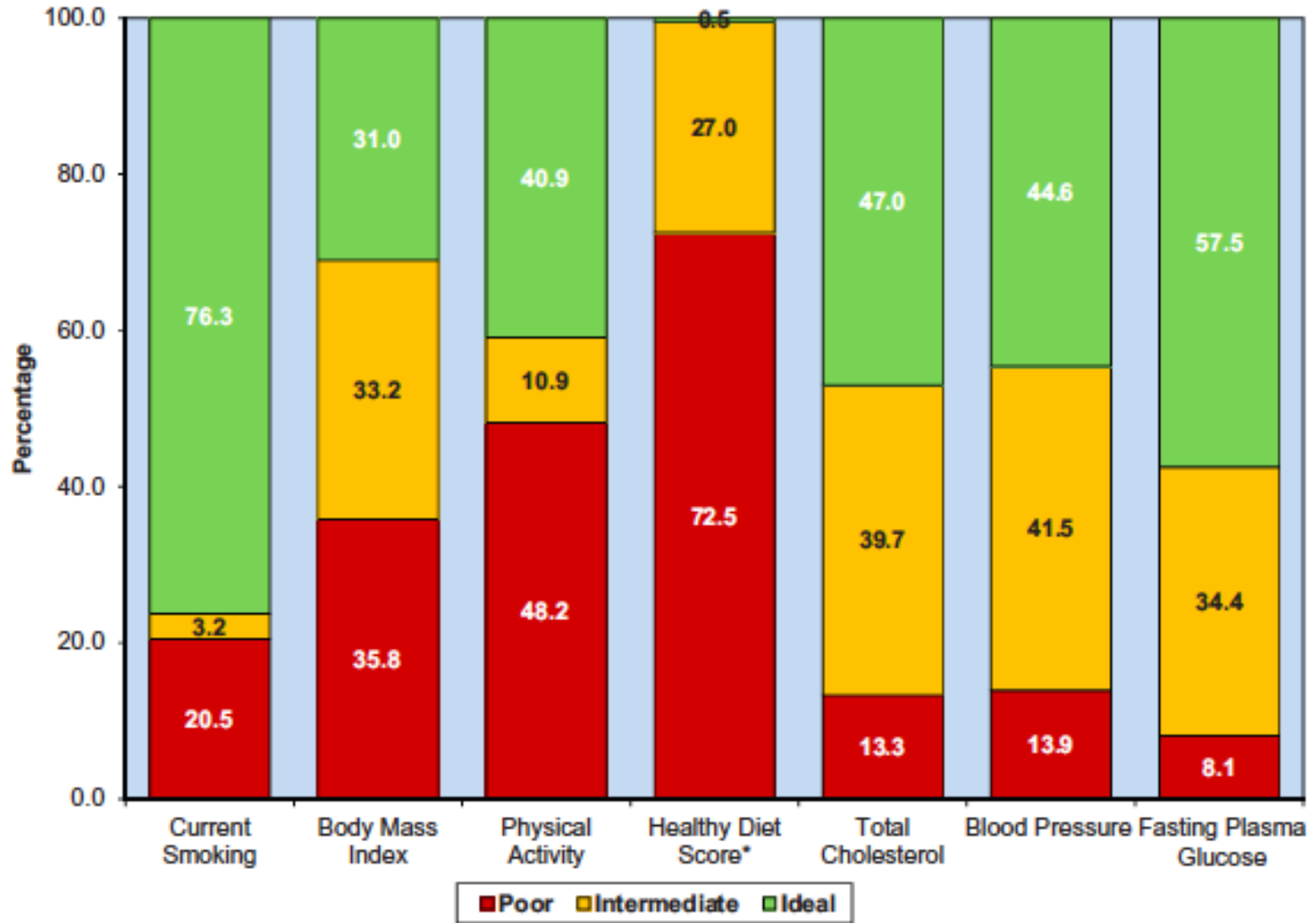## Proportional Contribution to Premature Death

Genetic predisposition 30%

Social circumstances 15%

Behavior patterns 40%

Health care 10%

Environmental exposure 5%

Schroeder: NEJM 357:1221, 2007

MAYO CLINIC

©2013 MFMER | 3301614-8

Numbers of U.S. Deaths from Behavioral Causes – 2000

Lifestyle factors and survival

Deaths (000s)

Sexual behavior | Alcohol | Motor vehicle | Guns | Drug induced | Obesity and inactivity | Smoking

Schroeder SA: NEJM 357:1221, 2007
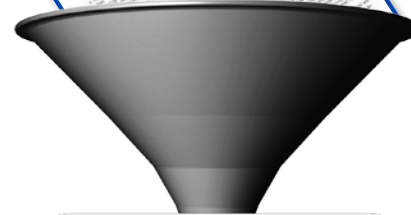
Adherence to AHA 2020 Recommendations

(Go, AS, et al. *Circulation*. 2014)

Self Monitoring Platform
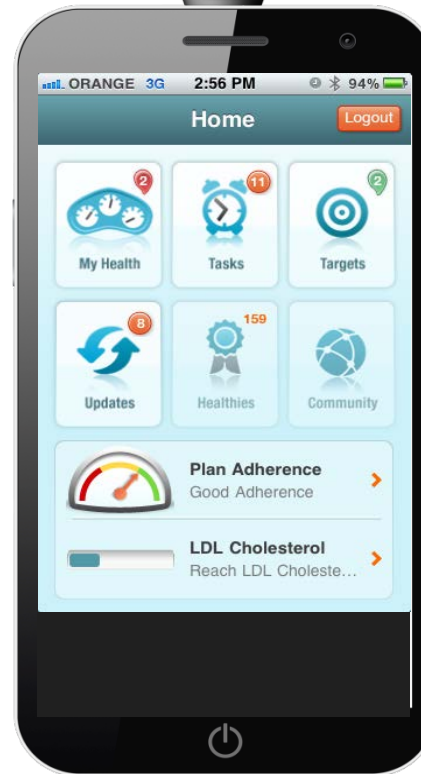
- Primary prevention

- Cardiac rehabilitation post PCI and ACS

The Design of the Application
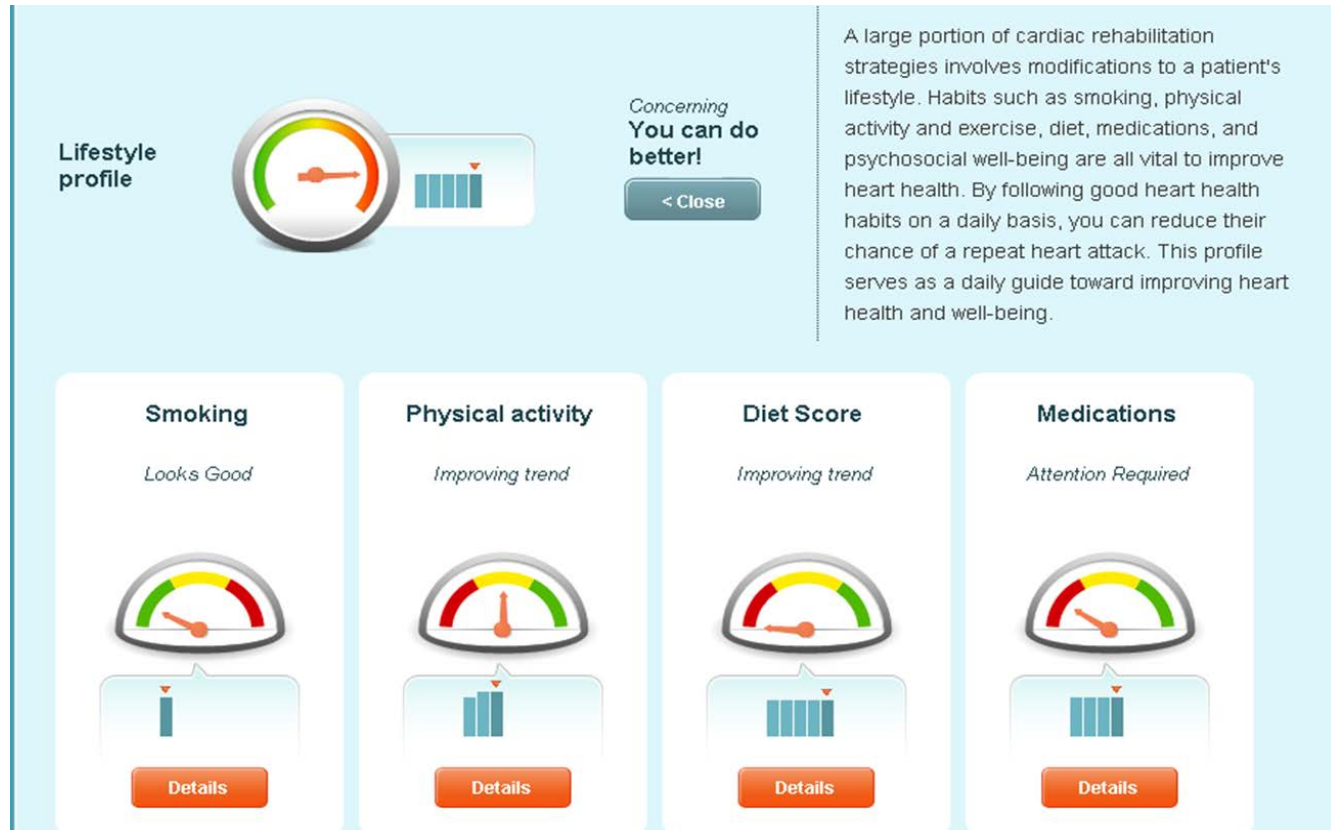
Mayo expertise
Guidelines ACC/AHA/EDC

healarium

Funding: BIRD Foundation

Shared IPs

The Patients
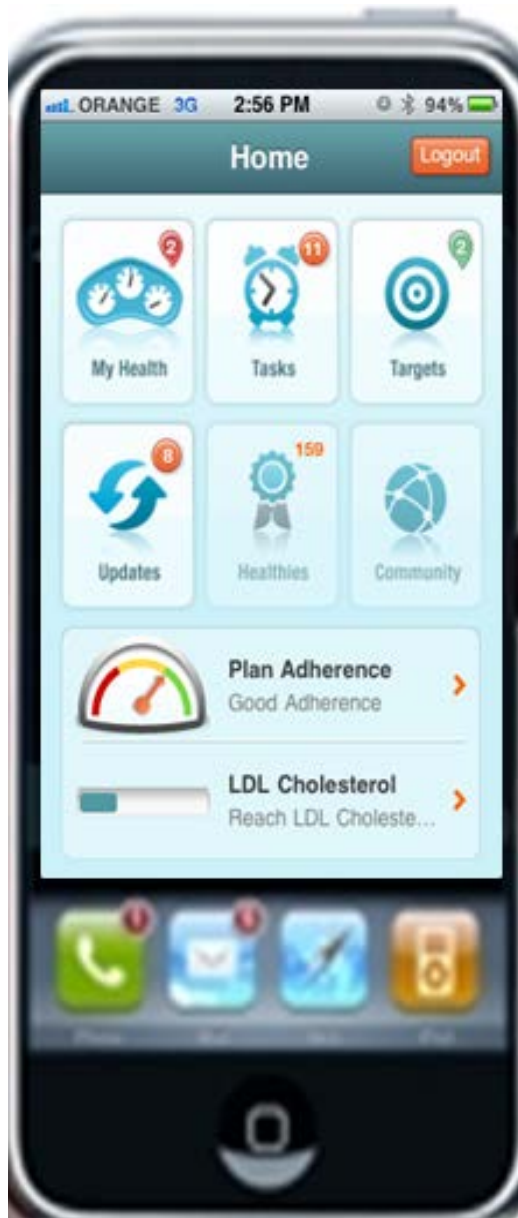
- Health organization
- Large employee

- Reward system
- Social network

Personalized Digital Health Application

Schematic displaying the smartphone (left) and online (right) versions of the cardiac rehabilitation program currently being used in a randomized controlled trial.

Dietary Tasks, example

Primary and Secondary Prevention Studies

Primary prevention:

- One site 500 individuals 3 months follow up
- Multiple sites 37,000 individuals follow up 1 year

Secondary prevention following ACS

- During the 3 months of cardiac rehabilitation

- During the 3 months following completion of the cardiac rehabilitation

Use of Personalized Digital Health in Primary Prevention

- Employer-implemented incentive plan to motivate healthier employees in coordination with CareHere LLC.

- All participants required to complete the following:
  - Biometric screening and questionnaire regarding personal health
  - 90 day follow-up

- Biometric benchmarks met:
  - Assign to Healthy Benefit Plan/eligible for incentive

- Biometric benchmarks not met:
  - Plan of care created with provider and completed through CareHere Connect
  - Return for 90 day follow up

Demographics

Category	Eligible, Completing (n=508)	Excluded (n=772)	Eligible, Not Initiating (n=127)	Eligible, Not Completing (n=201)	Total (n=1608)
Age (yrs)	46.5±11.1	42.2±12.0	46.1±11.2	46.0±12.5	44.3±11.9
Female	382 (75%)	630 (82%)	91 (72%)	135 (67%)	1238 (77%)
Caucasian	389 (77%)	581 (75%)	95 (75%)	148 (74%)	1213 (75%)
Smokers	3 (0.01%)	5 (0.01%)	30 (24%)	23 (11%)	61 (4%)
Htn Rx	135 (27%)	80 (10%)	26 (20%)	41 (20%)	282 (18%)
DM Rx	25 (5%)	8 (1%)	3 (2%)	5 (3%)	41 (3%)
HLD Rx	39 (8%)	21 (3%)	6 (5%)	10 (5%)	76 (5%)

Widmer, et al. *Am H J.* 2013.

Using an online, personalized program reduces cardiovascular risk factor profiles in a motivated, adherent population of participants

R. J. Widmer, MD, PhD,[a] Thomas G. Allison, PhD,[a] Brendie Keane, RN,[c] Anthony Dallas, MD,[c] Lilach O. Lerman, MD, PhD,[b] and Amir Lerman, MD[a] *Rochester, MN and Nashville, TN*

Methods: A cohort of employees in Tennessee was subjected to a health risk assessment at baseline. Those who did not meet all 5 healthy benchmarks – body mass index, blood pressure, glucose, total cholesterol and smoking status – were prospectively assigned to a web-based personal health assistant and had repeat measurements taken at 90 days

Schematic displaying the smartphone (B) and online (A) versions of the cardiac rehabilitation program currently being used in a randomized controlled trial.
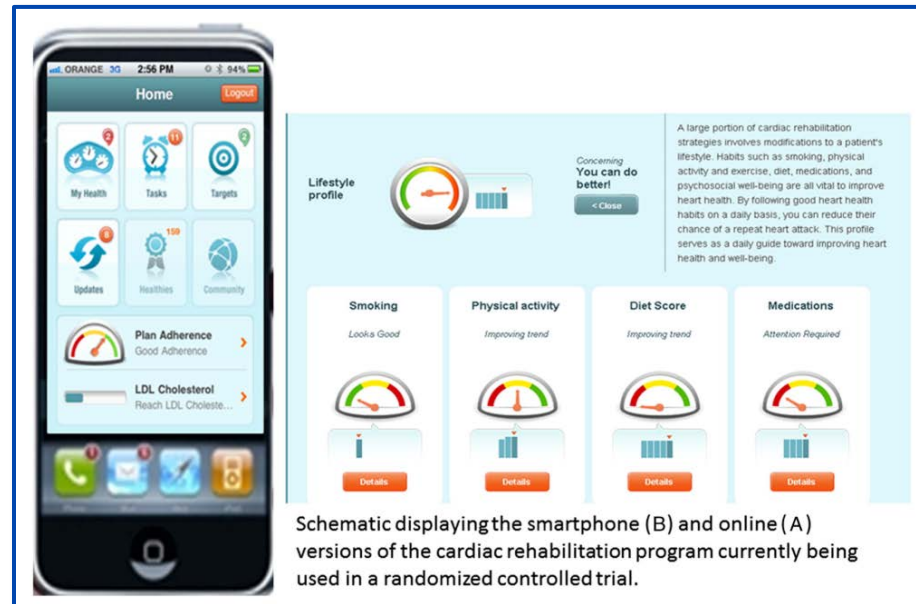
Reductions in Raw FRS (left) and Converted FRS 10-year cardiovascular risk percentage (right)
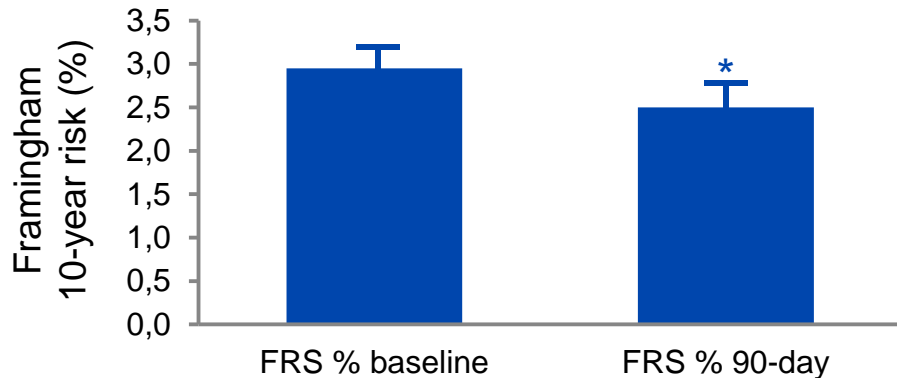
Percent Change from Baseline in Risk Factors After Completing the Online PHA
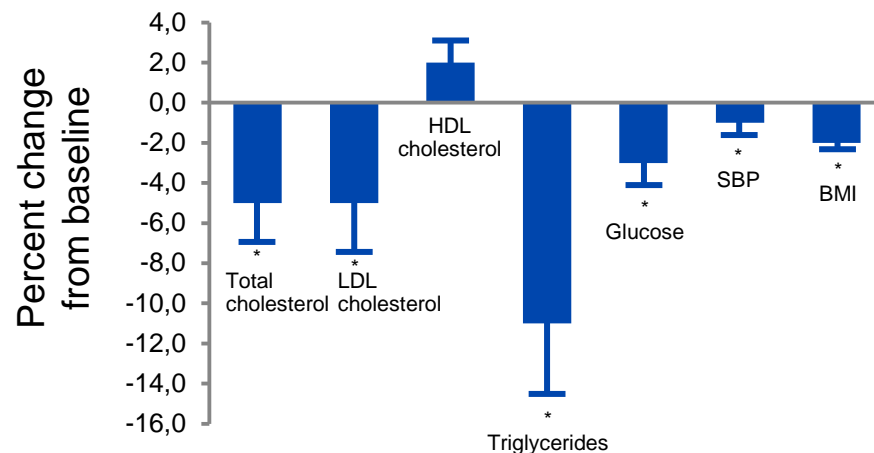
Use of Personalized Digital Health in Primary Prevention: multi center study

- To prospectively follow a large cohort of employees across multiple employers in an effort to

  1) Validate the previously studies DHI in a larger population

  2) Study potential factors associated with patterns in adherence or success in reducing CVD risk factors with this particular WHP DHI.

Study design

30,974 Participants Enrolled

16,802 Users

14,173 Non-Users

14,304 Logged in < 26 times (twice monthly)

2,381 Logged in > 26 times (twice monthly)

One year follow up
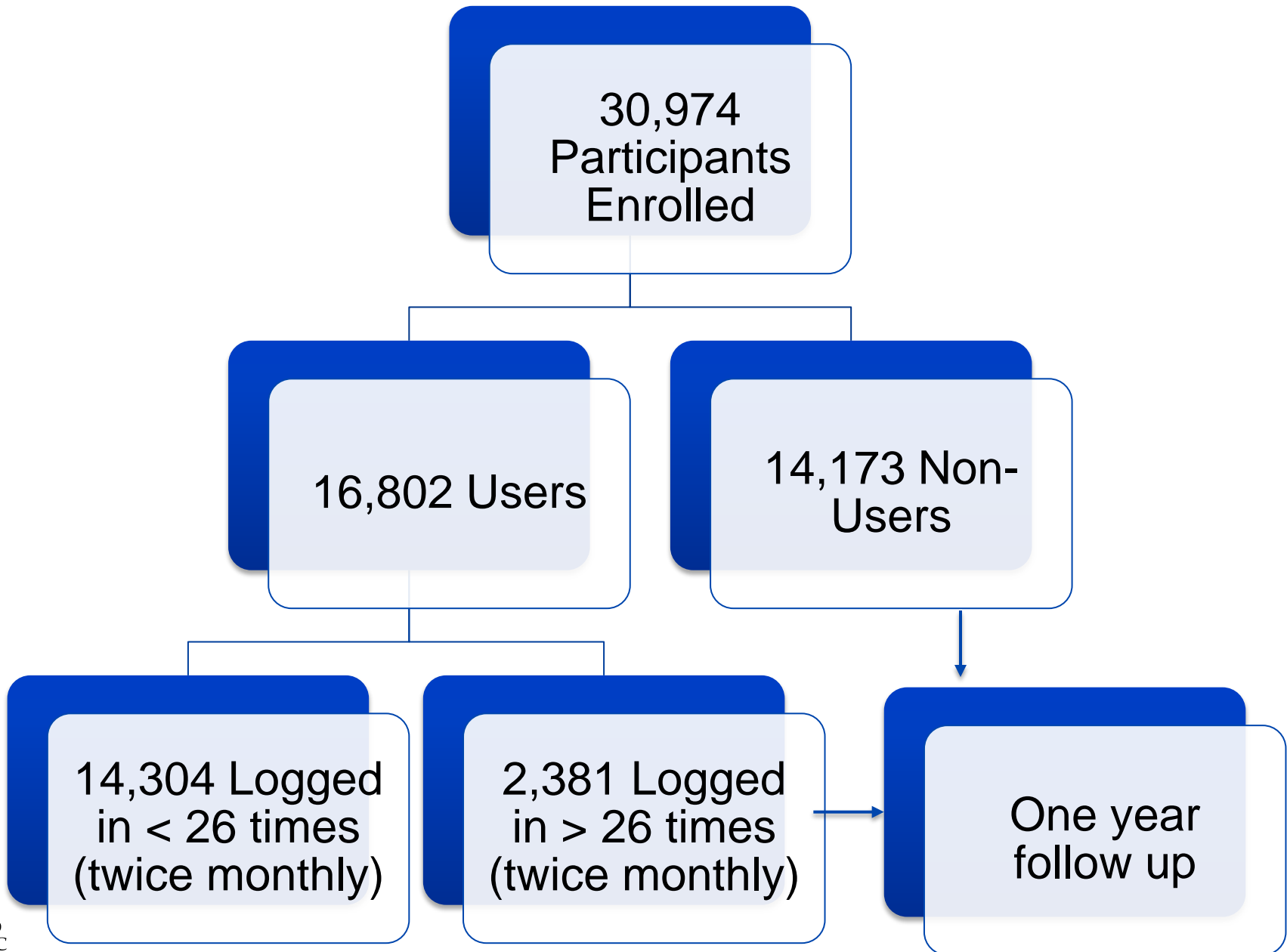
Category	Non-Participant (n=14,173)	Low-Participant (n=14,304)	High-Participant (n=2,381)	Total
Age (yrs)	47.7± 12.2	48.4± 11.2	48.1± 11.3	48.1± 11.7
Weight (lbs)	196.3± 50.0	198.8± 50.9	195.8+ 49.2	197.4± 50.4
Waist Circ (in)	36.8± 6.2	38.0± 6.5	37.6+ 6.3	37.4± 6.4
BMI (kg/m^2)	30.1± 6.7	31.2± 7.1	30.7+ 6.7	30.7± 6.9
Systolic BP (mmHg)	123.6± 14.5	123.3± 14.0	122.6± 13.3	123.4± 14.2
Diastolic BP (mmHg)	77.7± 9.7	77.8± 9.2	77.7± 9.0	77.8± 9.4
Triglycerides (mg/dL)	130.8± 80.2	139.4± 81.5	135.0± 75.9	134.7± 80.6
LDL (mg/dL)	111.2± 32.0	111.9± 32.5	110.5± 32.1	111.5± 32.3
HDL (mg/dL)	52.2± 15.0	51.7± 15.0	52.0± 14.5	52.0± 15.0
Glucose (mg/dL)	98.8± 27.4	101.0± 29.5	101.2± 29.7	99.9± 28.5
HbA1C (%)	6.6± 1.6	6.5± 1.5	6.4± 1.5	6.5± 1.6

Change from baseline after one year

Waist Circumference (in)

HDL Cholesterol (mg/dL)

Triglycerides (mg/dL)

Systolic BP (mmHg)

*

Weight (lbs)

Glucose (mg/dL)

LDL Cholesterol (mg/dL)

*

■ Non-Users

■ Low-Frequency Users

■ High-Frequency Users

©2013 MFMER | 3310564-23
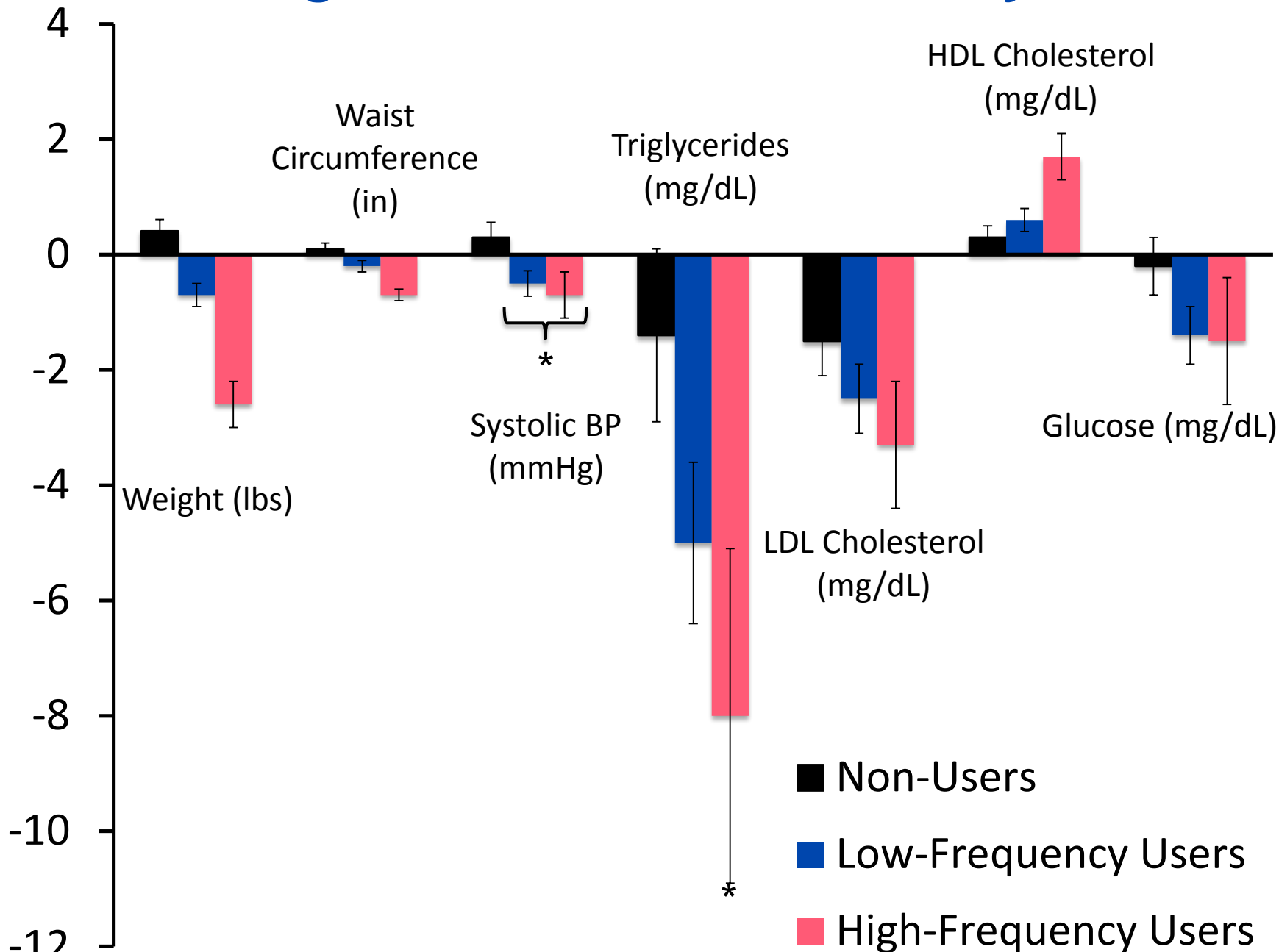
Univariate Analysis For the Prediction of Frequent Users

Term	Estimate	Std Error	t Ratio		Prob>|t|
Gender[Female]	1.0478503	0.12198	8.59		<.0001*
Baseline Weight	0.013892	0.002492	5.58		<.0001*
Age	0.052951	0.009829	5.39		<.0001*
Systolic BP, Baseline	-0.034422	0.008668	-3.97		<.0001*

Primary and Secondary Prevention Studies

Primary prevention:

- One site 500 individuals 3 months follow up
- Multiple sites 37,000 individuals follow up 1 year

Secondary prevention following ACS

- During the 3 months of cardiac rehabilitation

- During the 3 months following completion of the cardiac rehabilitation

Cardiac Rehabilitation and Mortality Impact After PCI

Mayo Clinic Study

- Patients undergoing PCI

- 1994-2008

- CR vs no CR

- 5-year death rates 45% lower for CR participants

- Benefit began in year 1 and persisted
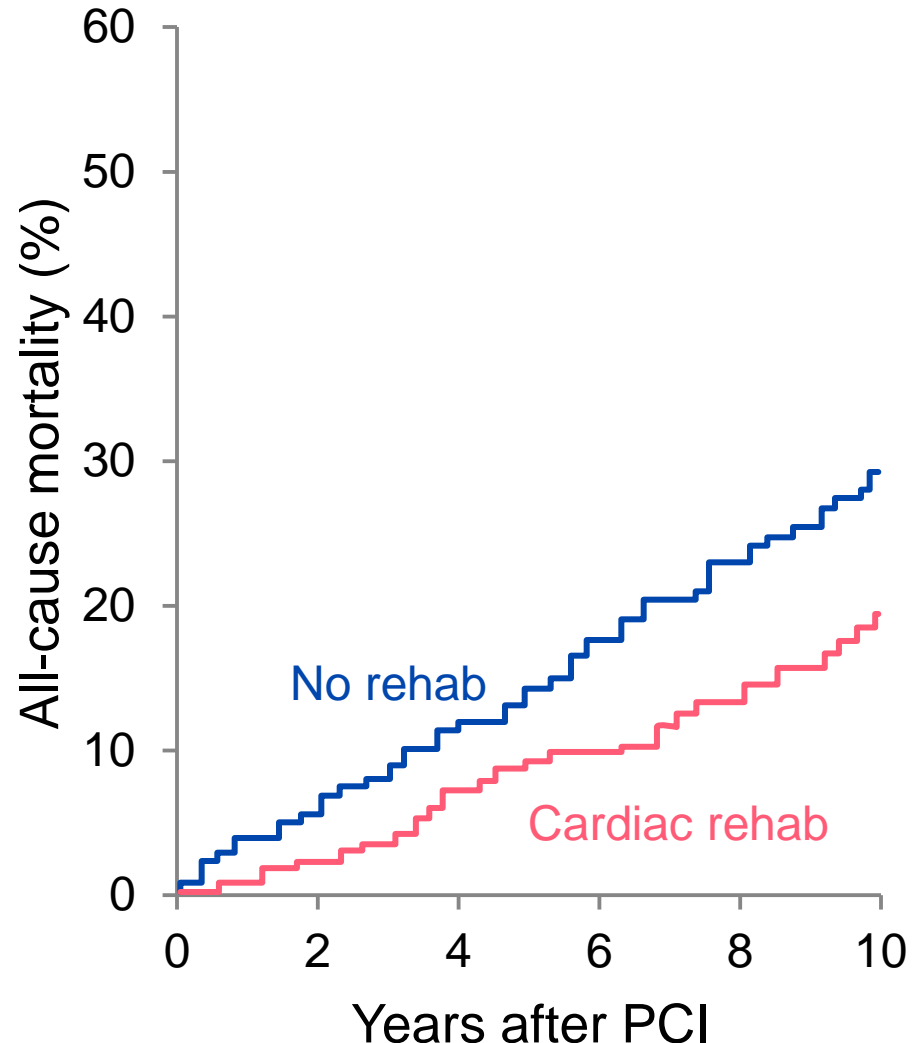
Association between cardiac rehabilitation (CR) participation and mortality matched groups.

Goel K et al. Circulation 2011;123:2344-2352
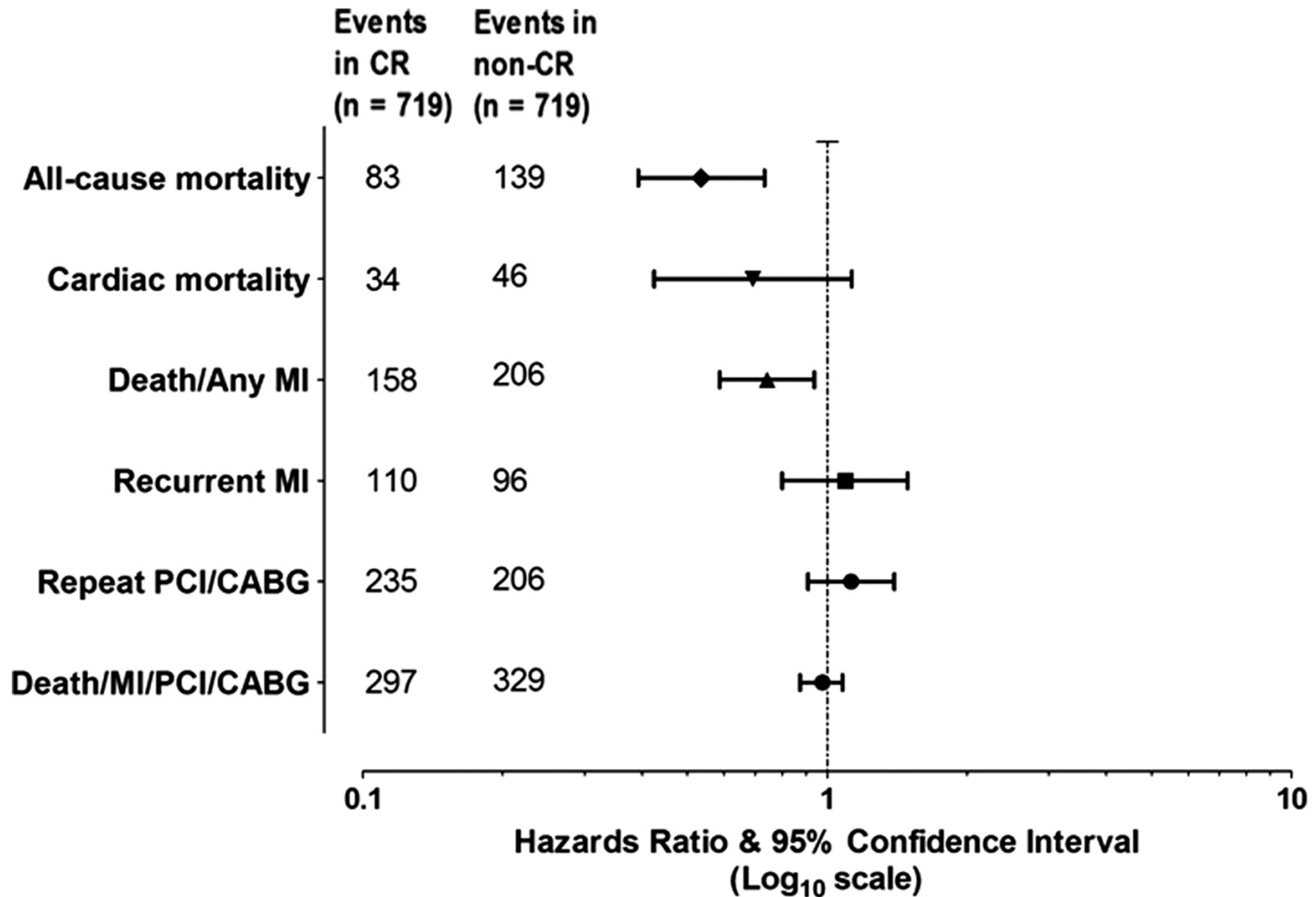
Affordable Care Act (Section 3025) Readmission-Reductions Program

DRGs: CHF, AMI and Pneumonia
Readmission rates exceed calculated average

↓

Financial penalty applied to all Medicare admissions for subsequent year

| 2013 Penalty = 1% | 2014 Penalty = 2% | 2015 Penalty = 3% |

- - - - - - - - - - - - - - - →

COPD; Knee and Hip Replacement
?…and PCI and CABG?

MAYO CLINIC

The Feasibility Design

Patients s/p PCI for ACS

Three Months Mayo Clinic CR

After Three Months Mayo Clinic CR

Usual Mayo Clinic CR (n=25)

Usual Mayo Clinic CR plus PHA-enhanced CR (n=19)

Usual Post-CR Care (n=11)

Usual Post-CR Care plus PHA Intervention (n=17)

Baseline Demographic Data

Category	CR+DHI (n=18)	CR (n=19)	Post CR+DHI (n=17)	Post CR (n=11)
Age, yrs	62.1±10.0	70.4±9.9	66.9±8.3	69.4±10.1
Male	13/18 (72.2%)	17/19 (89%)	11/15 (73%)	6/11 (66%)
*Weight, kg	92.1±17.5	90.7±18.8	95.5±22.9	86.8±19.1
BMI, kg/m^2	30.1±4.6	30.6±5.6	30.4±4.9	29.9±6.3
**Systolic Blood Pressure, mmHg	124.8±12.3	123.6±13.8	127.5±16.6	124.0±16.9
Glucose, mg/dL	121.8±42.4	122.7±42.4	115.9±30.5	102.1±13.0
Total Cholesterol	185.2±44.0	173.8±51.8	167.7±34.3	137.1±33.0
LDL-Cholesterol, mg/dL	105.4±44.8	94.9±41.08	89.5±26.7	69.9±26.0
HDL-Cholesterol, mg/dL	43.8±15.4	51.1±18.9	53.9±23.6	47.5±14.0
Triglycerides, mg/dL	163.3±87.2	185.5±253.9	142.1±135.2	114.3±58.1
Current Smoking	3/18 (17%)	2/19 (11%)	0/14 (0%)	1/11 (11%)

MAYO CLINIC

Use of DHI During CR Resulted in a Reduction in Risk Factor at 3 Months
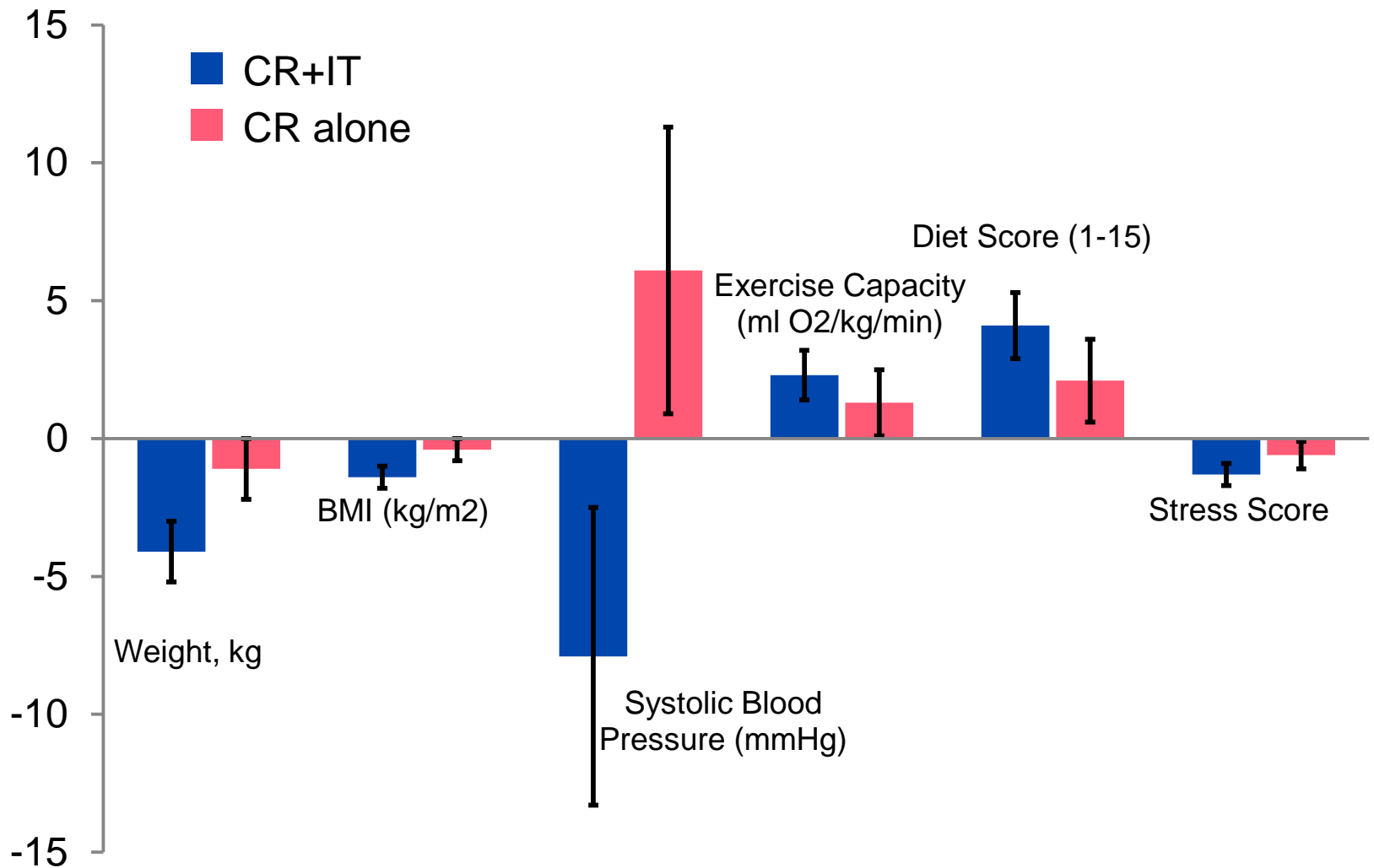
Association Between Change in SBP and Usage Frequency
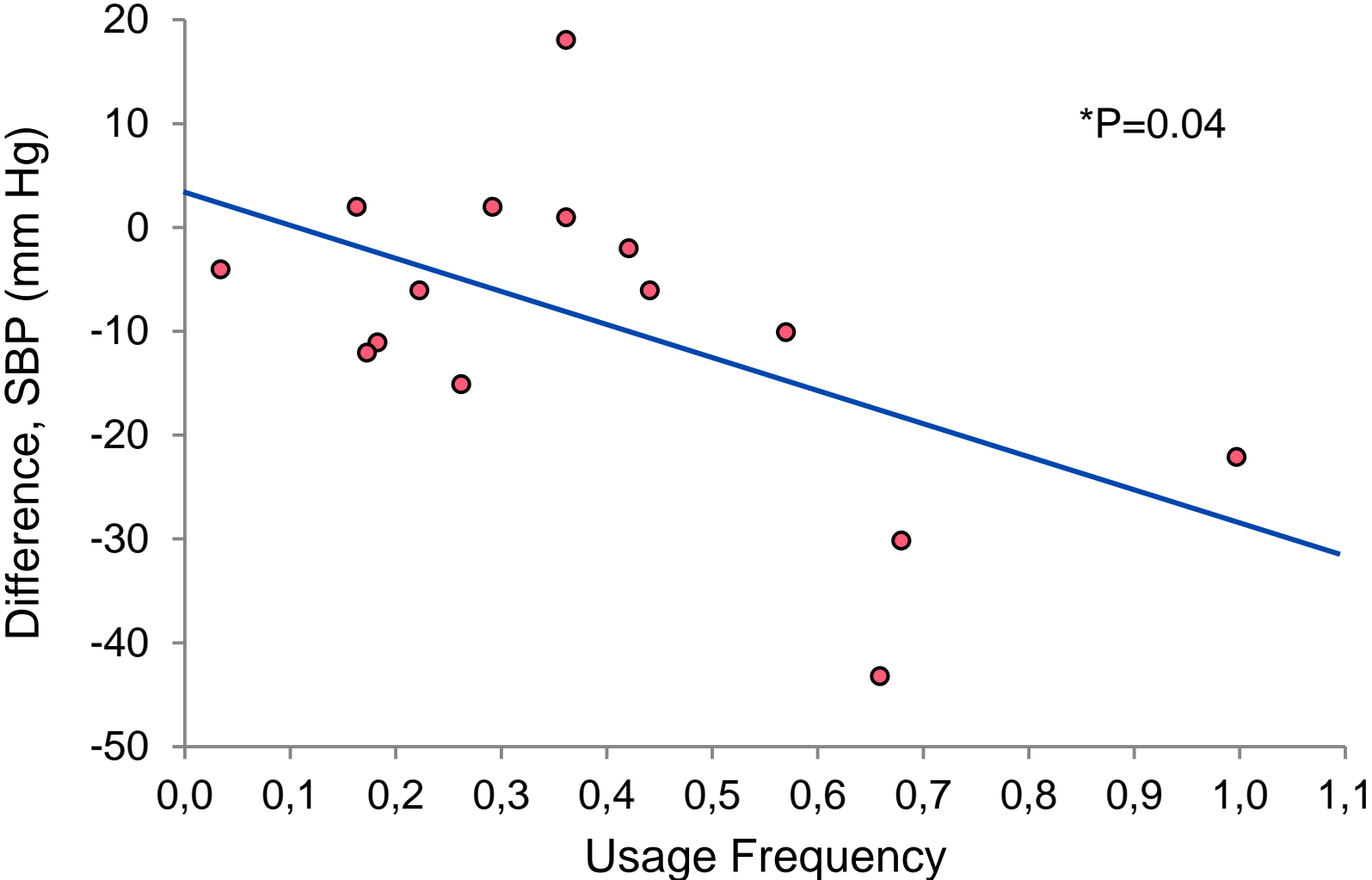
Use of DHI During CR Resulted in a Reduction in Hospitalization at 3 Months

Baseline Demographic Data

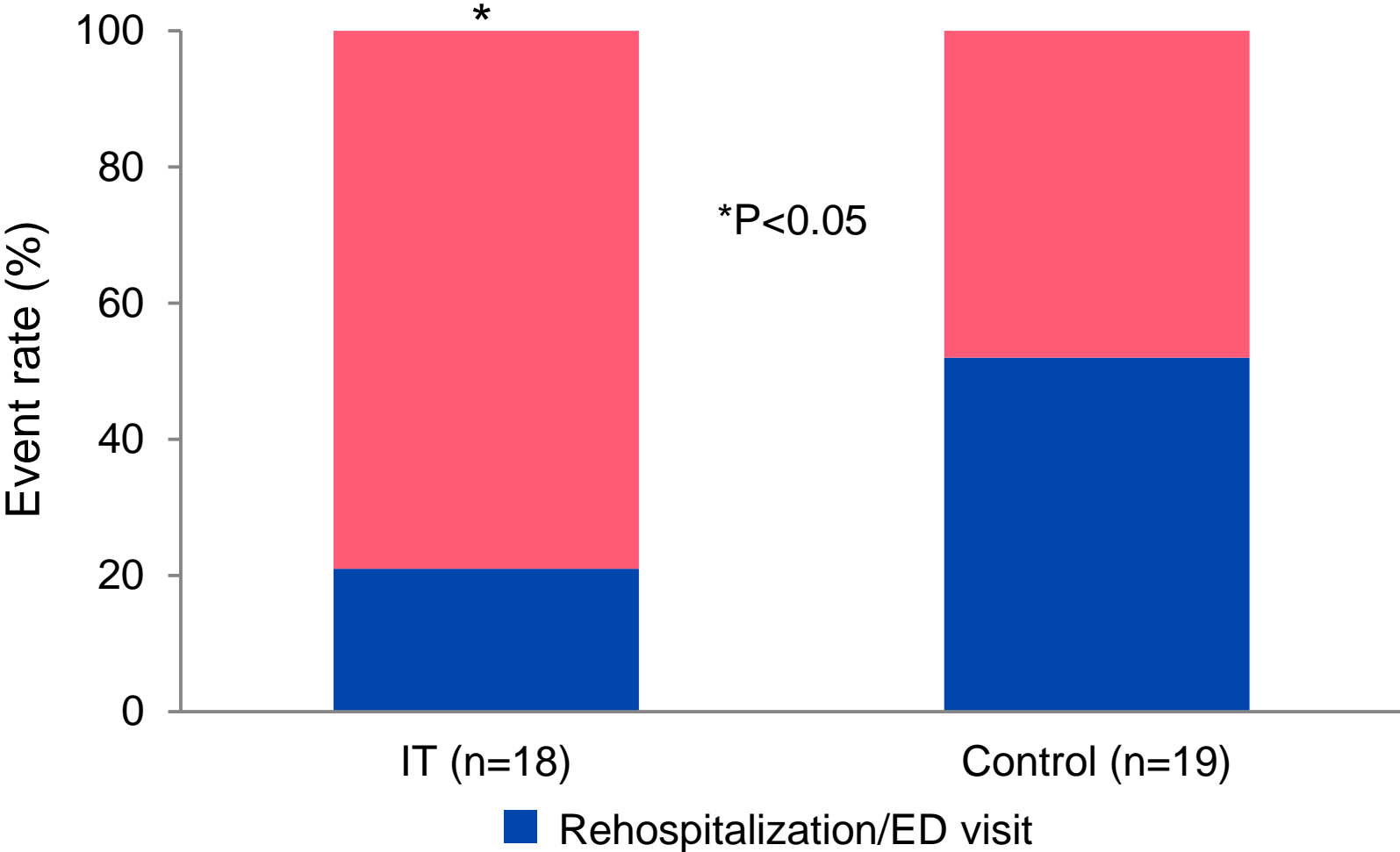| Category	CR+DHI (n=18)	CR (n=19)	Post CR+DHI (n=17)	Post CR (n=11)
Age, yrs	62.1±10.0	70.4±9.9	66.9±8.3	69.4±10.1
Male	13/18 (72.2%)	17/19 (89%)	11/15 (73%)	6/11 (66%)
*Weight, kg	92.1±17.5	90.7±18.8	95.5±22.9	86.8±19.1
BMI, kg/m^2	30.1±4.6	30.6±5.6	30.4±4.9	29.9±6.3
**Systolic Blood Pressure, mmHg	124.8±12.3	123.6±13.8	127.5±16.6	124.0±16.9
Glucose, mg/dL	121.8±42.4	122.7±42.4	115.9±30.5	102.1±13.0
Total Cholesterol	185.2±44.0	173.8±51.8	167.7±34.3	137.1±33.0
LDL-Cholesterol, mg/dL	105.4±44.8	94.9±41.08	89.5±26.7	69.9±26.0
HDL-Cholesterol, mg/dL	43.8±15.4	51.1±18.9	53.9±23.6	47.5±14.0
Triglycerides, mg/dL	163.3±87.2	185.5±253.9	142.1±135.2	114.3±58.1
Current Smoking	3/18 (17%)	2/19 (11%)	0/14 (0%)	1/11 (11%)

Use of DHI for 3 months following CR Resulted in a Reduction in Risk Factor at 6 Months

- ■ Post CR+PHA
- ■ Post CR

Weight, kg

Systolic Blood Pressure (mmHg)

*p<0.05
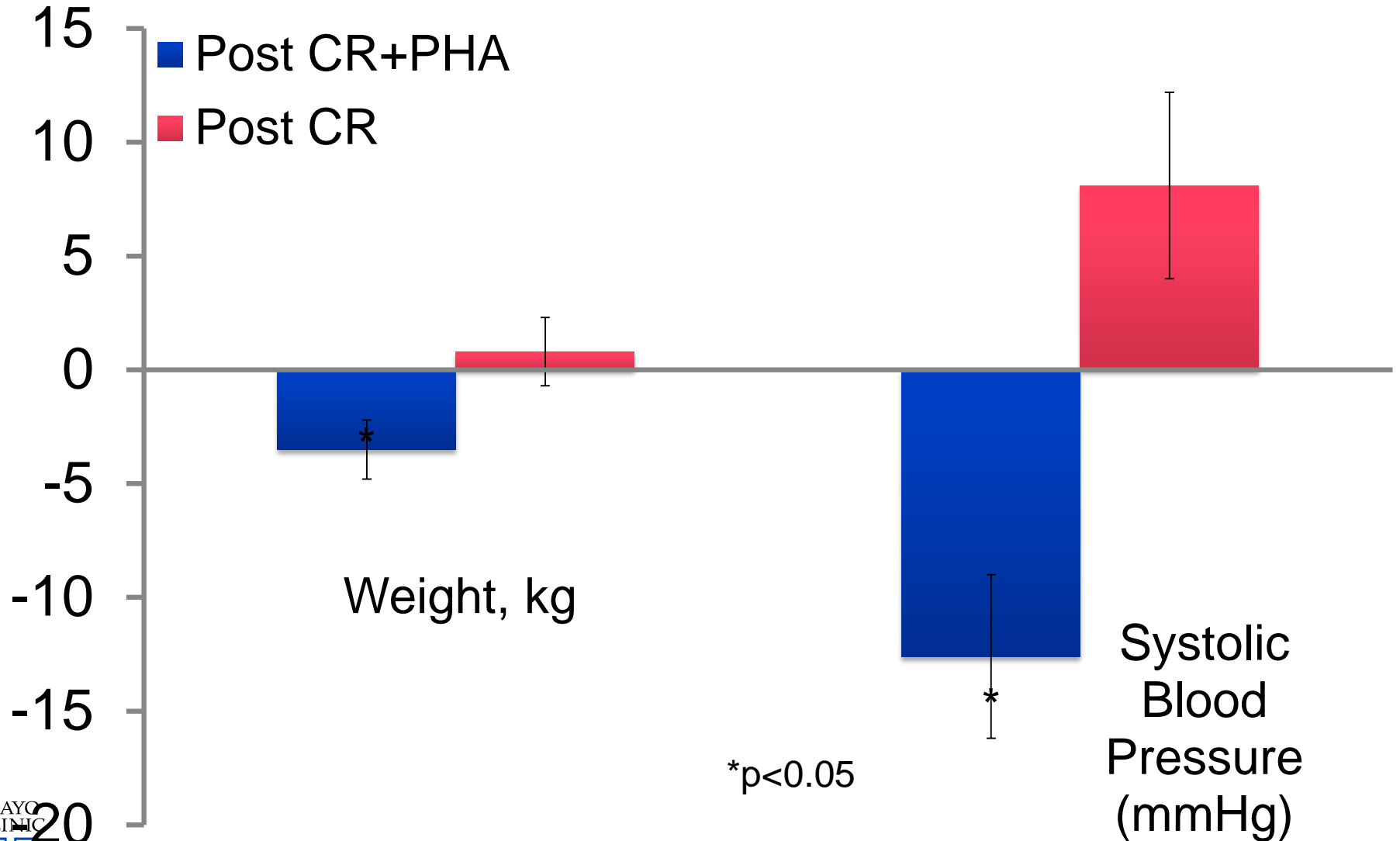
Reduction in Re-hospitalizations/ED Visits 3 months following completing CR
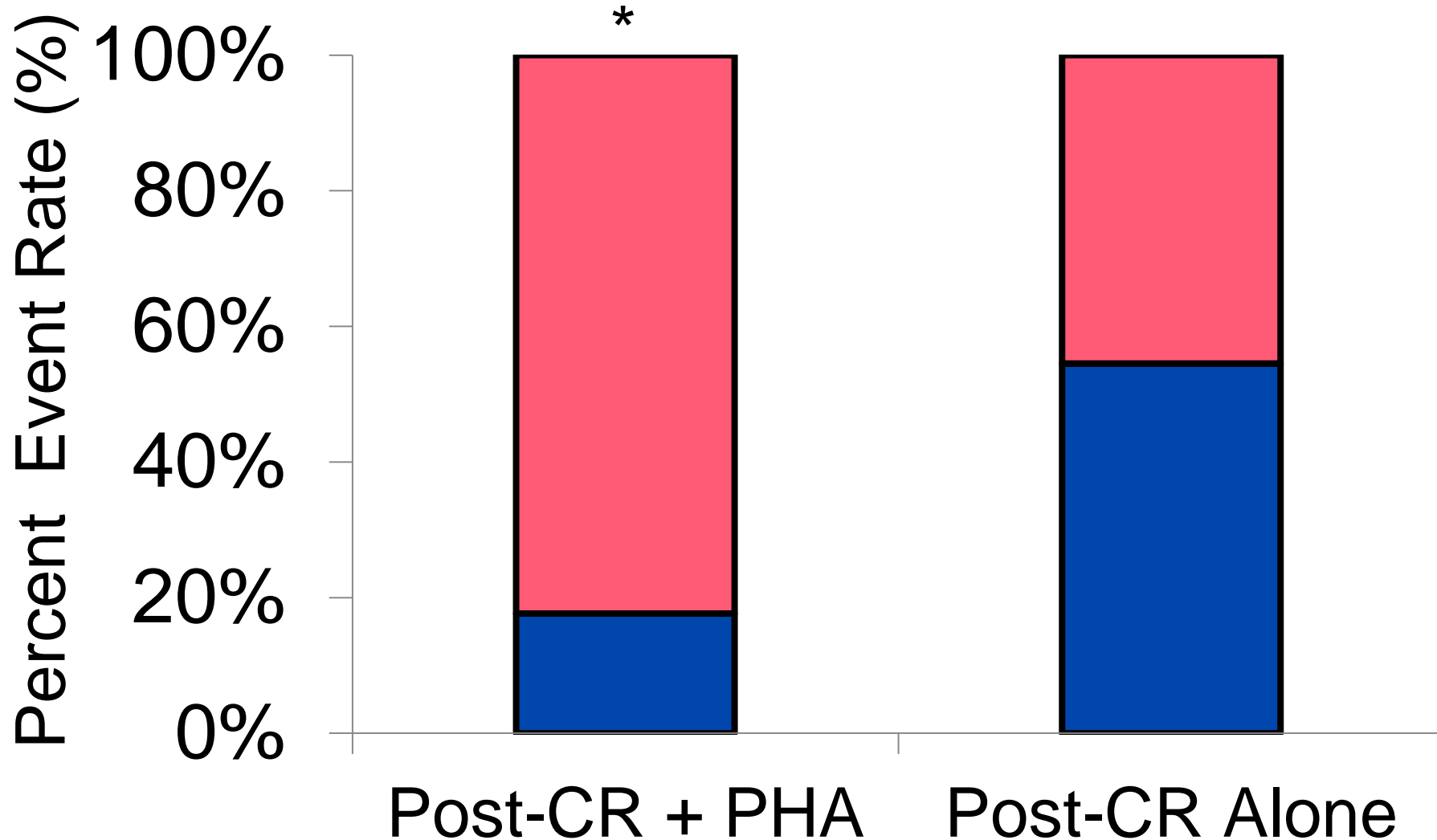
*p=0.04

Use of DHI Resulted in a Reduction in Re-hospitalizations/ ED Visits

Proportion Rehospitalized/ED Visit

*

*

0.0 –

PHA

Log-Rank *p<0.05

Time to Event (days)

CVD Outcomes

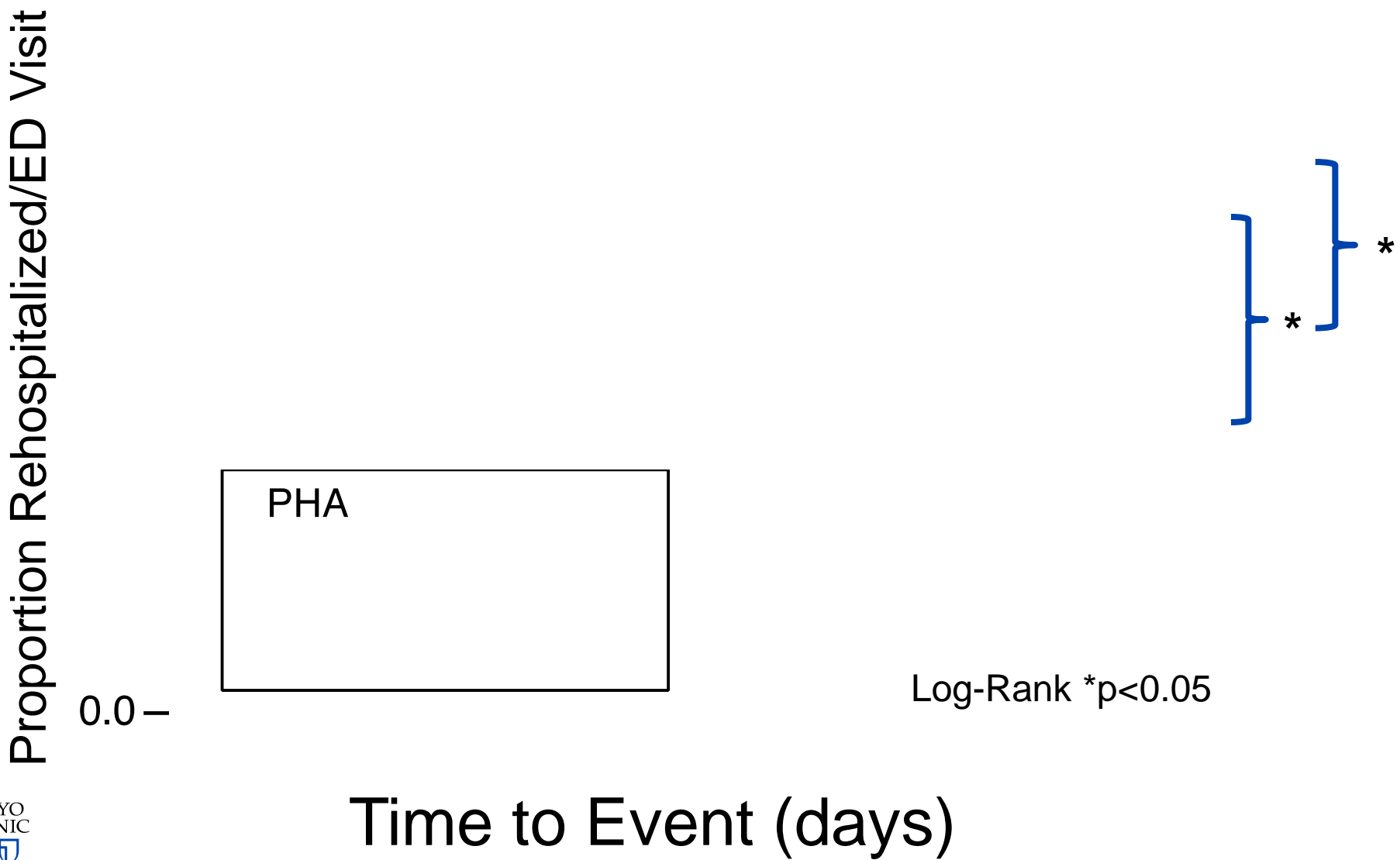| Study or Subgroup	Digital Health Events	Total	Usual Care Events	Total	Weight	Risk Ratio IV, Random, 95% CI
1.1.2 Primary Prevention						
Appel 2011	15	139	15	138	12.8%	0.99 [0.51, 1.95]
Green 2008	10	520	2	258	3.2%	2.48 [0.55, 11.24]
Subtotal (95% CI)		659		396	16.0%	1.21 [0.58, 2.54]
Total events	25		17			

Heterogeneity: Tau² = 0.06; Chi² = 1.18, df = 1 (P = 0.28); I² = 15%
Test for overall effect: Z = 0.51 (P = 0.61)

Study or Subgroup	Events	Total	Events	Total	Weight	Risk Ratio IV, Random, 95% CI
1.1.3 Secondary Prevention						
Blasco 2012	3	102	8	101	4.2%	0.37 [0.10, 1.36]
Frederix 2013	4	40	9	40	5.7%	0.44 [0.15, 1.33]
Reid 2012	4	115	9	108	5.3%	0.42 [0.13, 1.32]
Southard 2003	2	53	8	51	3.2%	0.24 [0.05, 1.08]
Vernooij 2012	32	164	45	166	25.6%	0.72 [0.48, 1.07]
Subtotal (95% CI)		474		466	44.0%	0.60 [0.43, 0.83]
Total events	45		79			

Heterogeneity: Tau² = 0.00; Chi² = 3.42, df = 4 (P = 0.49); I² = 0%
Test for overall effect: Z = 3.04 (P = 0.002)

Study or Subgroup	Events	Total	Events	Total	Weight	Risk Ratio IV, Random, 95% CI
1.1.4 Heart Failure						
Dendale 2012	23	80	48	80	26.3%	0.48 [0.32, 0.71]
Scherr 2009	11	54	18	54	13.7%	0.61 [0.32, 1.17]
Subtotal (95% CI)		134		134	40.0%	0.51 [0.37, 0.71]
Total events	34		66			

Heterogeneity: Tau² = 0.00; Chi² = 0.40, df = 1 (P = 0.53); I² = 0%
Test for overall effect: Z = 3.95 (P < 0.0001)

Study or Subgroup	Events	Total	Events	Total	Weight	Risk Ratio IV, Random, 95% CI
Total (95% CI)		1267		996	100.0%	0.61 [0.46, 0.80]
Total events	104		162			

Heterogeneity: Tau² = 0.04; Chi² = 10.23, df = 8 (P = 0.25); I² = 22%
Test for overall effect: Z = 3.52 (P = 0.0004)
Test for subgroup differences: Chi² = 4.35, df = 2 (P = 0.11), I² = 54.0%

Risk Ratio IV, Random, 95% CI (scale: 0.05, 0.2, 1, 5, 20)
Favours [Digital Health] Favours [Usual Care]
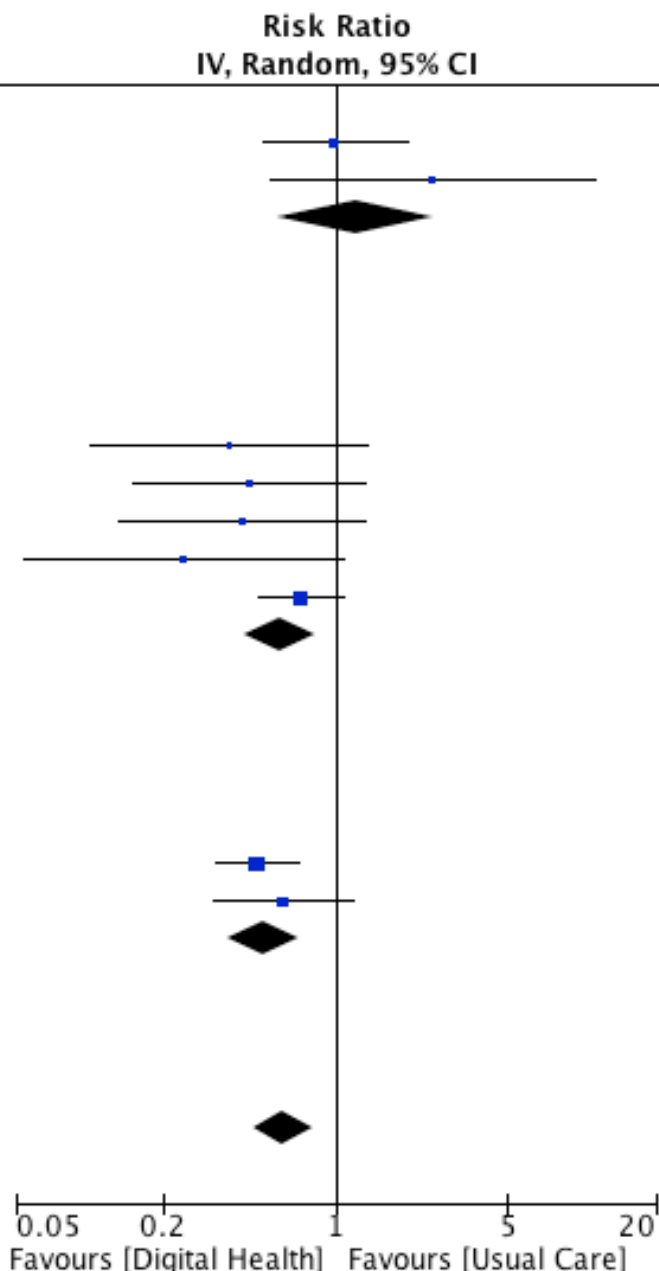
Conclusions

- In primary prevention: A DHI-based can reduce CVD risk factors in a large cohort of community-dwelling employees

- CVD risk factor reduction occurs in a dose-dependent fashion as those with more frequent use displayed significantly more gain

- Secondary prevention: The use of DHI reduces CV risk and re-hospitalization following ACS

71% more likely to have an office visit in which their blood pressure is checked

Studies Show Personalized
Messages and Incentives
Can Positively Influence Behavior

Two new studies from UnitedHealth Group show that personalized health messages and financial rewards can spur people to make positive changes about

31% more likely to get a

Study: Cost of treating diabetes to triple by 2034

By **Caleb Hellerman**, CNN Medical News senior producer
November 27, 2009 1:45 a.m. EST

Video | Comments

Harvard Business Review

www.hbr.org

The ROI data will surprise you, and the softer evidence may inspire you.

What's the Hard Return on Employee Wellness Programs?

by Leonard L. Berry, Ann M. Mirabito, and William B. Baun

MAYO CLINIC
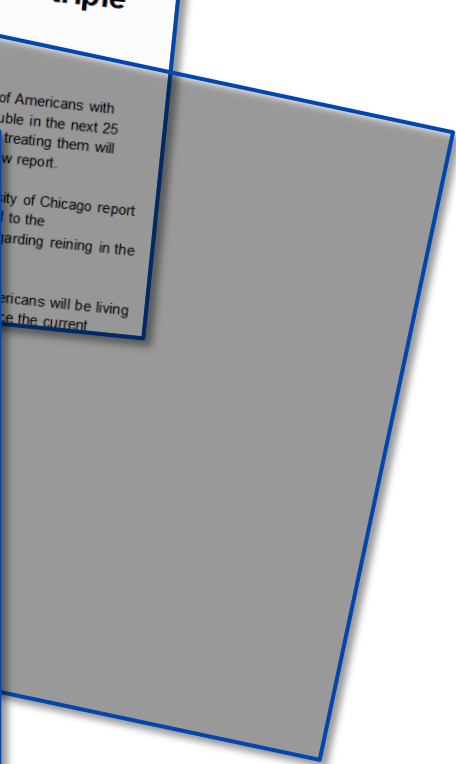
Criteria for a Successful Health Application

- **Evidence/Guideline-Based**
- **User Friendly**
- Incentive-Based
- **Flexible operating platform** – able to be easily modified based on new scientific data and guidelines
- **Interact with Social Media**
- Wide Applicability and Distribution (i.e. smartphones)
- Not dependent on proximity to medical center

keep track of your body's biorhythms")

IMS Institute for Healthcare Informatics, 2013