Reengineering Healthcare Delivery: Optimizing Outcomes in Chronic Disease and Hospital Care

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Our Discussion Today

Reengineering Care Delivery to Manage Chronic Disease

Reengineering Hospital Care to Improve Patient Outcomes

Reengineering Care Delivery to Manage Chronic Disease

- Overview of Global Health Status
- Factors Contributing to Poor Health Outcomes
- Encouraging Positive Behavior Change
- Intervening and Engaging Patients

Reengineering Care Delivery to Manage Chronic Disease

- **Overview of Global Health Status**
- Factors Contributing to Poor Health Outcomes
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Population Health Facts

86% U.S. health care dollars goes to treatment of chronic disease

75% Percentage of deaths in U.S. from chronic disease

#1 Cause of disability in U.S. is chronic disease

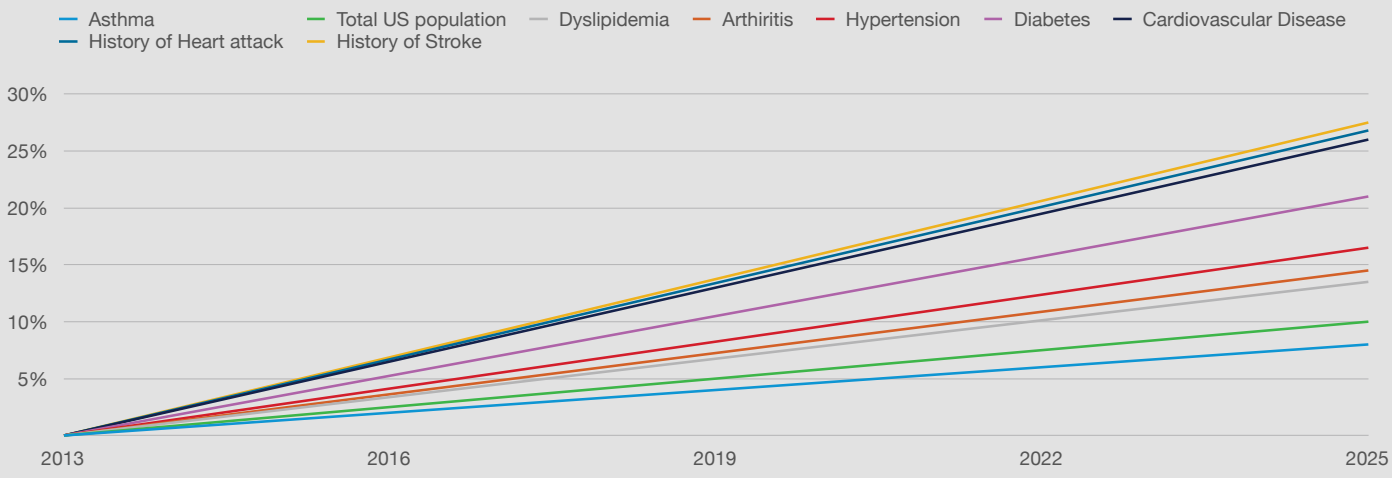
50% Adult Americans with at least one chronic disease

90% Seniors with at least one chronic disease
(77% have 2+ chronic conditions)

Centers for Disease Control and Prevention. http://www.cdc.gov/chronicdisease/index.htm
BMJ 2013;346:f2614. http://transformativehealth.info/a-c-suite-view/patient-engagement-a-strategic-imperative-for-preventing-readmissions/
WHO: http://www.searo.who.int/entity/noncommunicable_diseases/en/
http://www.who.int/nmh/countries/dnk_en.pdf

Projected Growth

Projected growth in population with chronic conditions 2013–2025



Dall TM, et al Health Affairs 2013;32:2013–2020.

Major Causes of Chronic Disease

Health behaviors

- Lack of Physical Activity
- Poor Nutrition
- Tobacco Use
- Excessive Alcohol Consumption

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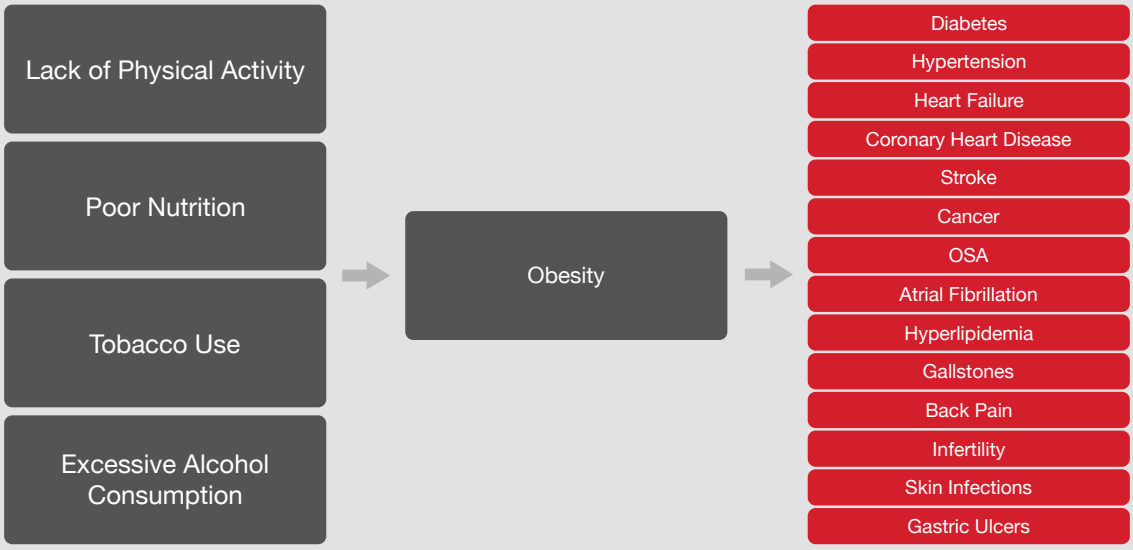

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Management of Chronic Disease Today

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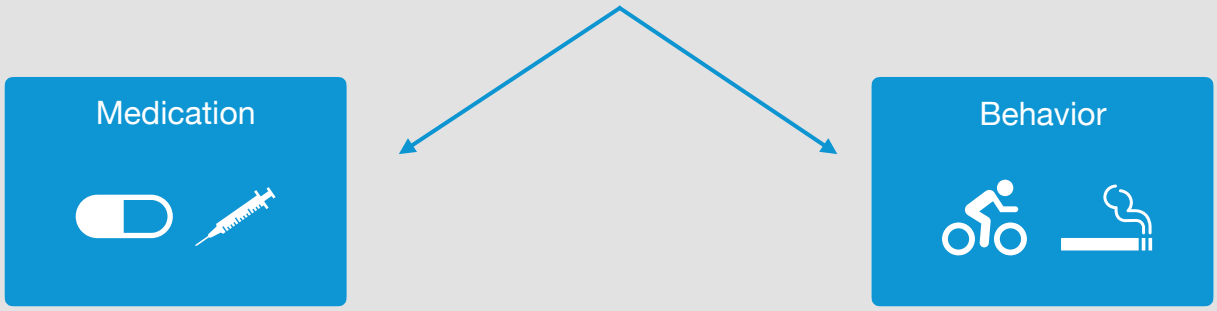
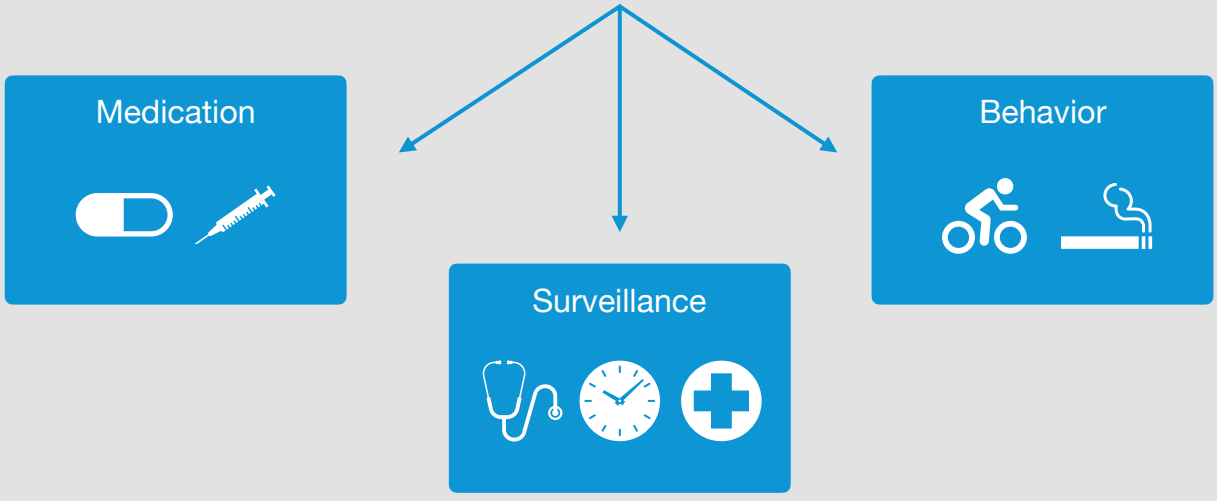


Management of Chronic Disease Today



Management of Chronic Disease Today

Adherence to Quality Indicators

In chronic disease

Condition	No. of Indicators	% of Recommended Care Received
Overall care	439	54.9%
Hypertension	27	64.7%
Heart failure	36	63.9%
COPD	20	58.0%
Asthma	25	53.5%
Hyperlipidemia	7	48.6%
Diabetes mellitus	13	45.4%
Peptic ulcer disease	8	32.7%
Atrial fibrillation	10	24.7%

n=6,712

McGlynn EA, et al. N Engl J Med 2003;348:2635–45.

Behavior Change

Healthy food

Behavior

Google Food Team and Yale Center for Customer Insights

- Wellness initiatives fail because they rely on placing too much emphasis on providing information
- Evidence from behavioral economics has shown that information rarely succeeds in changing behavior or building new habits or food choices
- Behavior often diverges from intentions
  - Self-control is taxed by any type of depletion
  - Necessity of making food decisions many times a day means we can't devote much processing power to each choice
  - Eating behaviors tend to be habit and instinct-driven

Chance Z, ey al. Harvard Business Review, March, 2016.

Surveillance

The average patient with **uncontrolled** hypertension sees the doctor 4 times/year.

Hyman DJ, et al, N Eng J Med 2001;345:479–486. Turchin A, et al. Hypertension 2010;56:68–74. Xu W, et al. BMJ 2015;350:1–9.

Consultation Length by Country

Surveillance

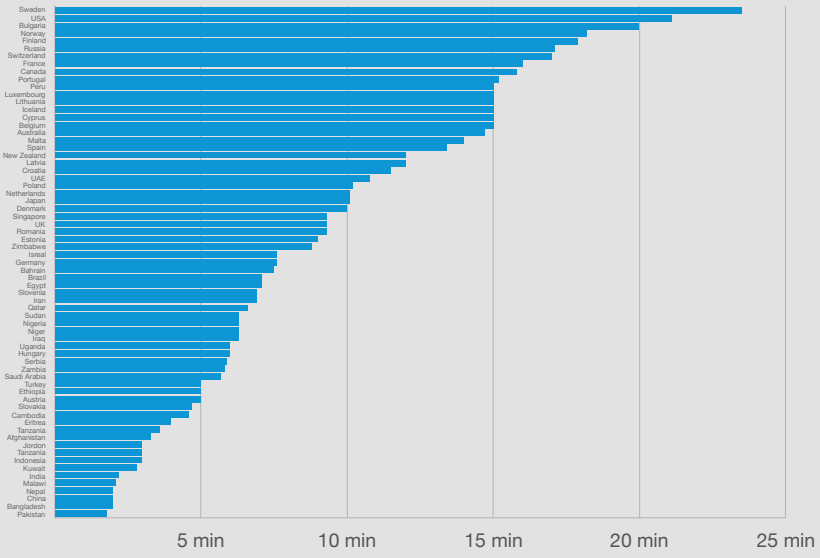
28,570,712 consultations in 67 countries:

The average time a Primary Care physician spends with each patient ranges from 48 seconds to 22.5 minutes.

Source: Irving G, et al. BMJ Open 2017;7:e017902. doi:10.1136/ bmjopen-2017-017902. Milani RV, et al. Am J Med 2015:128:337–343.

Consultation Length by Country

Surveillance



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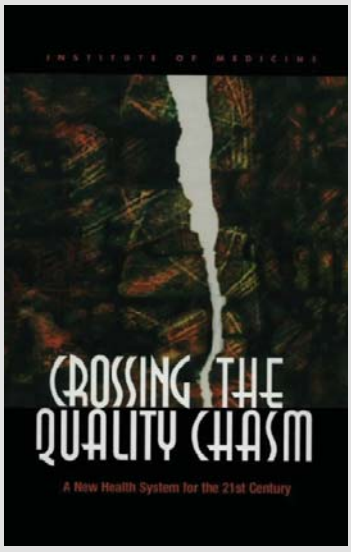
Why do we fail?

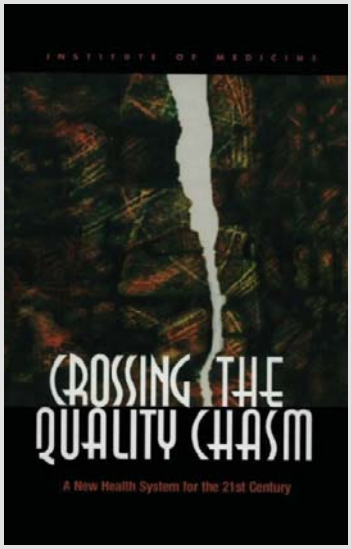


Quality problems occur typically
not because of failure of goodwill, knowledge, effort, or resources devoted to health care, but because of fundamental shortcomings in the way care is organized…

Trying harder will not work…Changing care systems will.

Institute of Medicine

The National Academies Press



Our current health care delivery system, which is organized around professionals and types of institutions, grew out of a need to provide primarily acute care rather than chronic care.

This is one kind of chasm we have to cross.

The health care delivery system must be reorganized to meet the real needs of patients.

Institute of Medicine

The National Academies Press

Challenges Physicians Face

Milani RV, et al. Am J Med 2015:128:337–343.

Challenges Physicians Face

Time
Face-to-face patient care accounts for 55% of average workday (guidelines for just 10 chronic diseases would require 10.6 hours/day)

Milani RV, et al. Am J Med 2015:128:337–343.

Challenges Physicians Face

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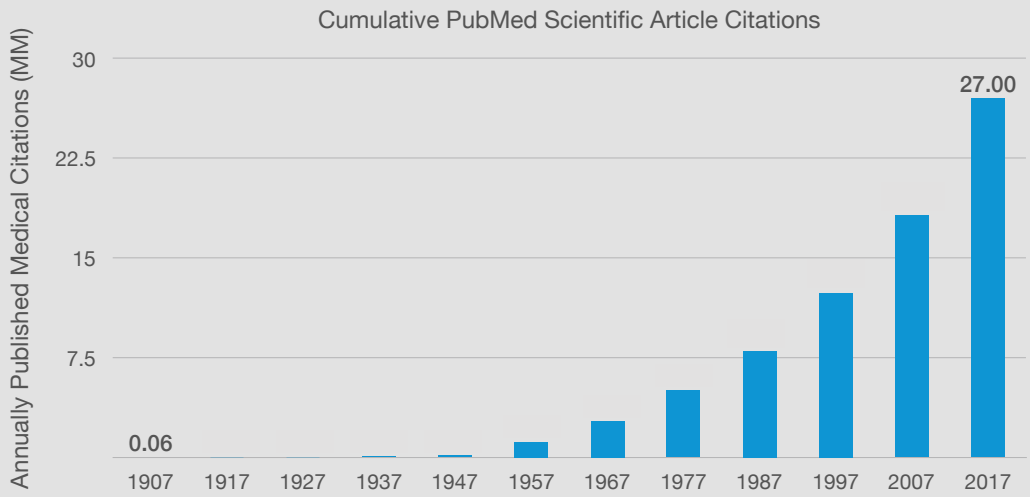
Rapidly Growing Medical Database
Now 1.9 million peer-reviewed articles/year

Milani RV, et al. Am J Med 2015:128:337–343.

Rise in Inputs + Data

Medical research/knowledge growing exponentially



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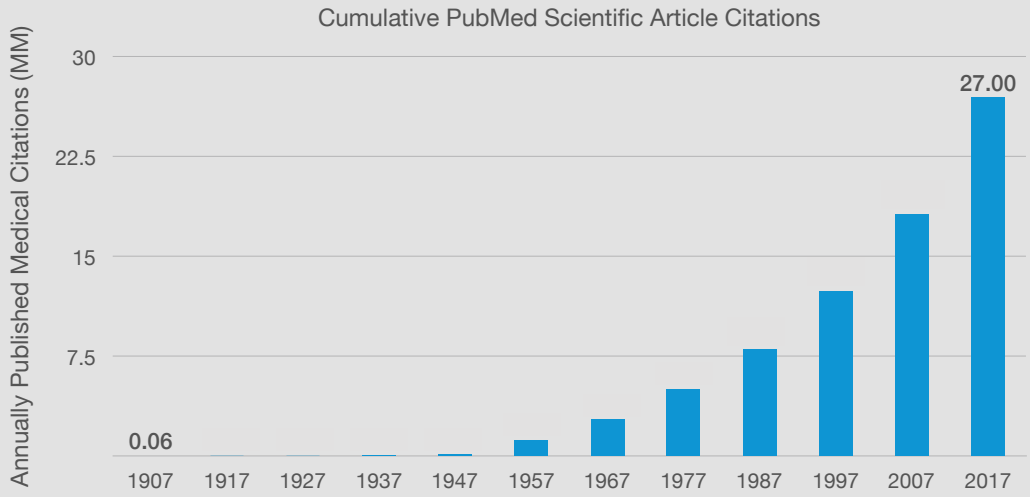
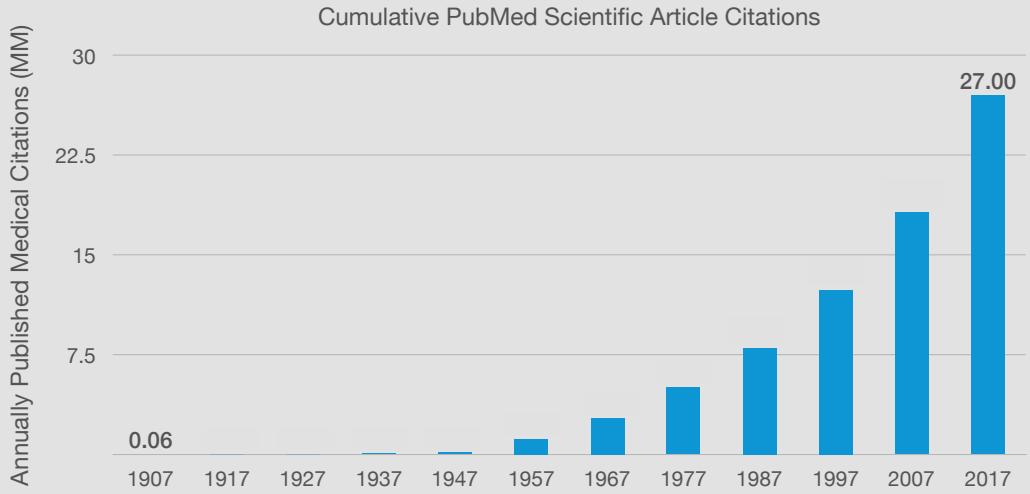


Years to Double Medical Knowledge

1950
50 Years

Rise in Inputs + Data

Medical research/knowledge growing exponentially



Years to Double Medical Knowledge

1950
50 Years

1980
7 Years

Rise in Inputs + Data

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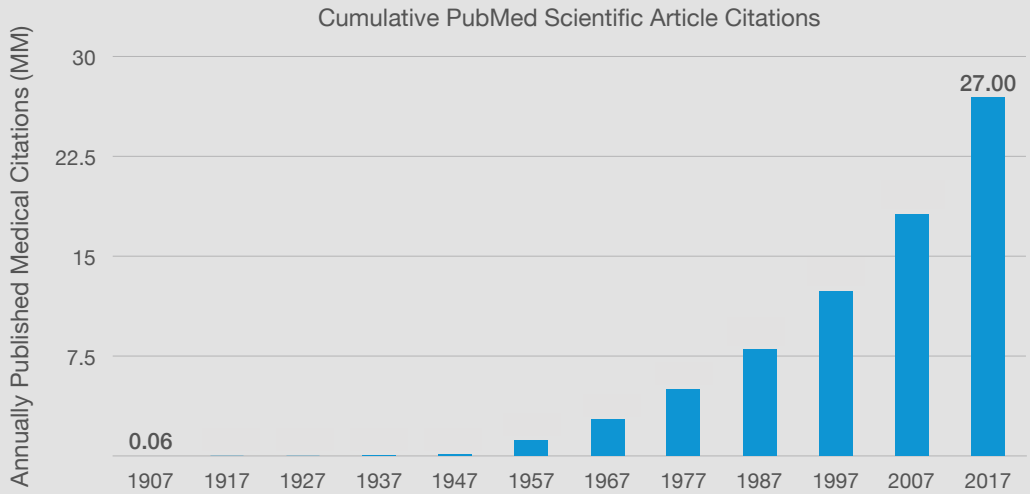


Years to Double Medical Knowledge

1950
50 Years

1980
7 Years

2010
3.5 Years

Challenges Physicians Face

Time
Face-to-face patient care accounts for 55% of average workday (guidelines for just 10 chronic diseases would require 10.6 hours/day)

Rapidly Growing Medical Database
Now 1.9 million peer-reviewed articles/year

Therapeutic Inertia
Noted in 87% of visits for uncontrolled hypertension

Model of Care Delivery
Limits patient touches, actionable biologic data, course correction

Milani RV, et al. Am J Med 2015:128:337–343.

Reengineering Care Delivery to Manage Chronic Disease

Overview of Global Health Status

Factors Contributing to Poor Health Outcomes

Encouraging Positive Behavior Change

Intervening and Engaging Patients

Health Care

Care delivery

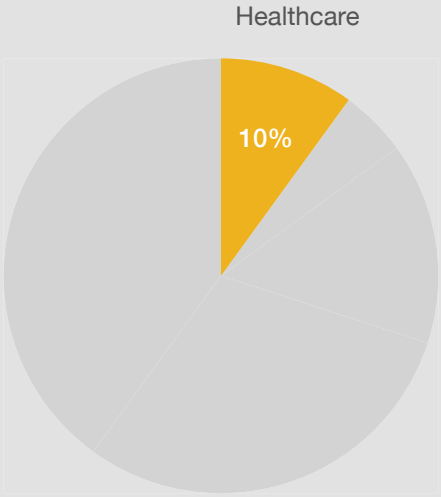
VS

Health of a Population

Health determinants

Health Status

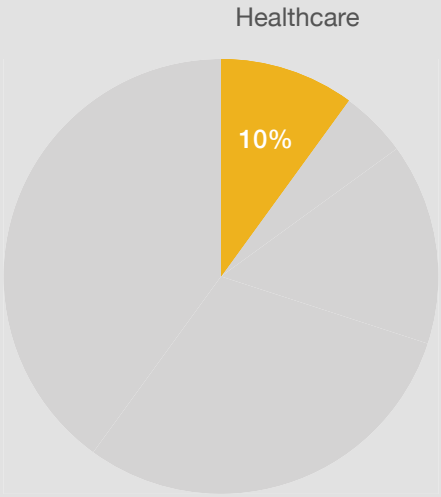
Influencing factors



Schroeder SA. N Engl J Med 2007;357:1221–8.

Health Status

Influencing factors



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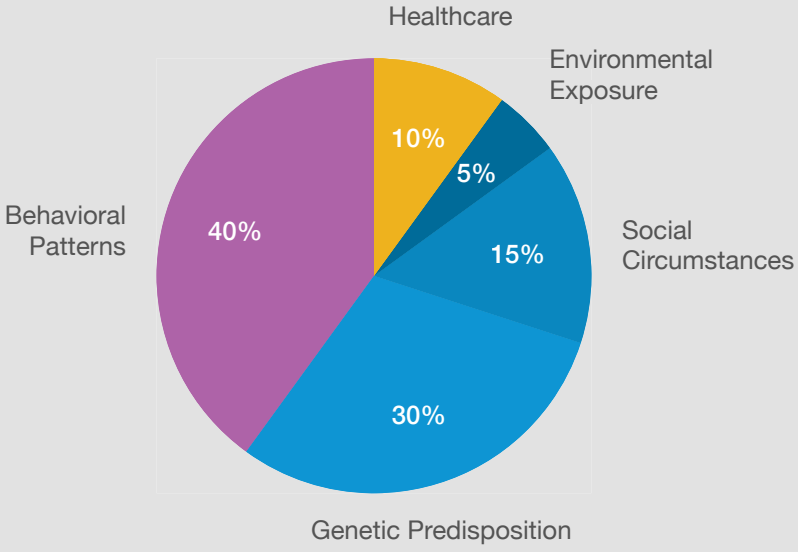

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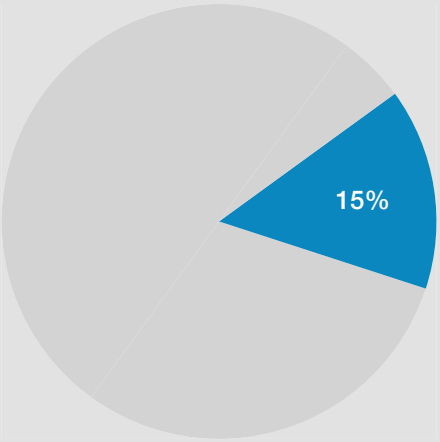

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Social Isolation

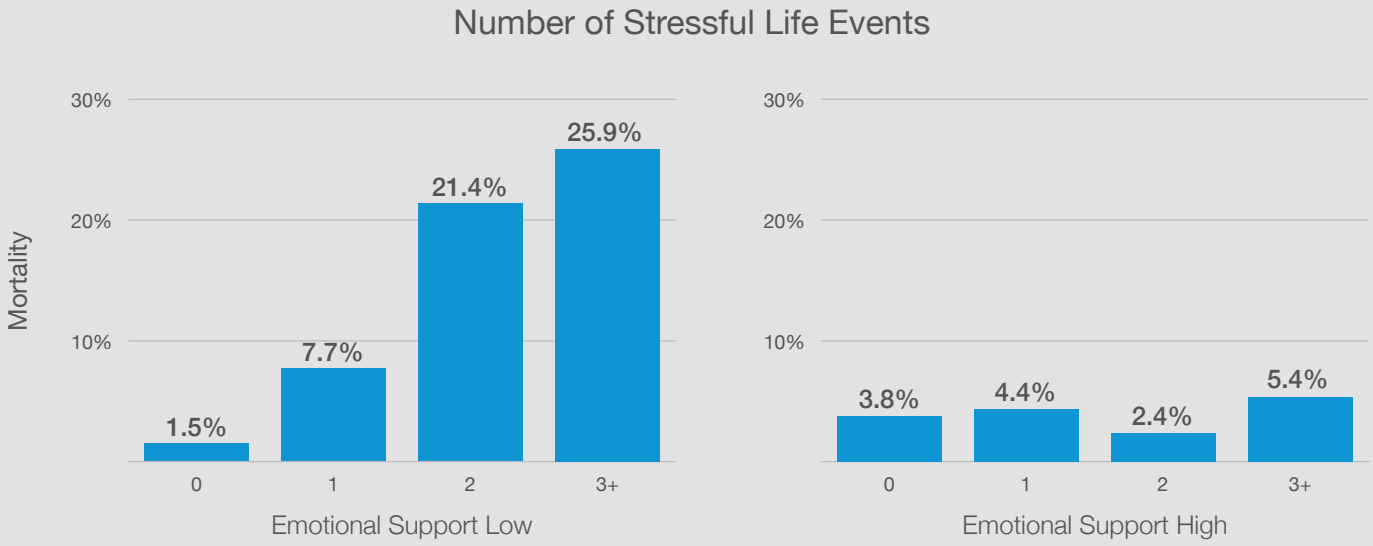
About 28% (12.1M) of noninstitutionalized older persons (≥ 65 years) live alone

Almost half of women ≥ 75 years (45%) live alone

Associated with a 29% increase in CHD and 31% increase in stroke

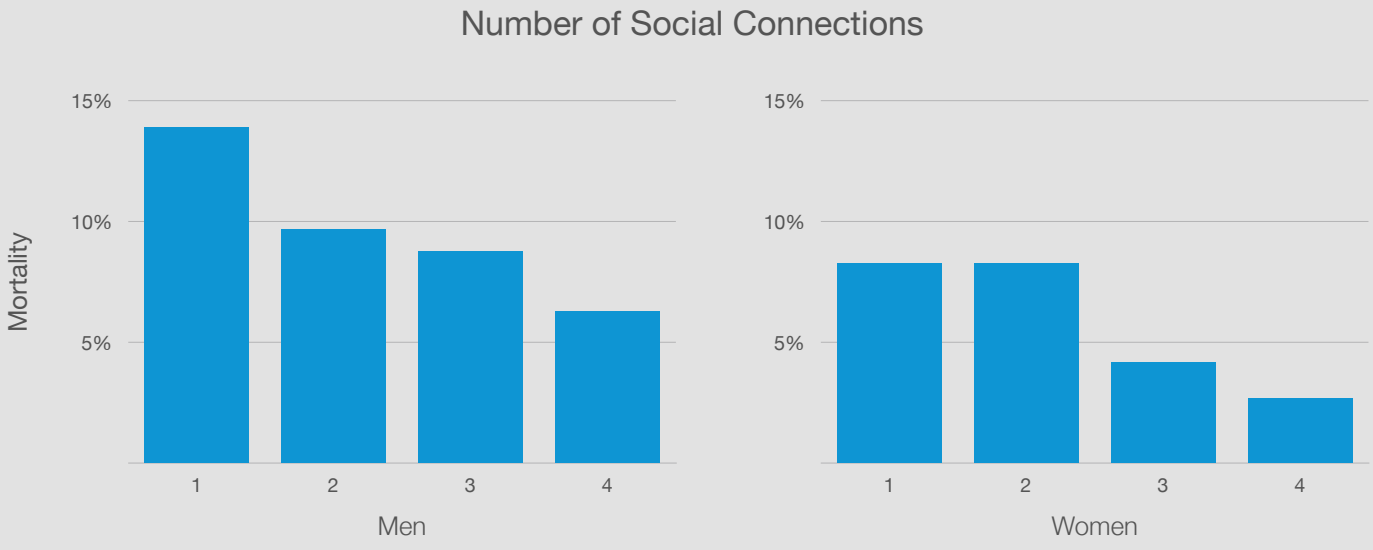
A Profile of Older Americans: 2013. U.S. Dept. of Health and Human Services. Valtorta NK, et al. Heart. 2016

Emotional Support Buffers Stressful Life Events

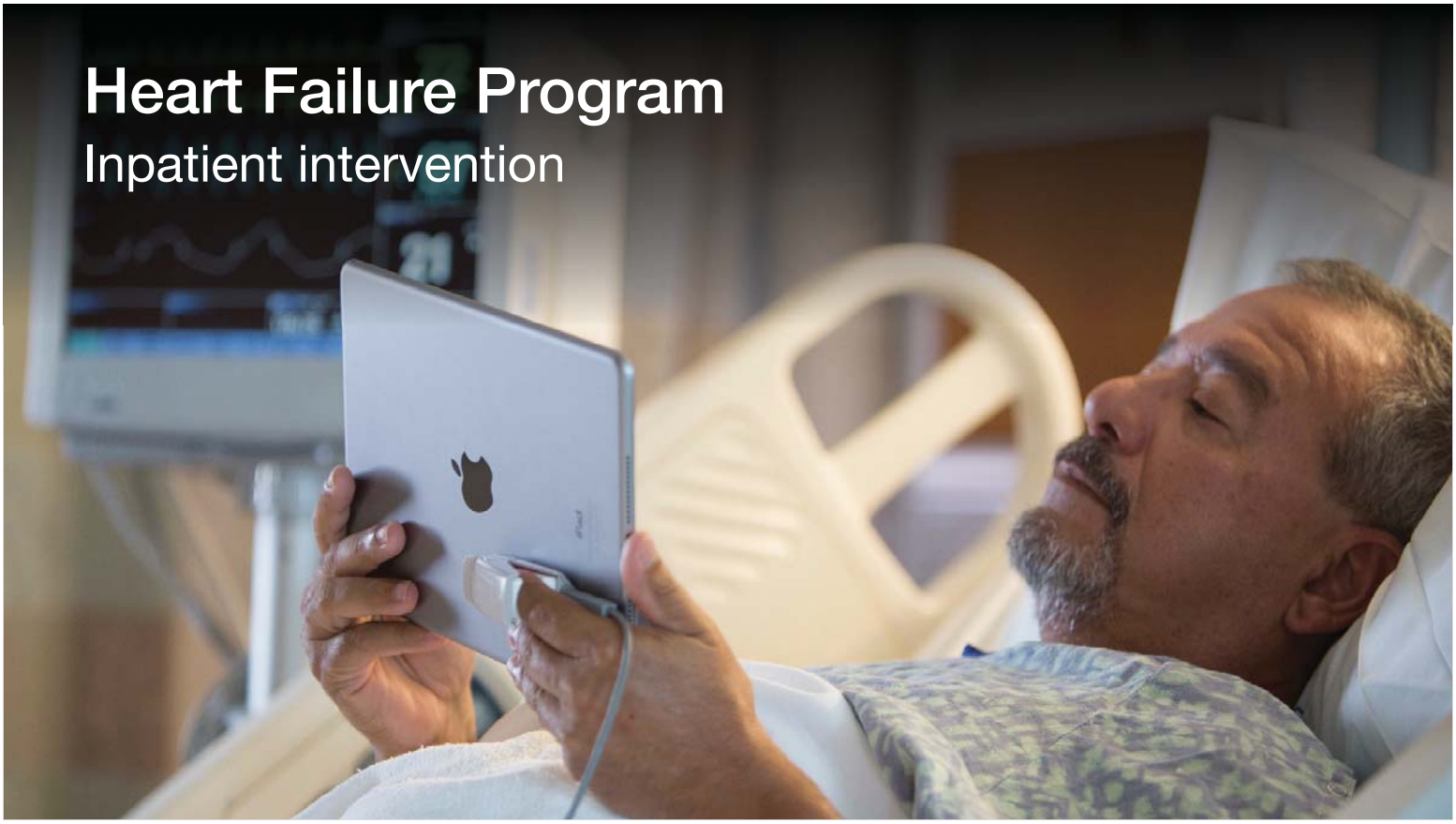


Rosengren A, et al. BMJ 1993;307:1102–1105.

Social Integration in Chronic Disease



Berkman LF, et al. Am J Epidemiology 1979;109:186–204.

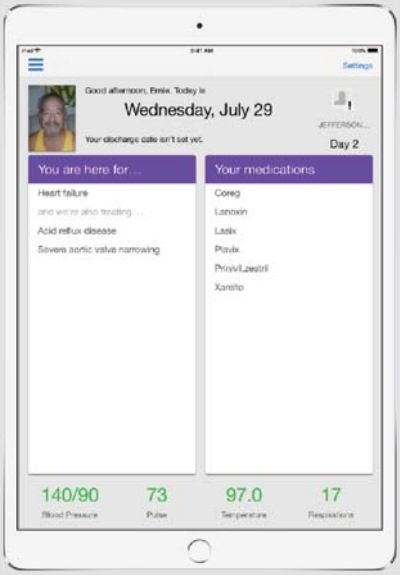


Heart Failure Program
Inpatient intervention

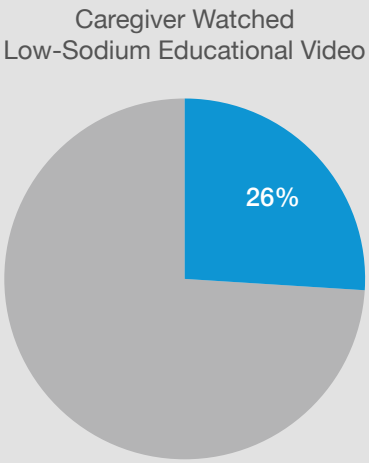
Heart Failure Program
Inpatient intervention

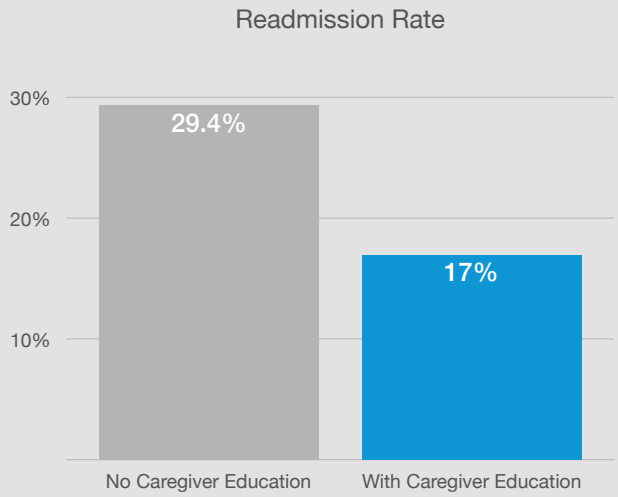
Scores high on sodium consumption

- “Who shops for your groceries?”
- “Who prepares your meals?”
- Patient views video on importance of low sodium foods
- Individual(s) who shops for and prepares meals sent email with literature and video link

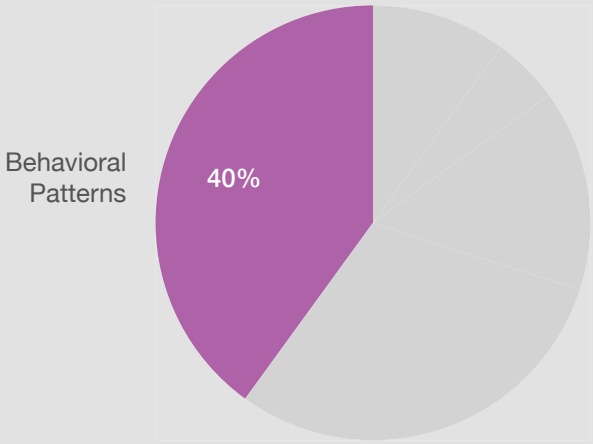


Impact of Caregiver Dietary Education on Readmission





How Much of an Impact?



Schroeder SA. N Engl J Med 2007;357:1221–8.

Medication Adherence

Facts

50% of patients with chronic disease do not take meds as prescribed

Increased morbidity and death

Estimated cost ~**$100B/year**

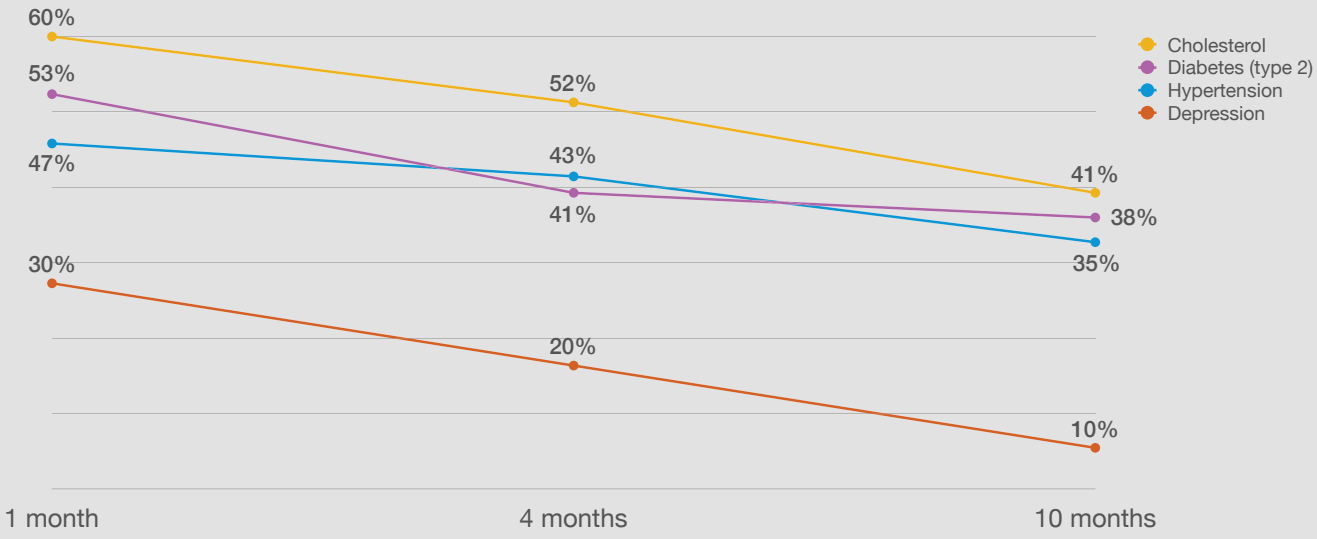
Increasing the effectiveness of adherence interventions may have a far greater impact on health of the population than any improvement in specific medical treatments.

World Health Organization

Brown MT, et al. Mayo Clin Proc. 2011;86:304–314
Sabate E, et al. World Health Organization. Geneva, Switzerland. 2003

Therapeutic Adherence

Levels plummeting over time



Cognizant 20-20 insights, October 2014.

Patient Activation

An incremental process

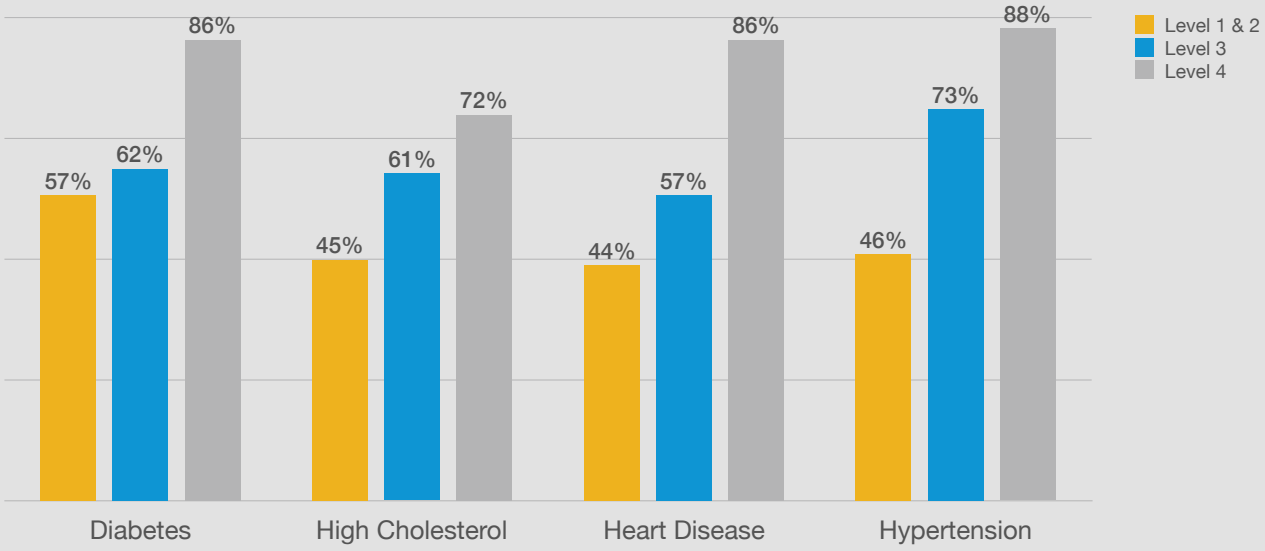
Level 1	Level 2	Level 3	Level 4
Disengaged and overwhelmed	**Becoming aware, but still struggling**	**Taking action**	**Maintaining behaviors and pushing further**
Individuals are passive and lack confidence. Knowledge is low, goal-orientation is weak, and adherence is poor. Their perspective: “My doctor is in charge of my health.”	Individuals have knowledge, but large gaps remain. They believe health is largely out of their control, but can set simple goals. Their perspective: “I could be doing more.”	Individuals have the key facts and are building self-management skills. They strive for the best practice behaviors, and are goal oriented. Their perspective: “I’m part of my health care team.”	Individuals have adopted new behaviors but may struggle in times of stress or change. Maintaining a healthy lifestyle is a key focus. Their perspective: “I’m my own advocate.”

Increasing Level of Activation

Hibbard JH, Greene J. What The Evidence Shows About Patient Activation: Better Health Outcomes And Care Experiences; Fewer Data On Costs. Health Affairs, 32, no.2 (2013):207–214

Patient Activation Level

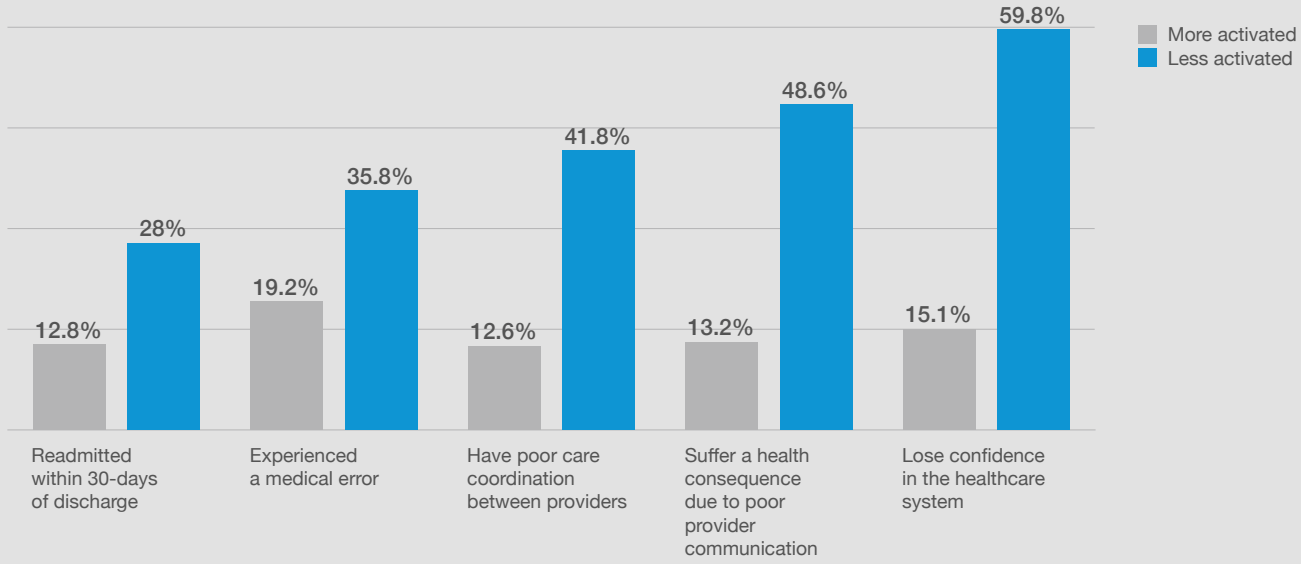
Medication adherence in chronic disease



Increasing Patient Activation to Improve Health and Reduce Costs. Judith H. Hibbard, DrPH. Institute for Policy Research and Innovation. University of Oregon

Patient Activation Level

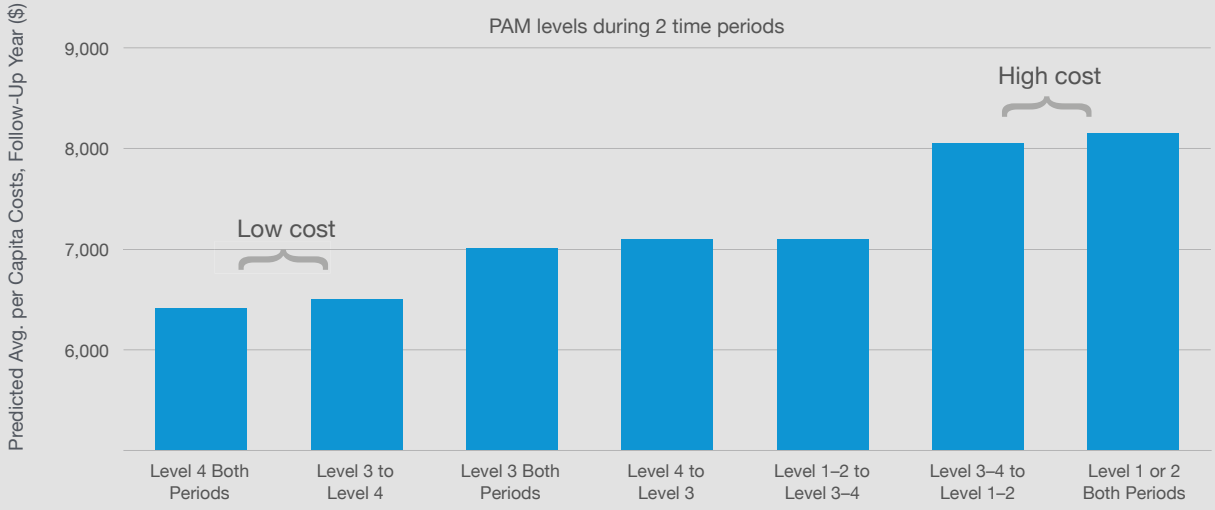
Healthcare quality



Adapted from AARP & You, "Beyond 50.09" Patient Survey. Published in AARP Magazine. Study population age 50+ with at least 1 chronic condition. More Activated = Levels 3 & 4, Less Activated = Levels 1 & 2

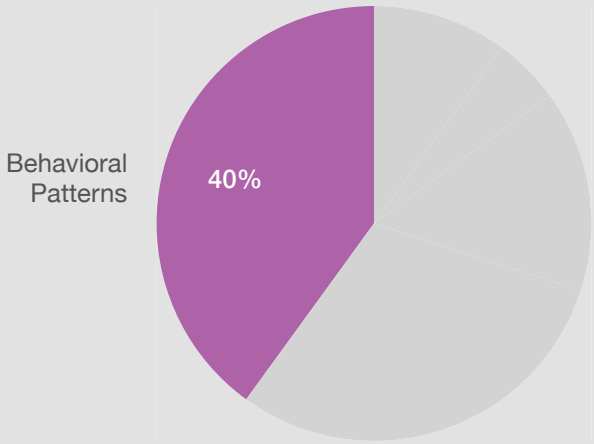
Patient Activation Level

Healthcare costs in follow-up year by change in PAM



Greene J, et al. Health Aff 2015;34:431–437

Does Changing Behaviors Change Outcomes?



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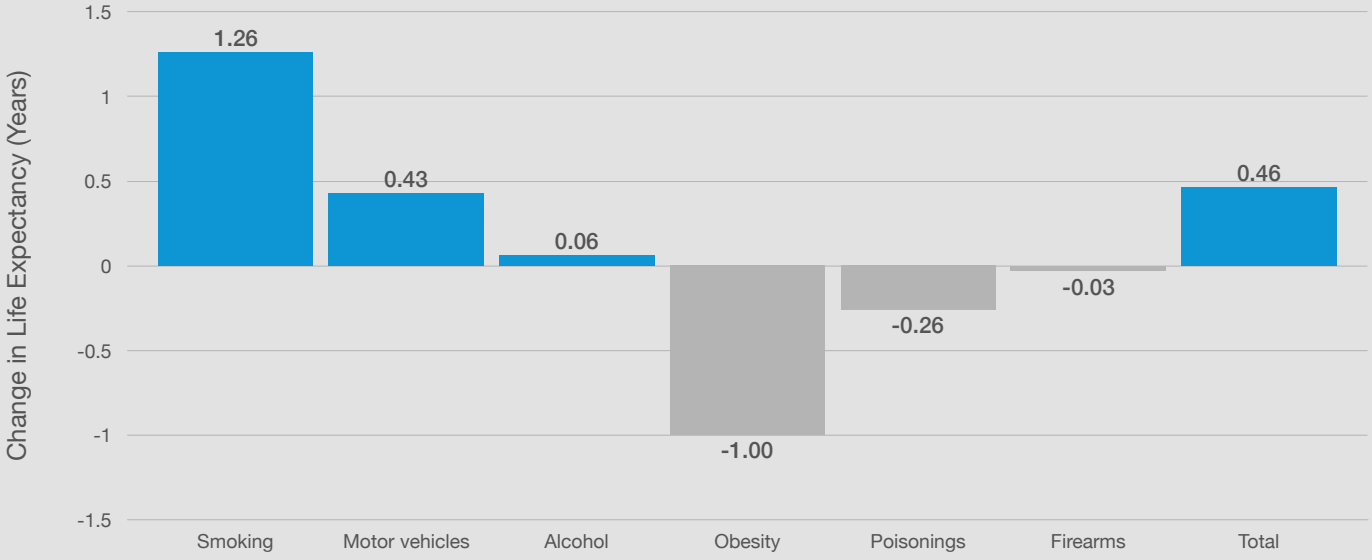
Behavioral Changes

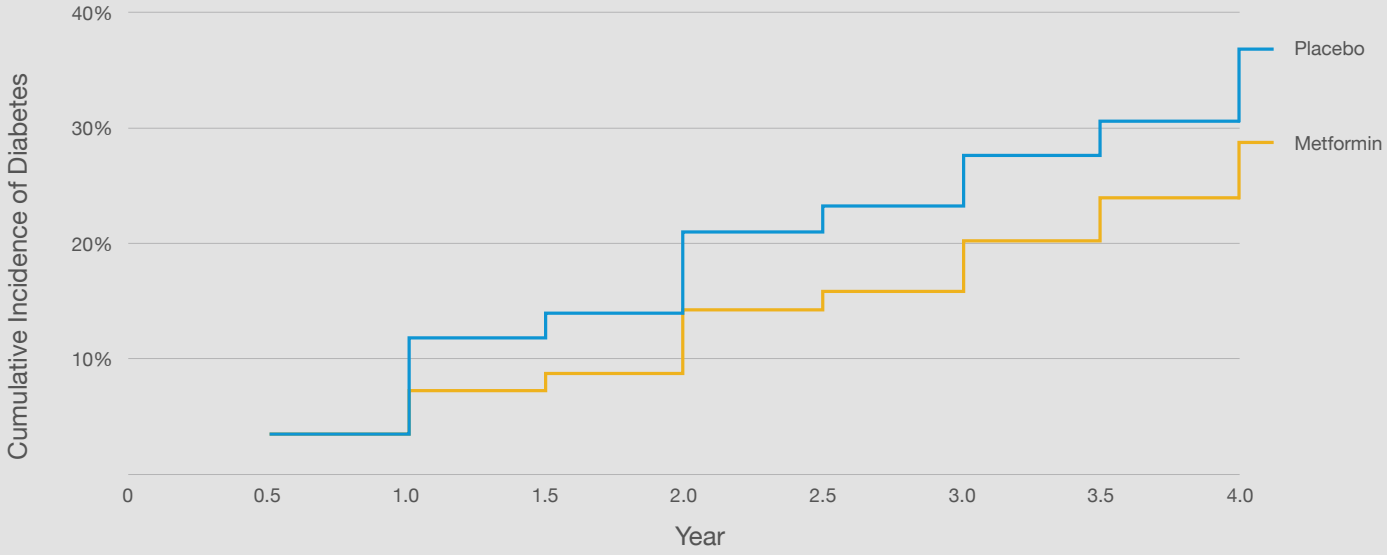
Impact on life expectancy



National Health Interview Survey, National Health and Nutrition Survey

Benefits of Behavior Change

Diabetes prevention program



Diabetes Prevention Program Research Group. N Eng J Med 2002;346:393–403.

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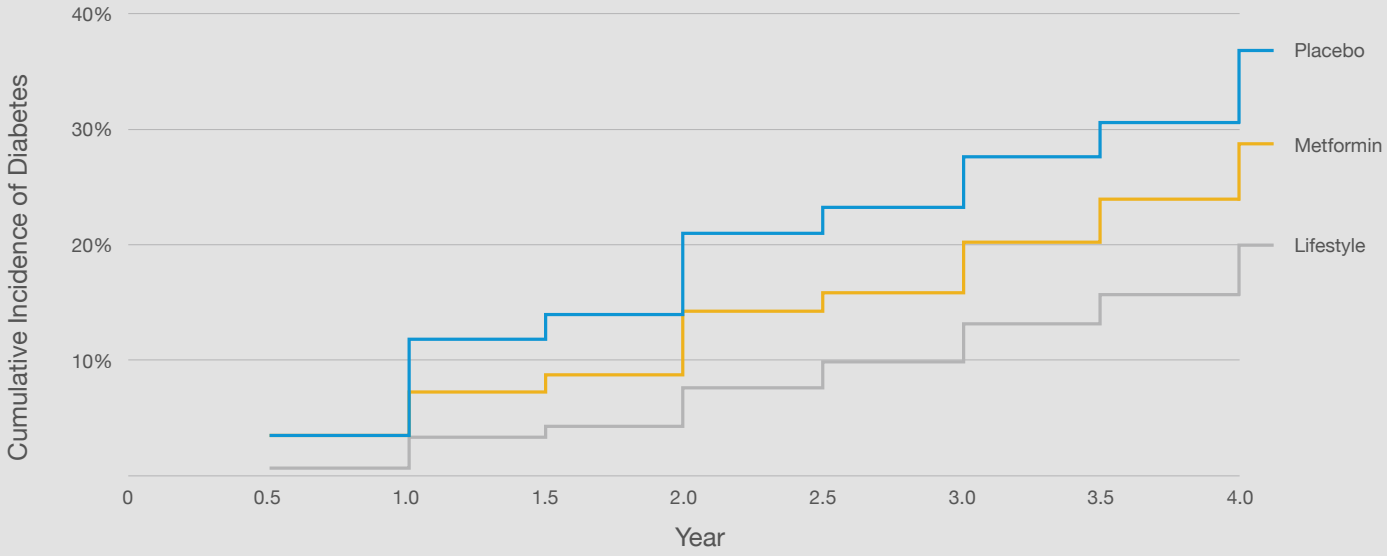

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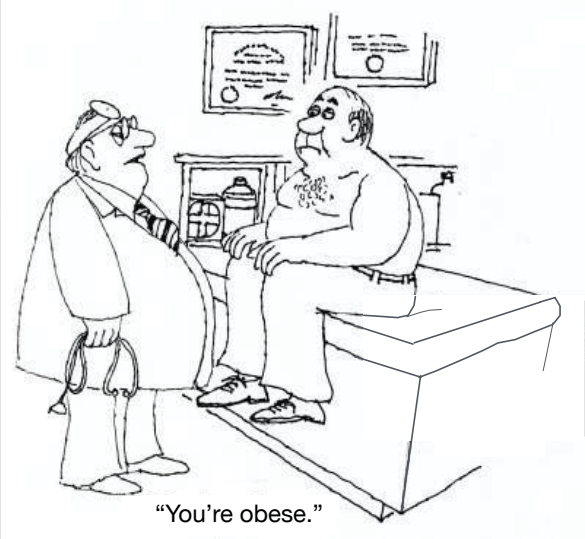
Encouraging Positive Behavior Change



"You're obese."

Social Contagion

Many health behaviors impacted through social interactions

Smoking

Eating

Exercise

Weight

Medication adherence

The Power of Peer Influence

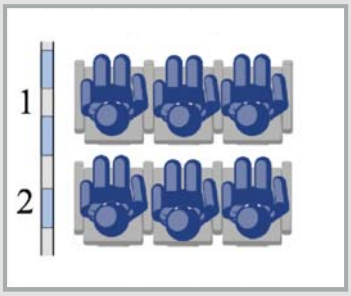
65,525 transactions

1,966 flights

257,000 passengers

Excluded people flying together, kids

Tests purely the effect of a stranger's choice



Time 1:
Purchasing window begins

Gardete, P.M. Journal of Marketing Research. 2015;52:360–374.

The Power of Peer Influence

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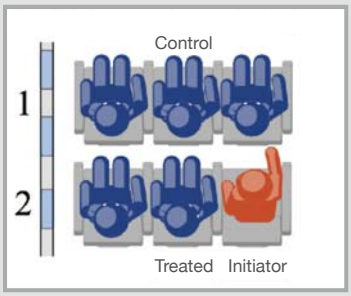

Time 2:
Purchase occurs
i.e. experiment begins

Gardete, P.M. Journal of Marketing Research. 2015;52:360–374.

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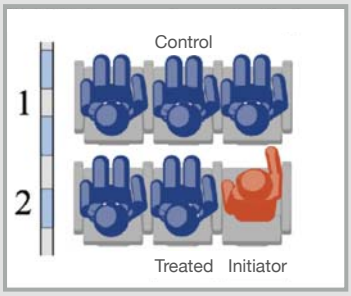

Time 2:
Purchase occurs
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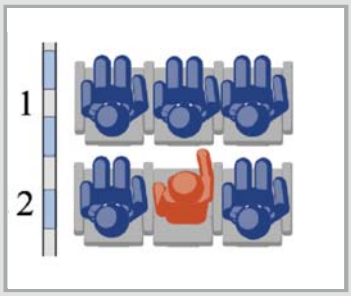
The Power of Peer Influence

On average, people purchased a movie or snack 15–16% of the time

If you saw someone next to you order something, your chances of buying something increased by 30%



Time 3A:
Treated passenger buys

Gardete, P.M. Journal of Marketing Research. 2015;52:360–374.

Aspirin Use and Cardiovascular Events in Social Networks

Women	Men
More likely to take aspirin if a brother had been recently taking aspirin	More likely to take aspirin if a male friend had recently been taking aspirin
More likely to take aspirin if a female friend recently had a CV event	More likely to take aspirin if a brother recently had a CV event

Strully KW, et al. Social Science and Medicine 2012;74:1125–1129.

Aspirin Use and Cardiovascular Events in Social Networks

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Aspirin use is correlated with the health and behavior of friends and family

Strully KW, et al. Social Science and Medicine 2012;74:1125–1129.

Smoking Cessation

Impacted through social interactions

Smoking cessation appears to spread from person-to-person

Decisions to quit smoking is not done in isolation, but rather reflect choices made by groups connected to each other

People appear to act under collective pressures within niches in their social network

Smoking Cessation

Impacted through social interactions

Relationship	Behavioral Impact	Requirements	Details
Spouse	67%	N/A	—
Friend 1	61%	Educated subject and friend	≥ 1 year college
Friend 2	57%	Educated subject	≥ 1 year college
Friend 3	55%	Educated friend	≥ 1 year college
Friend 4	43%	Mutual friends	↔
Friend 5	36%	Any friends	→
Co-worker	34%	Small firm	≤ 6 employees
Sibling	25%	N/A	—

Christakis NA, et al. N Engl J Med 2008;358:2249–2258.

Obesity

Impacted through social interactions

Relationship	Behavioral Impact	Requirements	Details
Spouse	37%	n/a	—
Friend 1	57%	alter friend	alter obese
Friend 2	0%	perceived friend only by alter	alter obese
Friend 3	71%	same sex alter friend	alter obese
Friend 4	171%	same sex mutual friends	↔
Friend 5	0%	opposite sex alter friend	
Adult sibling	55%	same sex	sibling obese
Immediate neighbor	0%		—

Christakis NA, et al. N Engl J Med 2007;357:370–9.

Changing Dietary Behavior

Fresh fruit consumption

National School Lunch Program began recommending apples to being served, to school children, however the majority of apples (> 60%) ended up in the trash, virtually untouched.

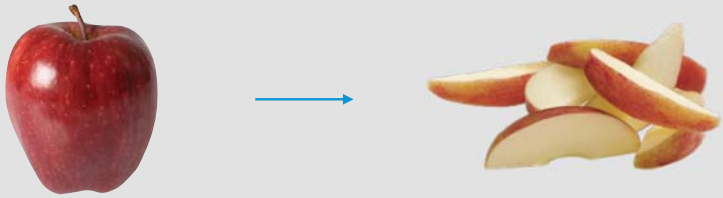
Lansink B, et al. Am J Prev Med 2013;44:477–480.

Changing Dietary Behavior

Fresh fruit consumption

National School Lunch Program began recommending apples to being served, to school children, however the majority of apples (> 60%) ended up in the trash, virtually untouched.

Studies have since demonstrated that apple consumption increases by more than 70% when apples were served as slices.



Lansink B, et al. Am J Prev Med 2013;44:477–480.

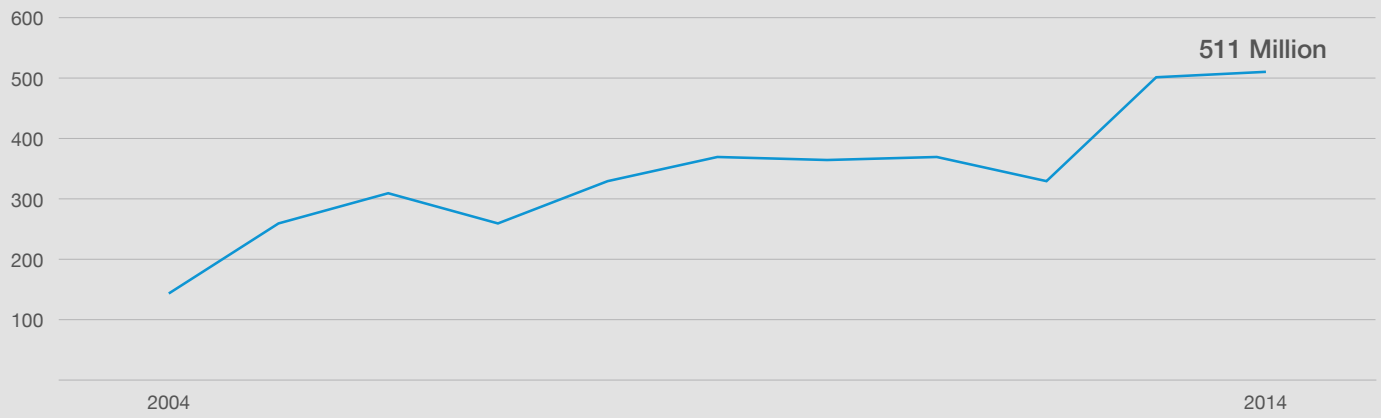
The Rise in Sliced Apples

U.S. Sliced Apple Consumption, Millions of Apples

USDA. WAPO.ST/WONKBLOG

The Rise in Sliced Apples

U.S. Sliced Apple Consumption, Millions of Apples



USDA. WAPO.ST/WONKBLOG

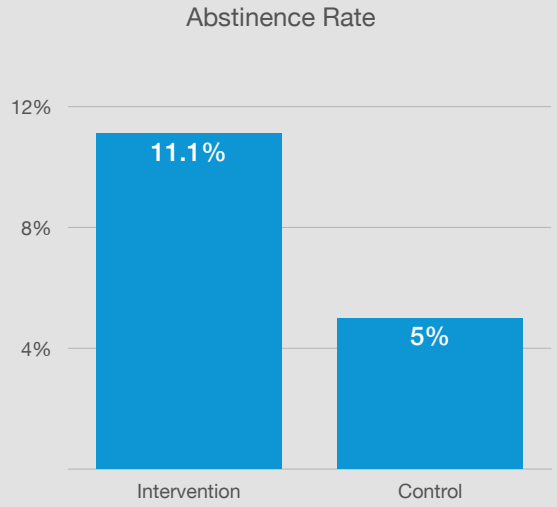
Timely or Unexpected Support

Smoking Cessation

Texting as a means of changing behavior

Messages tailored

- Participant's first name
- Gender
- Chosen quit date
- Top 3 reasons for quitting
- Money saved
- Person selected for social support
- Triggers for smoking (up to 5)



Abroms LC, et al. Am J Prev Med 2014;47:242–50.

Lifestyle-Focused Texts

Effect on patients with coronary heart disease

A Randomized Clinical Trial

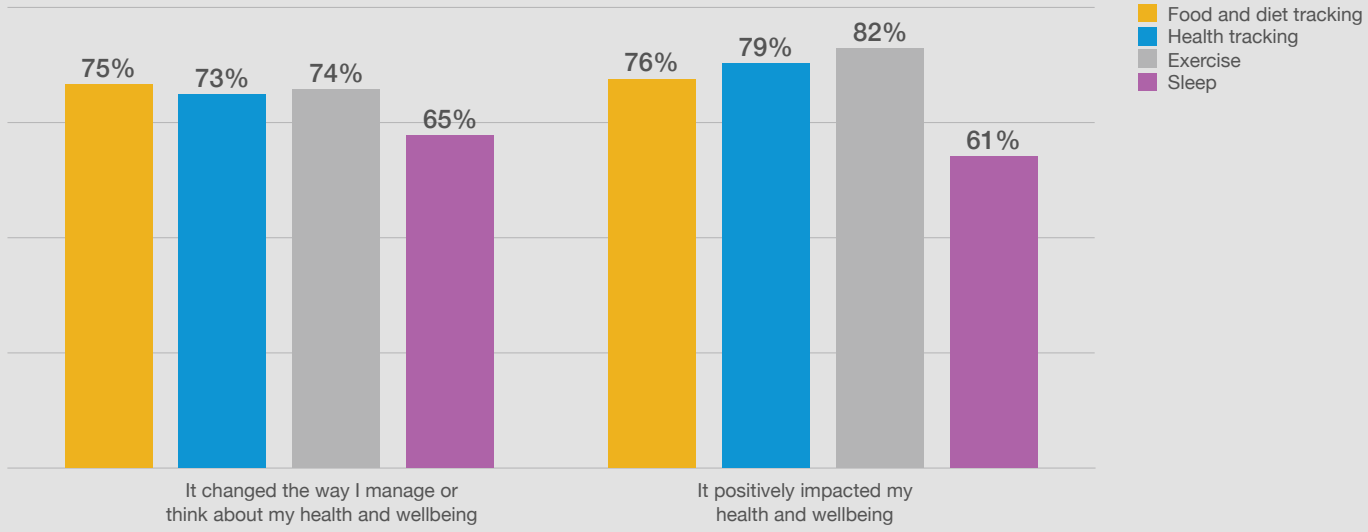
Clara K. Chow, MBBS, PhD; Julie Redfern, PhD; Graham S. Hillis, MBChB, PhD, Jay Thakkar, MBBS; Karla Santo, MBBS; Maree L. Hackett, PhD; Stephen Jan, PhD; Nicholas Graves, PhD; Laura de Keizer, BSc (Nutr); Tony Barry, BSc; Severine Bornpoint, BSc (Stats); Sandarine Stepien, MBiostat

LDL-C	-6%	0.04
Systolic BP	-6%	<0.001
BMI	-4%	<0.001
Physical activity (MET)	+46%	0.003
Smoking	-39%	<0.001

Original Investigation. Chow CK, et al. JAMA 2015; 314:1255–1263.

Mobile Apps

Impact on health and wellbeing



http://www.statista.com/statistics/472899/impact-of-health-and-wellbeing-mobile-apps-use-in-the-uk-by-mobile-app-type/

Patients Prefer Apps

In chronic disease

2,000 patients with chronic disease and a smartphone

Willing to fill a medication prescription prescribed by an MD

Willing to use an app prescribed by an MD

20 different chronic disease including cardiac, GI, respiratory, CNS, and diabetes

mobihealthnews.com/23418/most-patients-want-their-doctors-to-prescribe-apps/

Patients Prefer Apps

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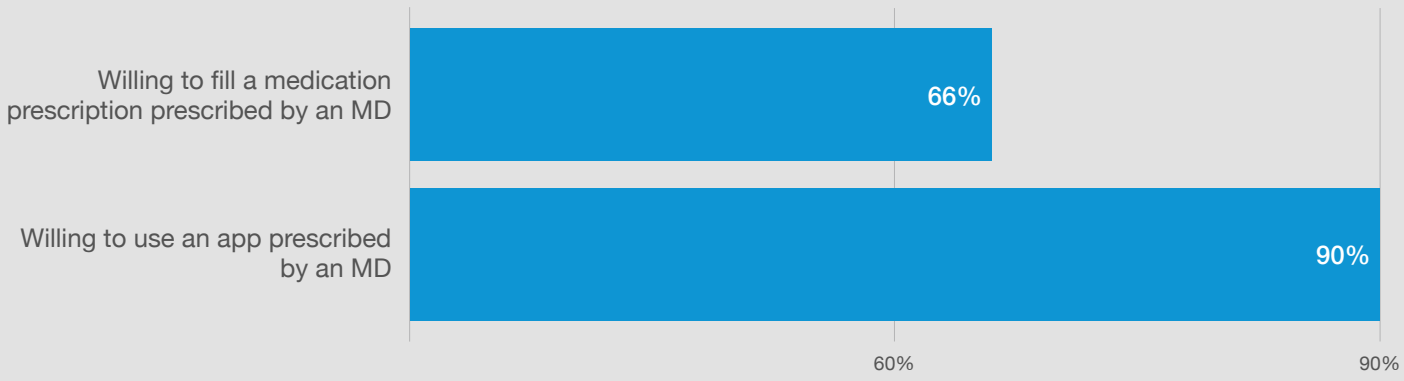
2,000 patients with chronic disease and a smartphone



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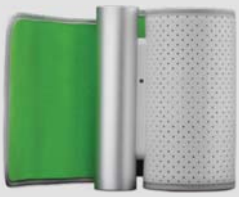
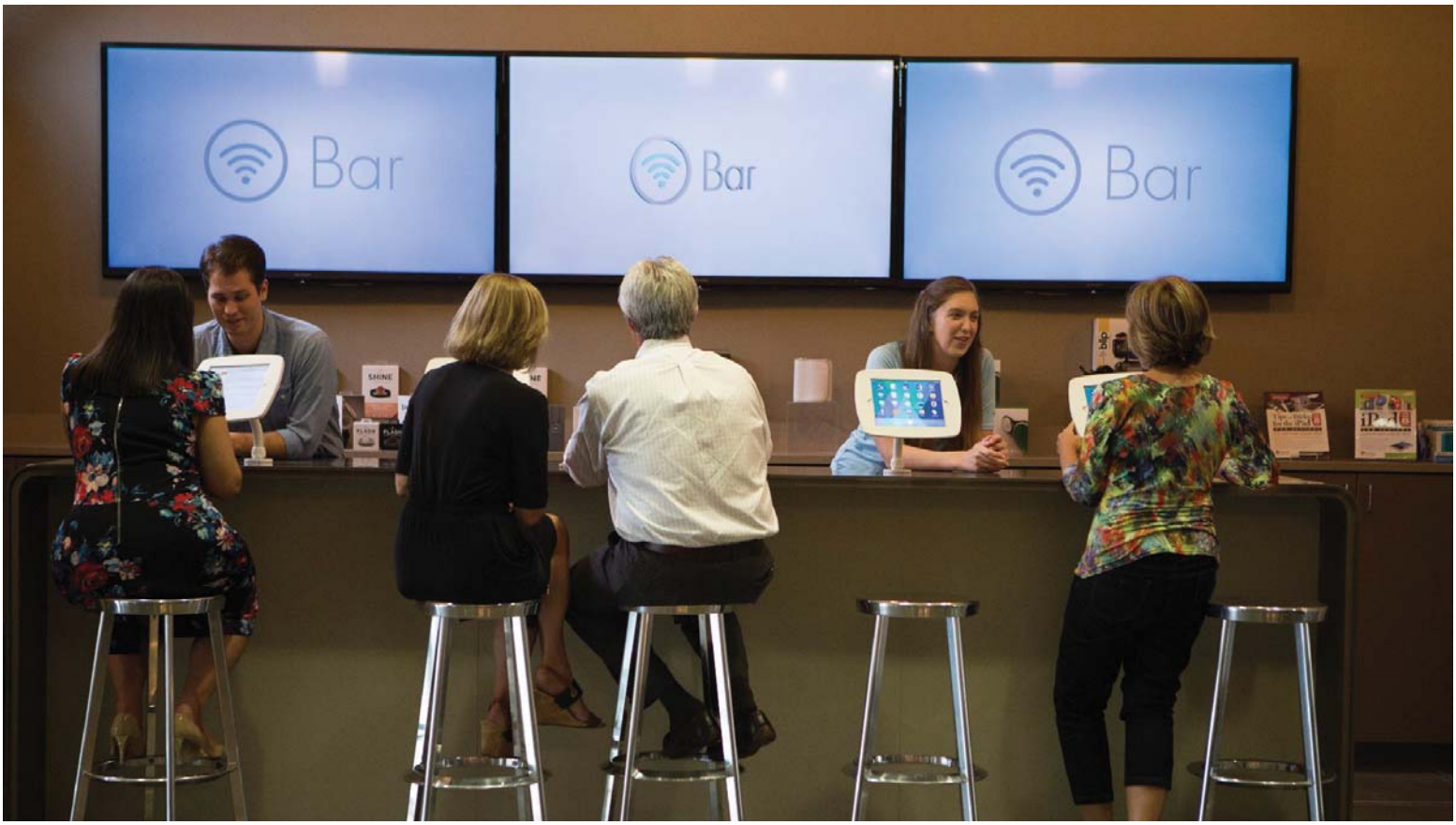
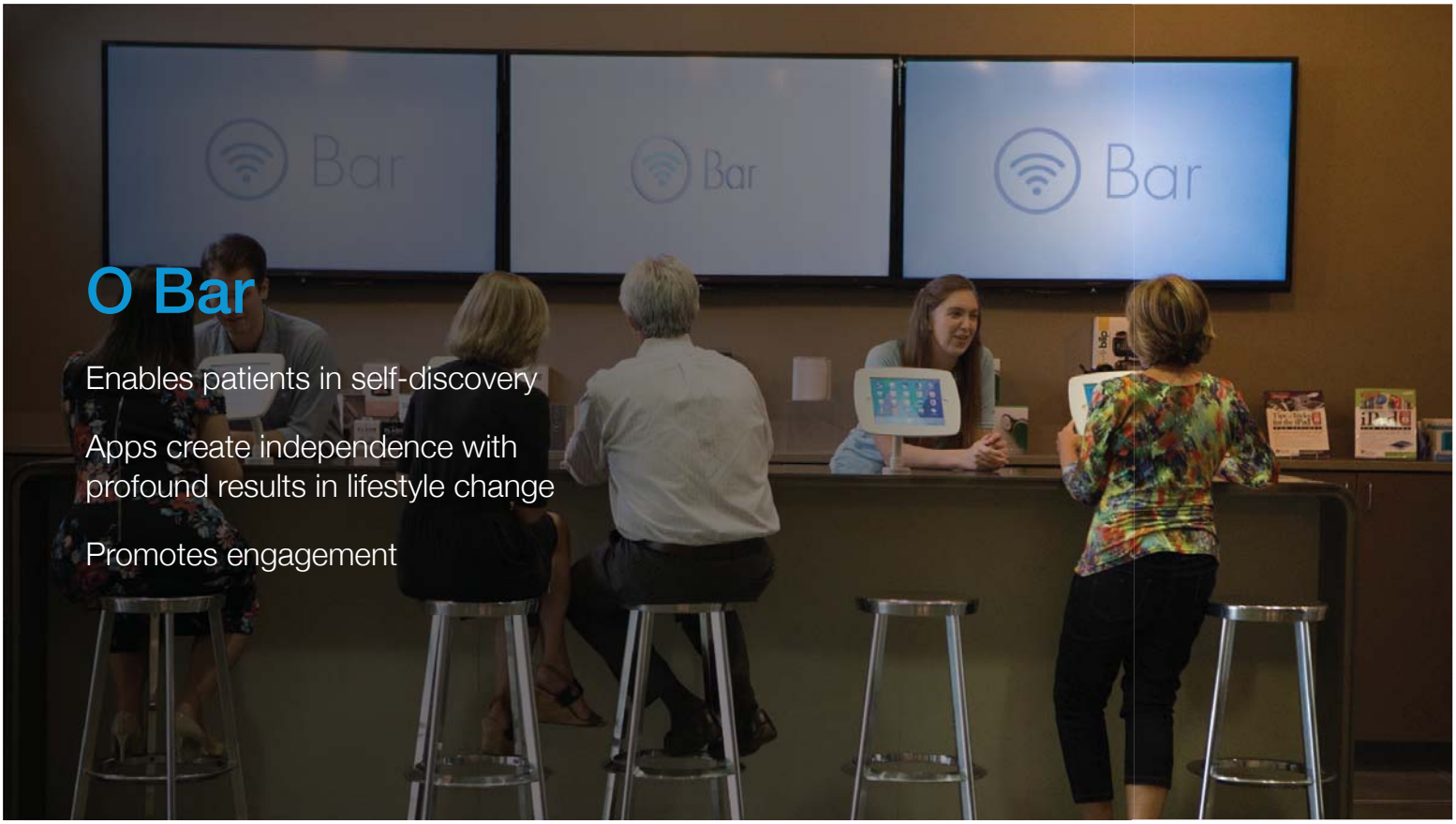
mobihealthnews.com/23418/most-patients-want-their-doctors-to-prescribe-apps/



Among the tens of thousands of health apps and numerous devices, how do you decide what's effective?





O Bar

Enables patients in self-discovery

Apps create independence with profound results in lifestyle change

Promotes engagement

Bar

Ochsner Center for Primary Care & Wellness
1401 Jefferson Highway, New Orleans, LA 70121

504.842.8566
ochsner.org/obar

Patient .....

Visit the Bar to get your apps & devices today!

Rx Your prescription for good health.

R_x APPS

- ◯ Nutrition
- ◯ Fitness
- ◯ Women's
- ◯ Oncology
- ◯ Diabetes
- ◯ Medication
- ◯ Smoking
- ◯ General Health

DEVICES

- ◯ Activity Monitor
- ◯ Blood Glucose Monitor with Bluetooth
- ◯ Wireless Scale
- ◯ Wireless Blood Pressure Monitor

Physician Signature .....

"Tell me and I forget, teach me and I may remember, involve me and I learn." – BEN FRANKLIN

Forbes

Ochsner is First in Nation to Manage Chronic Diseases with Apple Watch

Patients with hypertension have a new tool to keep their numbers in check.

CNBC

Ochsner Physicians Prescribe Mobile Apps

Ochsner Health System is using wellness apps to keep patients healthy.

CNNMoney

Apple HealthKit to Help Combat Chronic Diseases

Health care technology lets patients share important data with their physician between doctor visits.

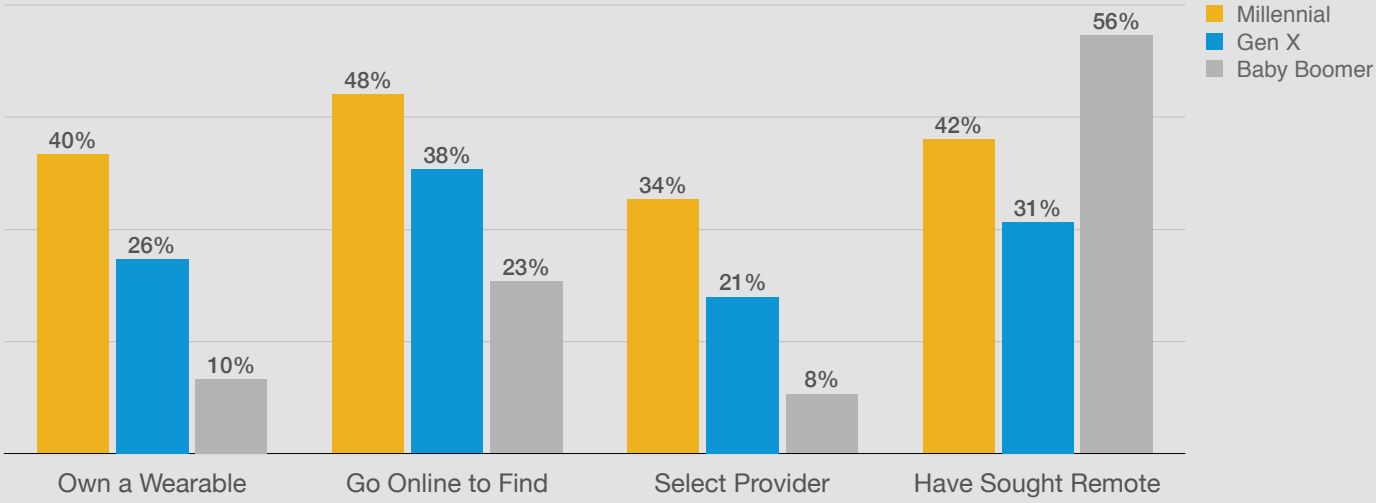
Reengineering Care Delivery to Manage Chronic Disease

- Overview of Global Health Status
- Factors Contributing to Poor Health Outcomes
- Encouraging Positive Behavior Change
- **Intervening and Engaging Patients**

100 Years Ago
The Human Touch

Consumers

Increasingly expect digital health services

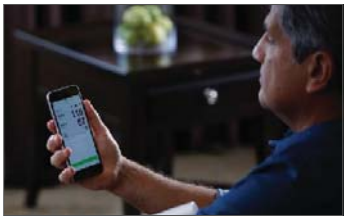


Source: Rock Health Digital Health Consumer Adoption (12/16)

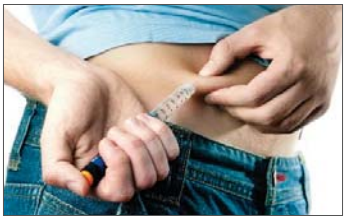
Where Can Digital Technology Have Its Greatest Effect in Healthcare?

In Disease Processes of Long Duration

Digital Hypertension



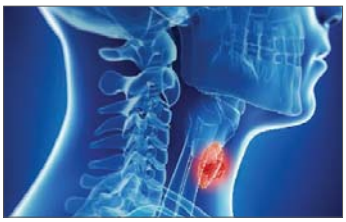
Digital Diabetes



Connected MOM

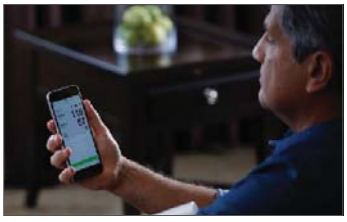
Digital COPD

Head and Neck Cancer

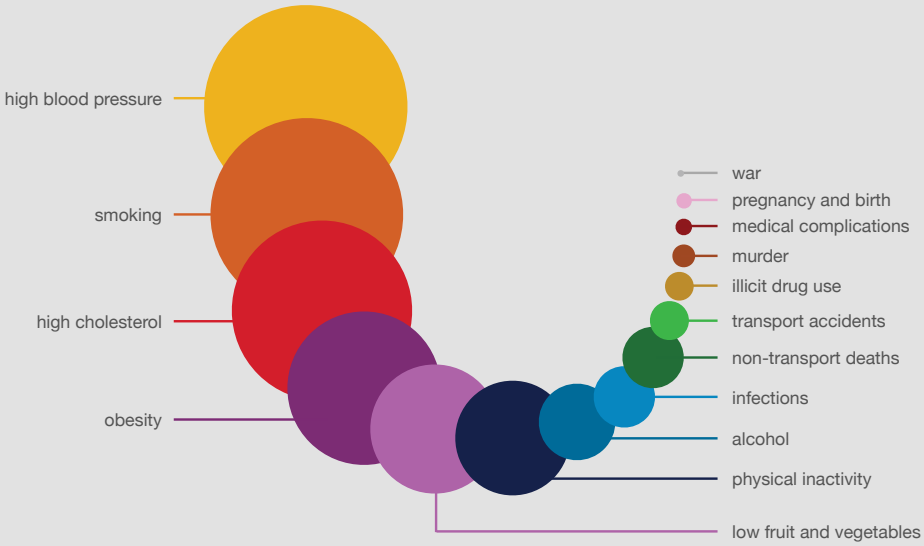


Peripheral Arterial Disease

Digital Hypertension



Risk Leading to Death



NHS. http://www.nhs.uk/Tools/Pages/NHSAtlasofrisk.aspx

Hypertension

Major public health concern

1.39 Billion
Number of people with HTN worldwide in 2010

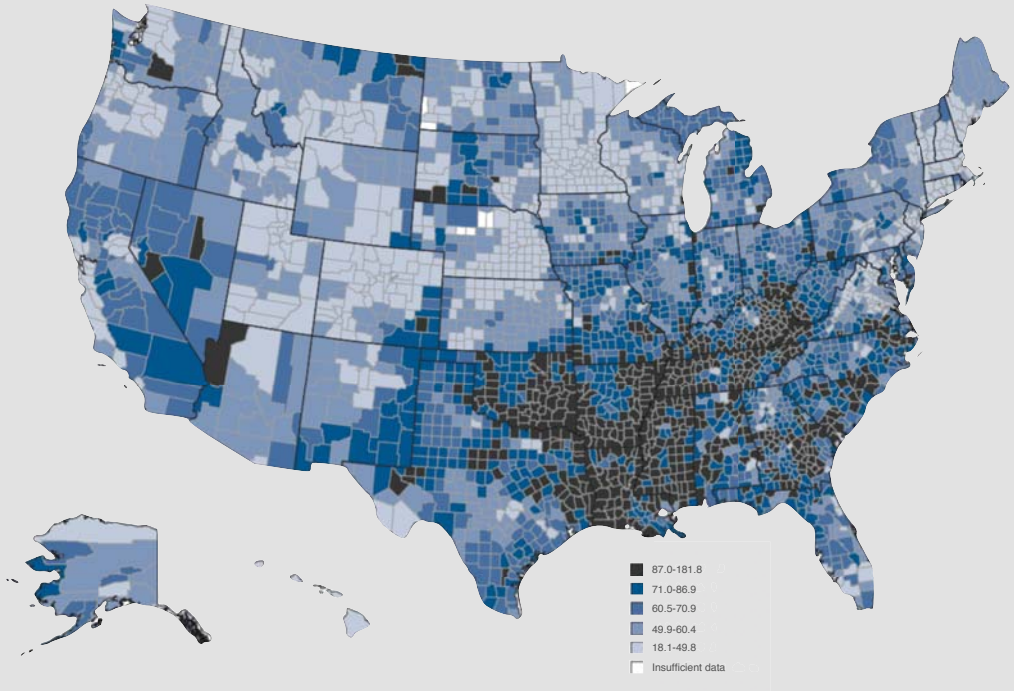
60%
Increase in the # of adults with HTN globally by 2025

10%
Percent of all global healthcare spending attributable to high blood pressure

$370 Billion
Annual worldwide cost of hypertension

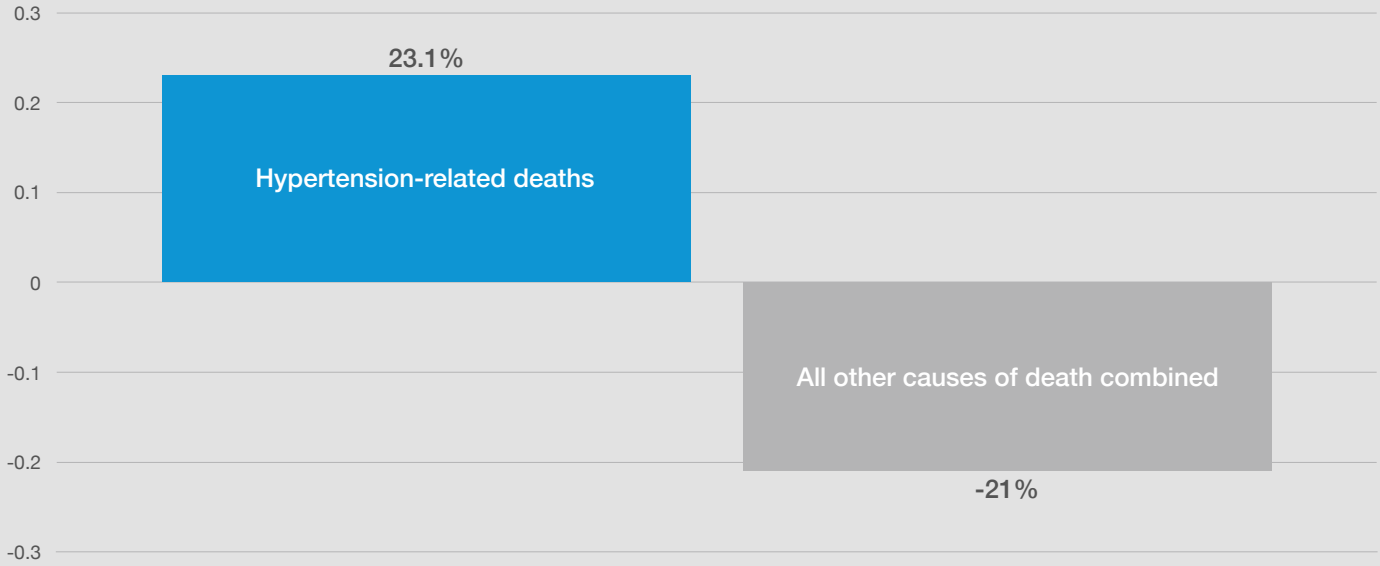
Kearney PM, et al. Lancet 2005;365:217–223. Gaziano AB, et al. J Hypertens 2009;27:1472–1477.
Source: World Health Organization. Noncommunicable Diseases in the South-East Asia Region. 2011.
http://apps.searo.who.int/PDS_DOCS/B4793.pdf Bloch MJ, et al. JASH 2016;10:753–754.

Hypertension-Related Deaths - United States, 2008-2010



U.S. Age-Adjusted Death Rates

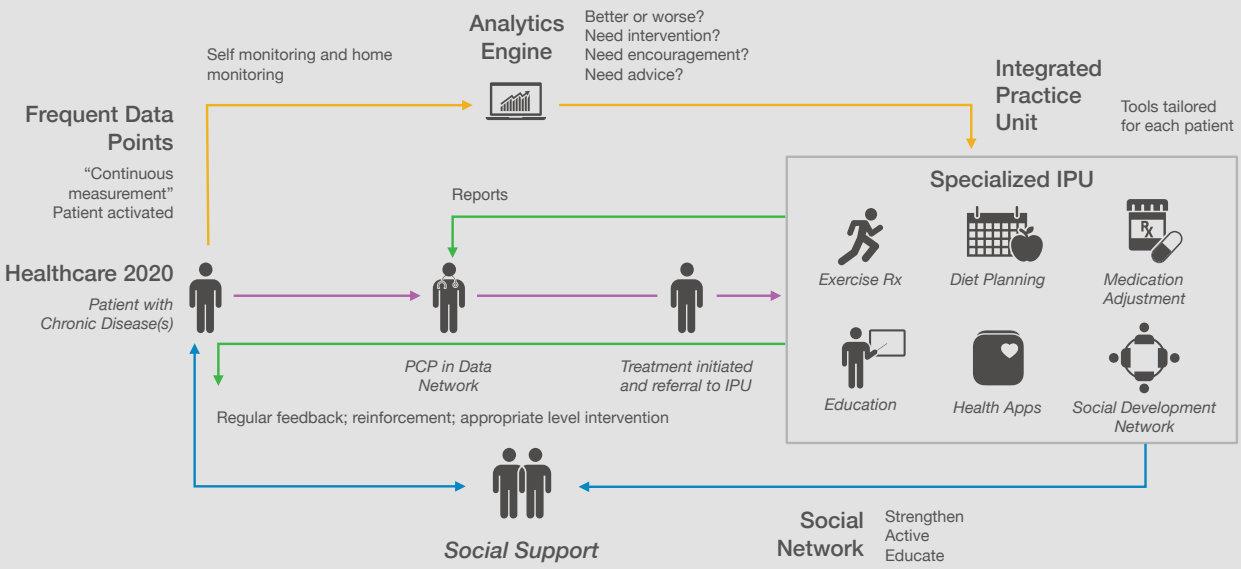
2000–2013



Kung H-C, et al. NCHS Data Brief, Centers for Disease Control, No. 193; March 2015

Chronic Disease Care

New delivery model



Milani RV, Lavie CJ. Am J Med 2015;128:337–343.

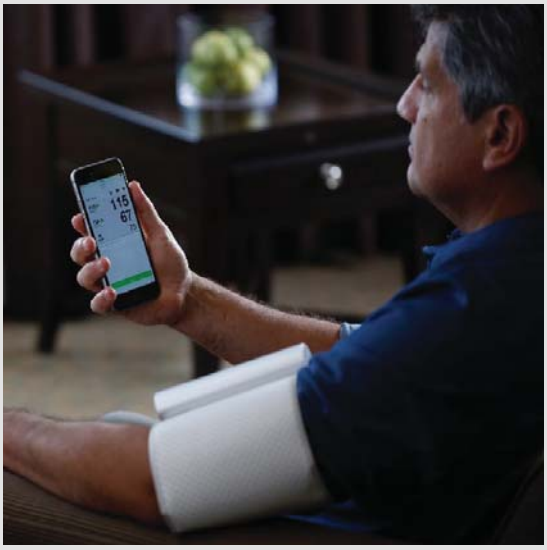
AHA/ASH Scientific Statement

Home blood pressure monitoring

Current technology is accurate, reliable, easy to use, and inexpensive

Home BP readings are

- Better predictor of CV risk than office measurements
- More reproducible and show better correlation with measures of target organ damage
- Shown to improve medication adherence

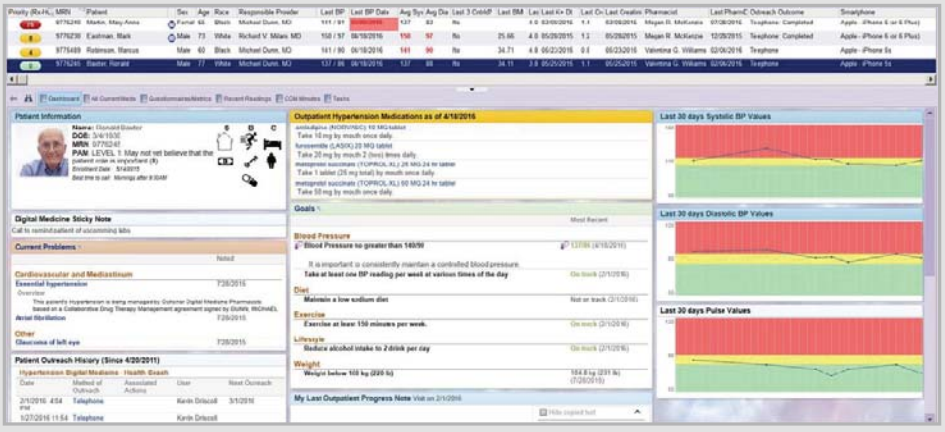


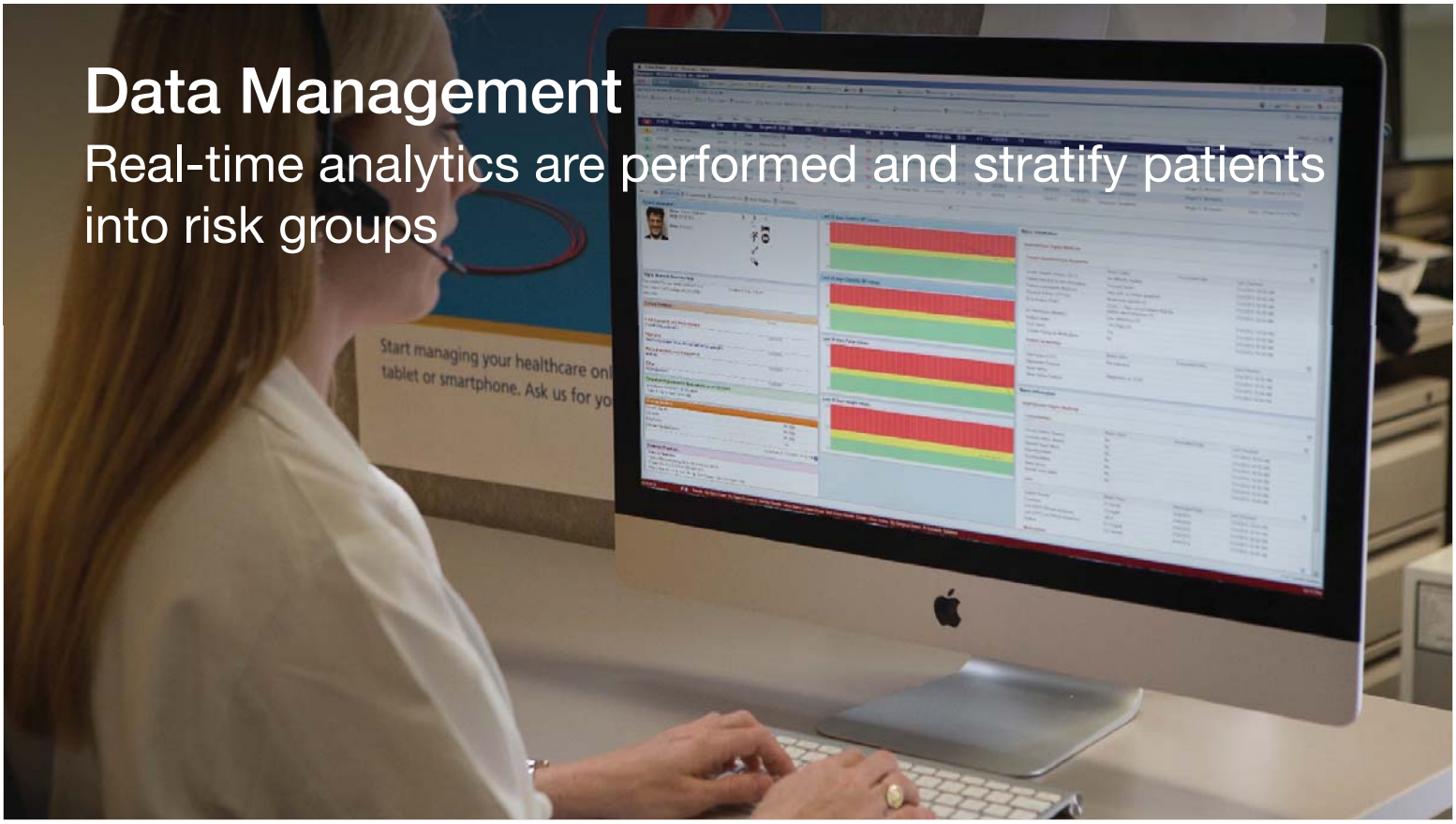
Pickering TG, et al. Hypertension 2008;52:10–29.

Data Management

Data algorithms

Customized data visualization tools that reduces chart time and maximizes care team efficiency and accuracy





Hypertension Enrollment

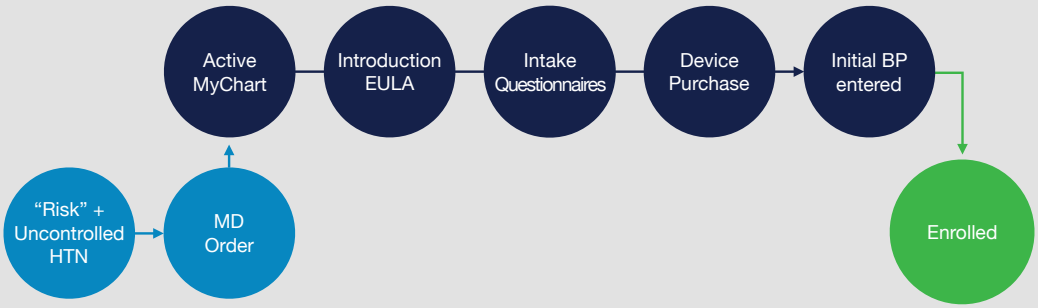
Start enrollment

Hypertension Enrollment

Start enrollment

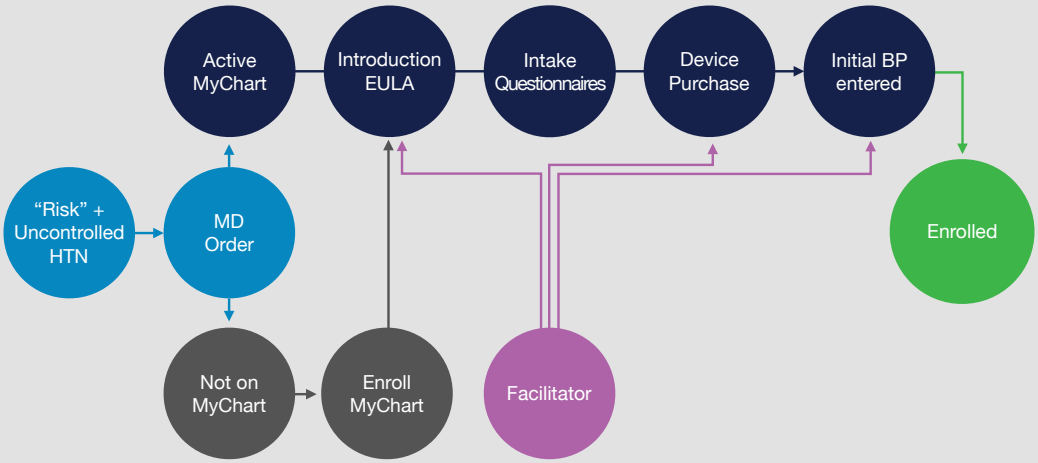
Hypertension Enrollment

Start enrollment



Hypertension Enrollment

Start enrollment



Patient Characterization

Onboarding

Milani RV, Lavie CJ. Am J Med 2015;128:337–343.

Patient Characterization

Onboarding

Dietary analysis

Medication adherence

Living circumstances

Medication affordability

Social network

Caregiver support

Depression

Patient activation measure

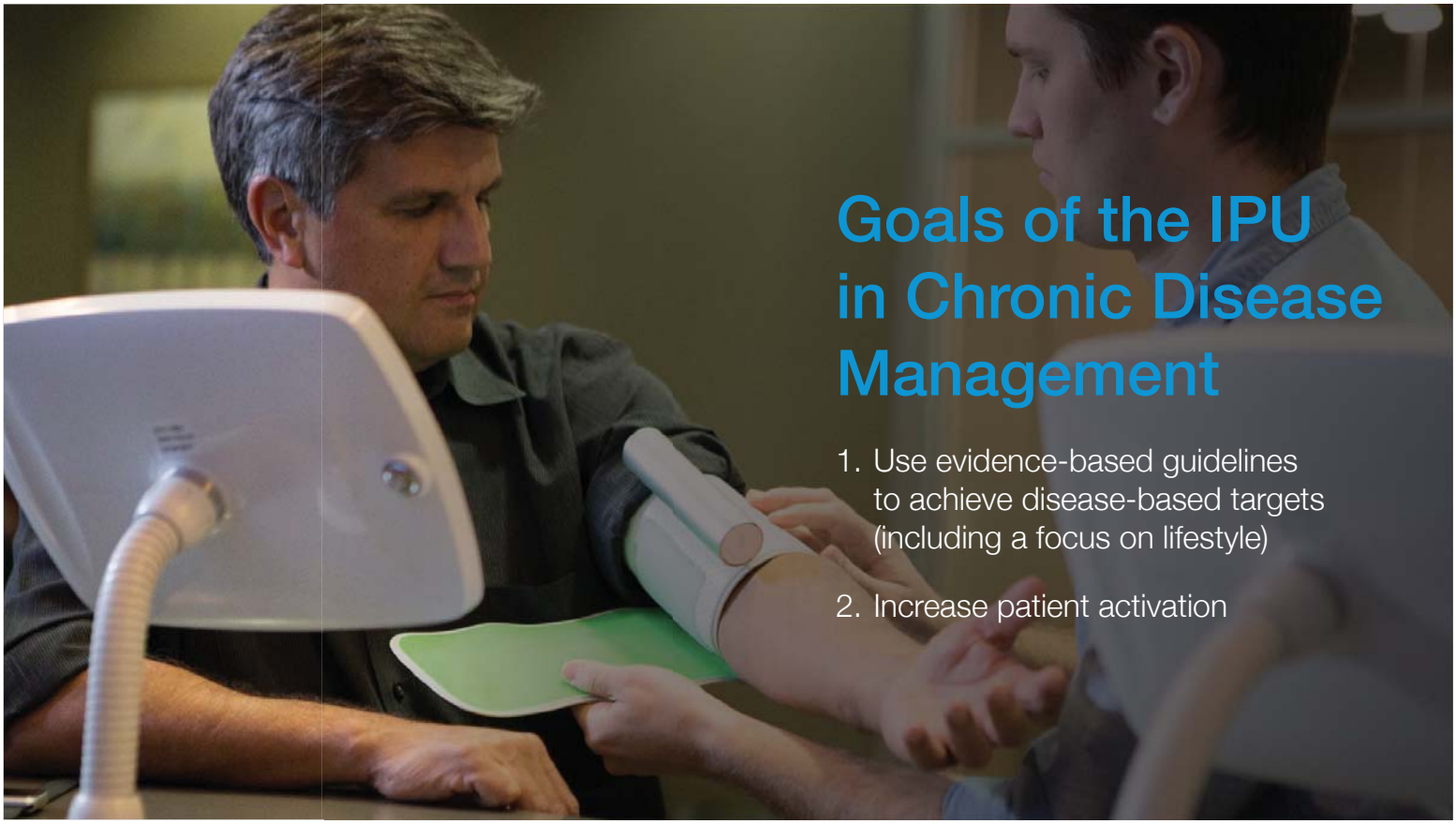
Physical activity index

Health literacy

Transportation issues

Access to care

Milani RV, Lavie CJ. Am J Med 2015;128:337–343.

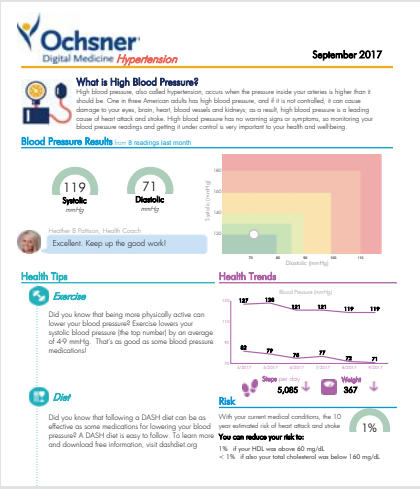


Goals of the IPU in Chronic Disease Management

1. Use evidence-based guidelines to achieve disease-based targets (including a focus on lifestyle)
2. Increase patient activation

Automated Patient Feedback

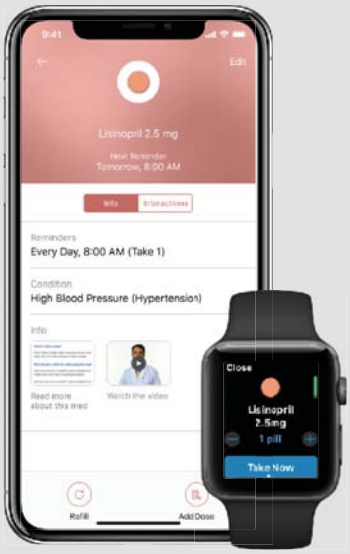
Patients receive a monthly report card



+

As well as encouragement

Medication Reminders



Outcomes

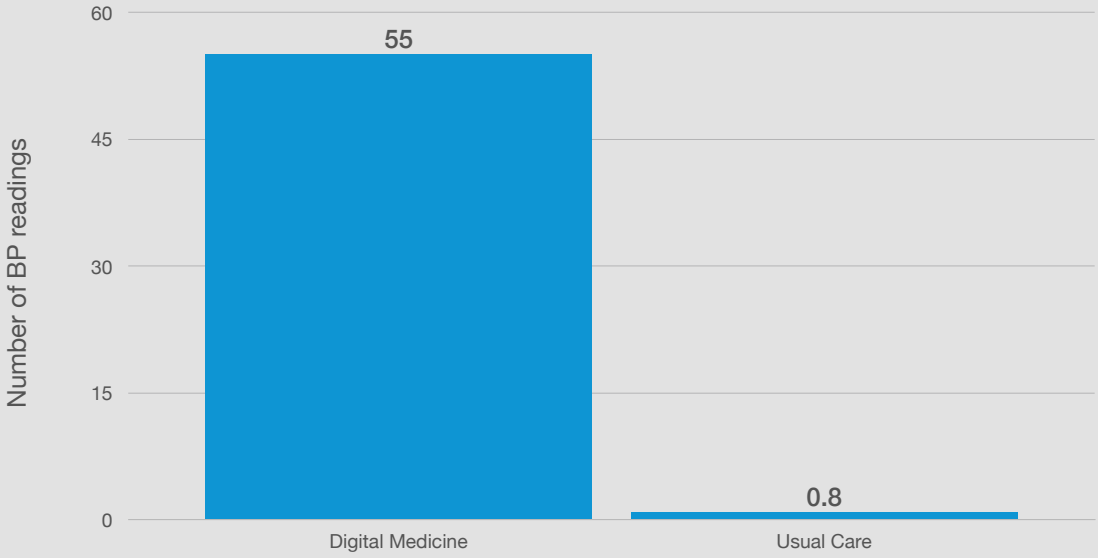
Blood pressure control

Patient satisfaction

Patient activation

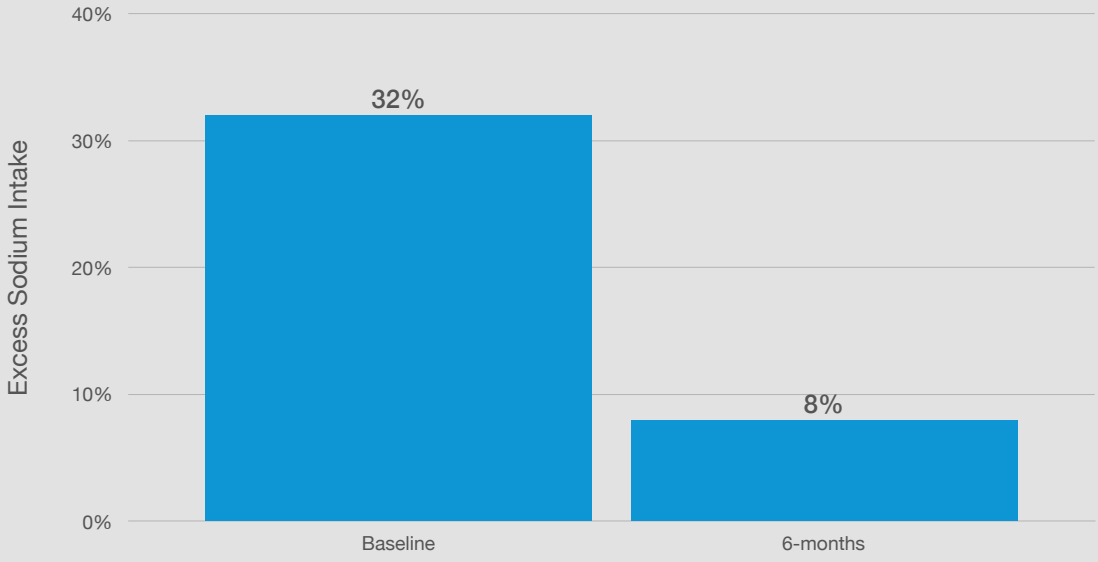
BP Data Collected

90-Days



Milani RV, et al. Am J Medicine 2017;130:14–20.

Reduction in Sodium Consumption



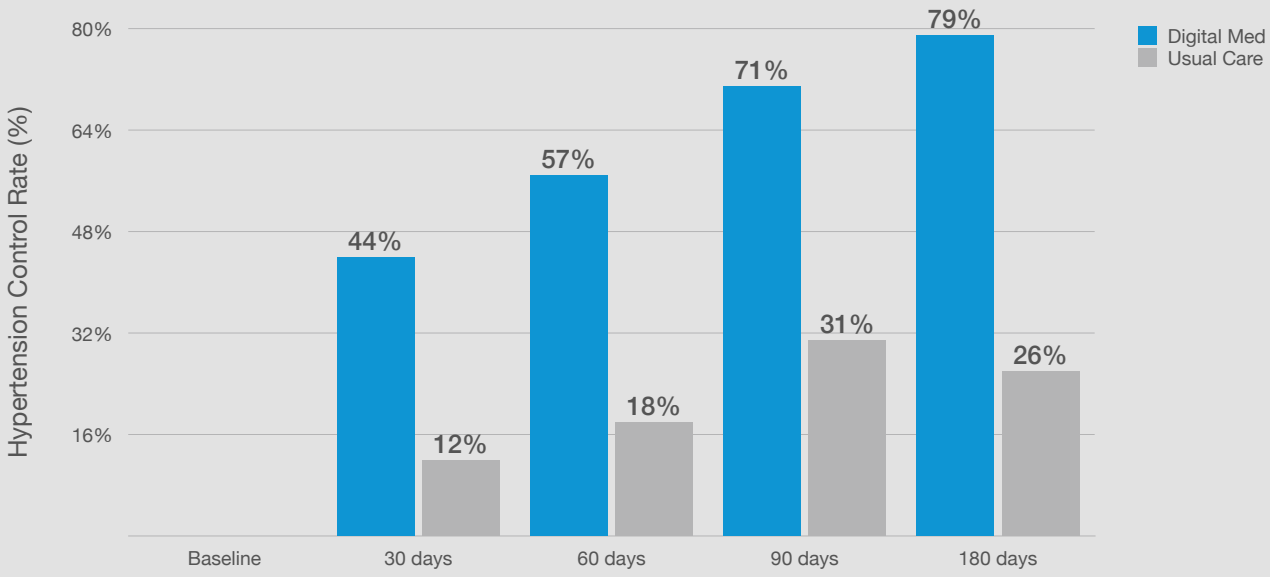
Milani RV, et al. Am J Medicine 2017;130:14–20.

Patients Achieving Goal BP

Hypertension Control Rate (%)

Milani RV, et al. Am J Medicine 2017;130:14–20.

Patients Achieving Goal BP



Milani RV, et al. Am J Medicine 2017;130:14–20.

Patient-Level Outcomes

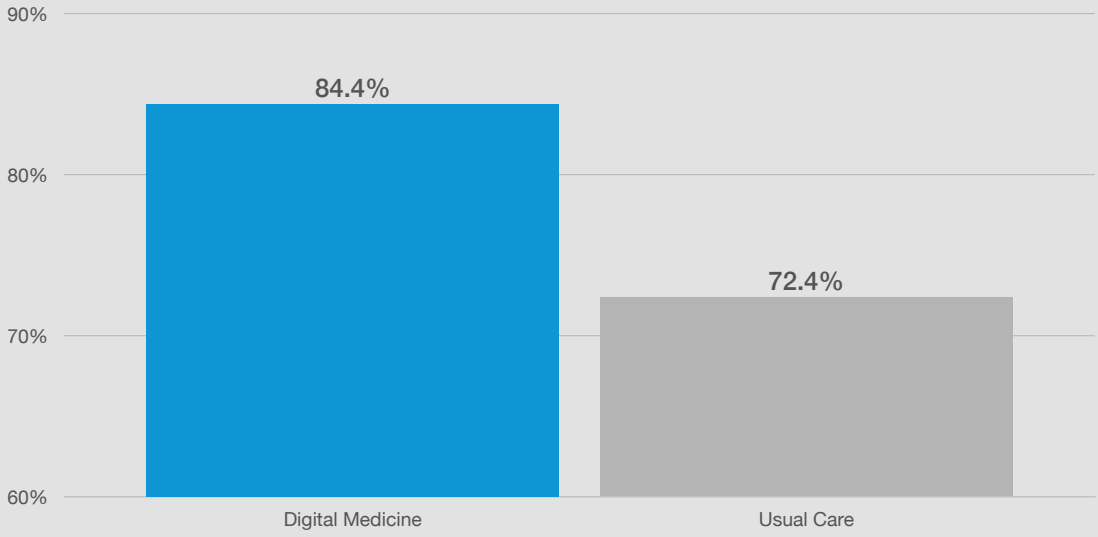
Overall satisfaction

p<0.001

Milani RV, et al. *Am J Medicine* 2017;130:14–20.

Patient-Level Outcomes

Overall satisfaction



p<0.001

Milani RV, et al. *Am J Medicine* 2017;130:14–20.

Patient-Level Outcomes

Activation

Mean Patient Activation

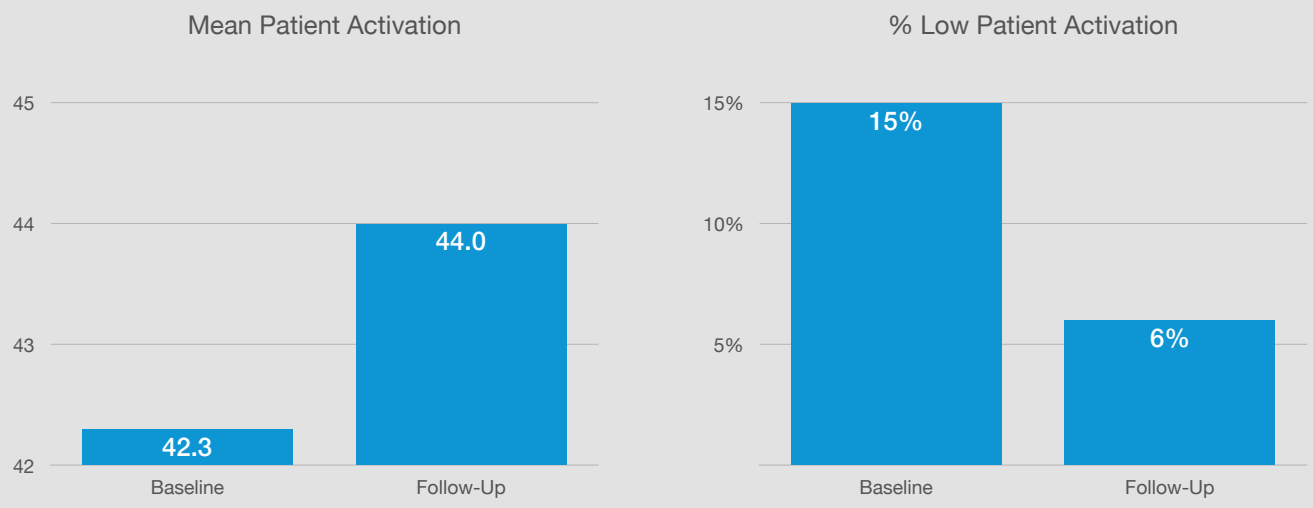
% Low Patient Activation

p<0.05

Milani RV, et al. Am J Medicine 2017;130:14–20.

Patient-Level Outcomes

Activation



p<0.05

Milani RV, et al. Am J Medicine 2017;130:14–20.

Medication-level Outcomes

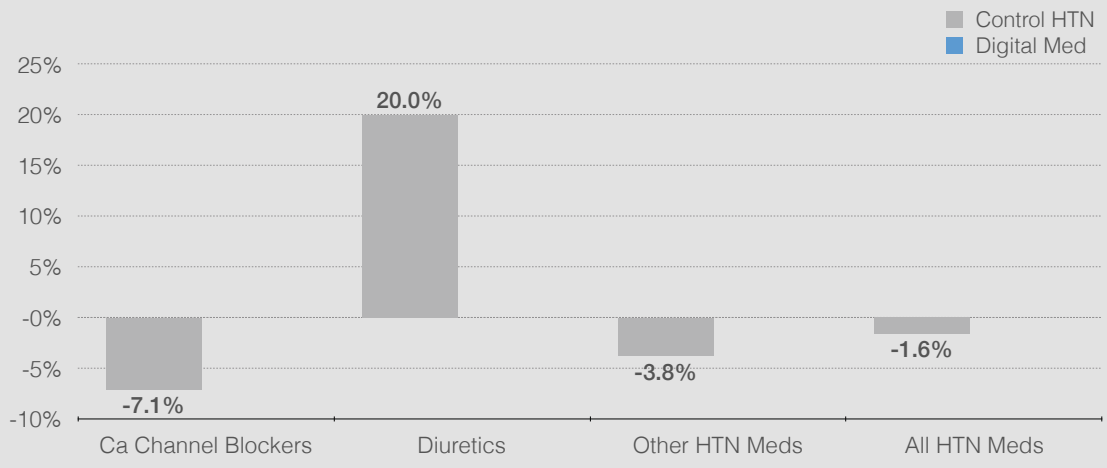
Adherence - Proportion of Days Covered (PDC)

Change in Medication Adherence (PDC ≥ 80%) at 6 months

Source: Blue Cross Blue Shield of Louisiana

Medication-level Outcomes

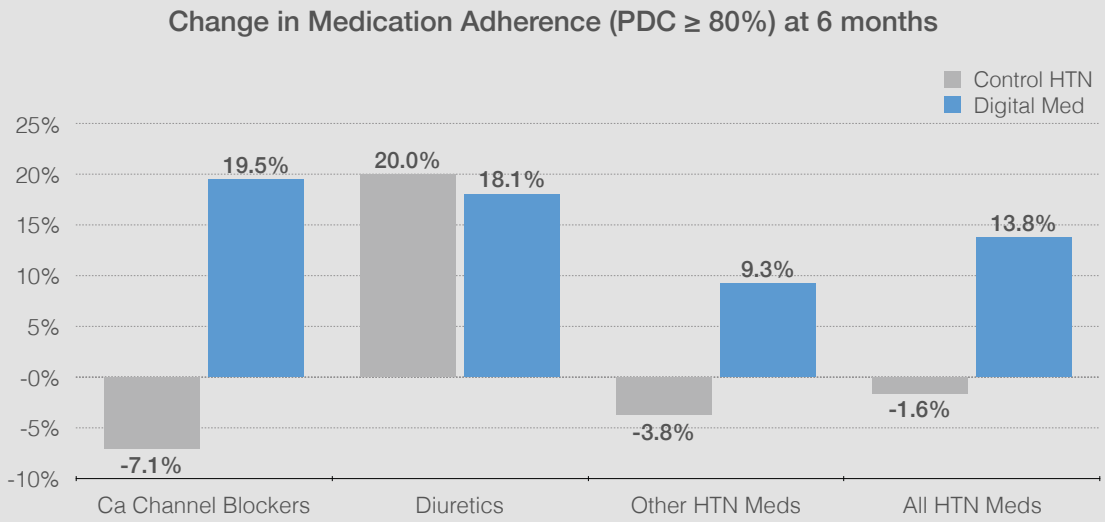
Adherence - Proportion of Days Covered (PDC)



Source: Blue Cross Blue Shield of Louisiana

Medication-level Outcomes

Adherence - Proportion of Days Covered (PDC)



Source: Blue Cross Blue Shield of Louisiana

Patient-Level Outcomes, Health

Consumer assessment of healthcare providers and systems

cahps

Overall Health

p<0.0004

Mental Health

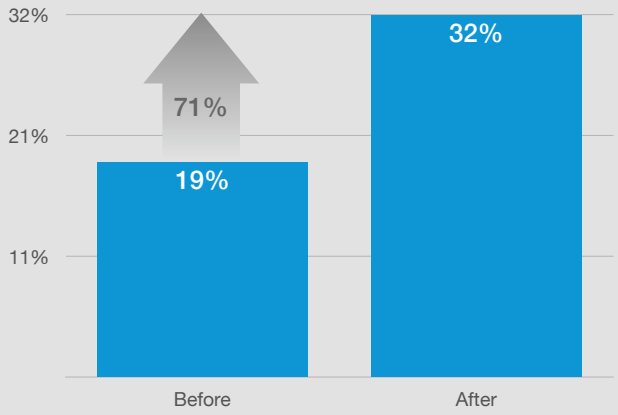
p<0.0001

Patient-Level Outcomes, Health

Consumer assessment of healthcare providers and systems

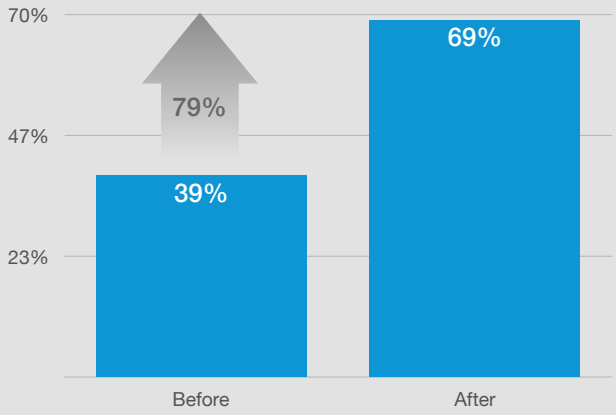
Overall Health

p<0.0004



Mental Health

p<0.0001



Patient-Level Outcomes, Medication

Consumer assessment of healthcare providers and systems

Taking Medication

p<0.0001

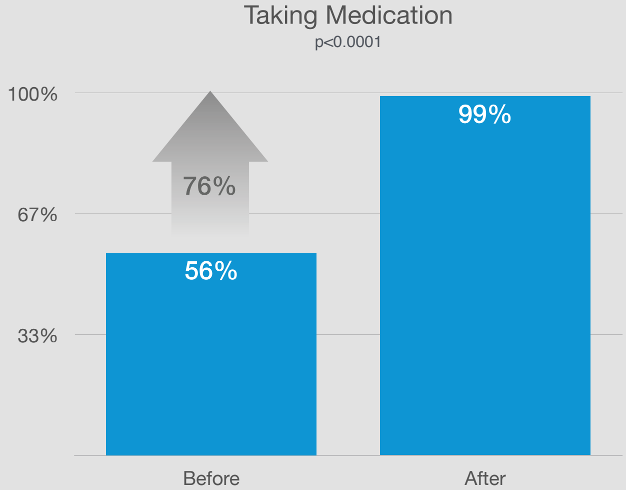
Discussing Medication

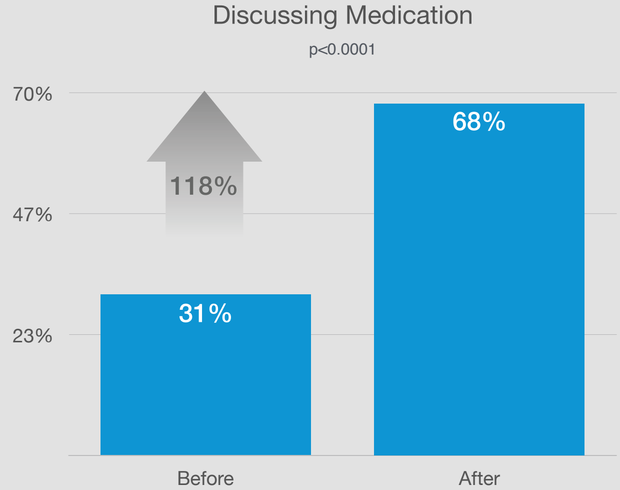
p<0.0001

Patient-Level Outcomes, Medication

cahps

Consumer assessment of healthcare providers and systems

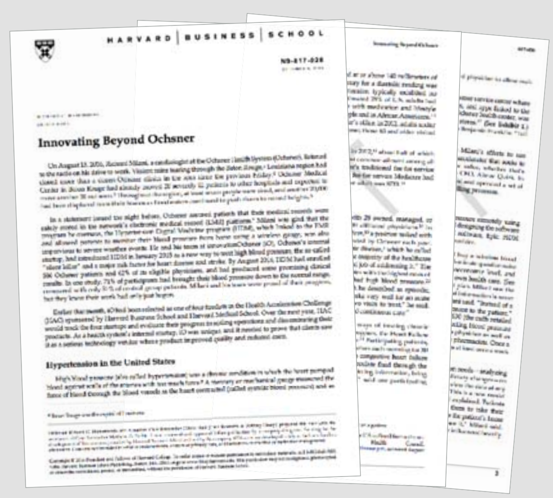




HealthIT.gov

HARVARD BUSINESS SCHOOL

HARVARD MEDICAL SCHOOL



Why Utilize Virtual Care?

Top three reasons why consumers tried virtual health

37%

It was more **convenient** than traditional, in-person health services

34%

I use technology in **all aspects** of my life and want to do the same with healthcare

34%

I was **curious** to try getting healthcare services virtually

Source: Accenture 2017 Consumer Survey on Virtual Health

Why Utilize Virtual Care?

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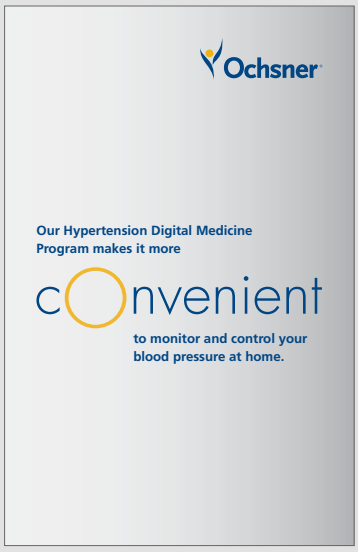
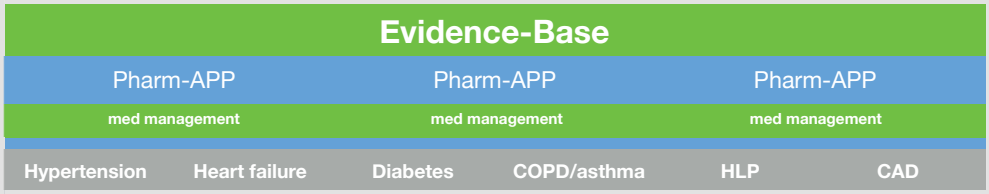
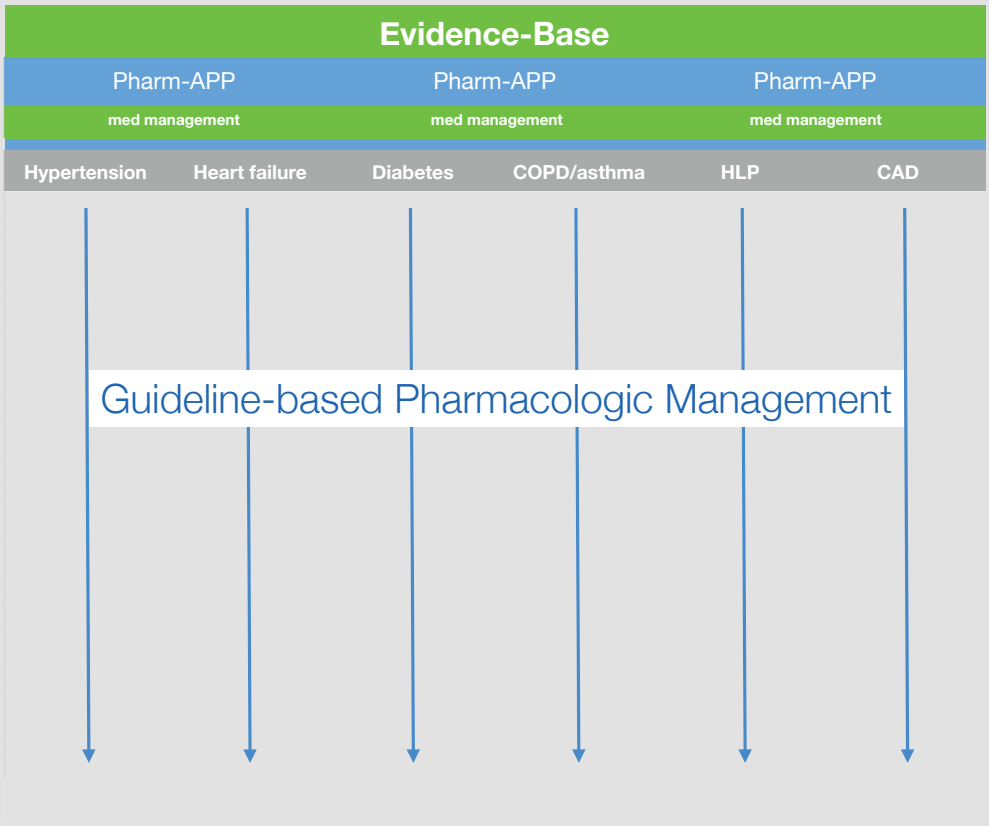



Evidence-Base
Pharm-APP
Pharm-APP
Pharm-APP
med management
med management
med management
Hypertension
Heart failure
Diabetes
COPD/asthma
HLP
CAD


Evidence-Base
Pharm-APP
Pharm-APP
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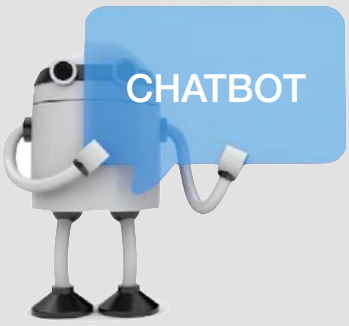
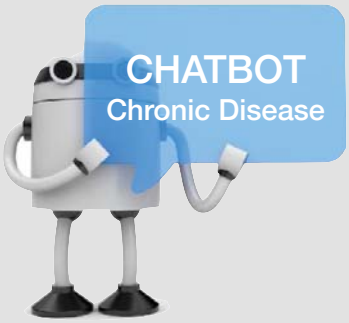
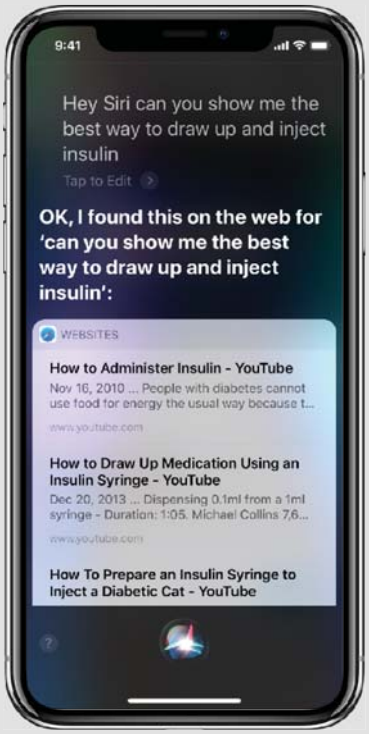
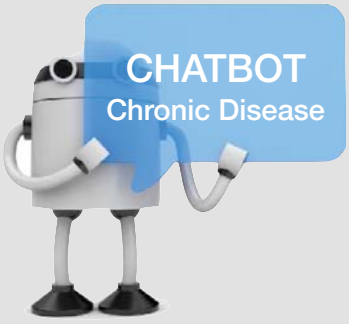
med management
med management
med management
Hypertension
Heart failure
Diabetes
COPD/asthma
HLP
CAD
Guideline-based Pharmacologic Management

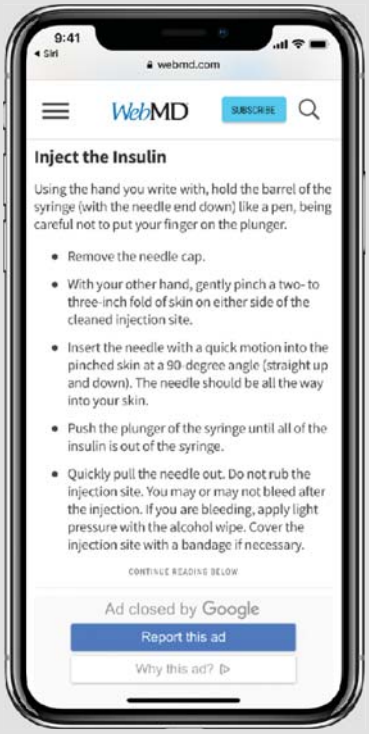
Social Behavioral	Evidence-Base		
	Pharm-APP	Pharm-APP	Pharm-APP
	med management	med management	med management
Health coach	Hypertension	Heart failure	Diabetes	COPD/asthma	HLP	CAD
Activity	→					
Diet	→					
Addiction	→					
Adherence	→					
Depression	→					
Social isolation	→					
Med afforability	→					
Transportation	→					
Health literacy	→					
Fam/caregiver support	→					
Education resources	→					
Reports (patient, MD)	→					
Auto-feedback loops	→					
Activation	→					
Peer-to-peer	→					
Device mgmt	→					
Environment	→					




CHATBOT
Chronic Disease


9:41
Hey Siri can you show me the best way to draw up and inject insulin
Tap to Edit
OK, I found this on the web for 'can you show me the best way to draw up and inject insulin':
WEBSITES
How to Administer Insulin - YouTube
Nov 16, 2010 ... People with diabetes cannot use food for energy the usual way because t...
www.youtube.com
How to Draw Up Medication Using an Insulin Syringe - YouTube
Dec 20, 2013 ... Dispensing 0.1ml from a 1ml syringe - Duration: 1:05. Michael Collins 7,6...
www.youtube.com
How To Prepare an Insulin Syringe to Inject a Diabetic Cat - YouTube


CHATBOT
Chronic Disease


9:41
Siri
webmd.com
WebMD
SUBSCRIBE
Inject the Insulin
Using the hand you write with, hold the barrel of the syringe (with the needle end down) like a pen, being careful not to put your finger on the plunger.
Remove the needle cap.
With your other hand, gently pinch a two- to three-inch fold of skin on either side of the cleaned injection site.
Insert the needle with a quick motion into the pinched skin at a 90-degree angle (straight up and down). The needle should be all the way into your skin.
Push the plunger of the syringe until all of the insulin is out of the syringe.
Quickly pull the needle out. Do not rub the injection site. You may or may not bleed after the injection. If you are bleeding, apply light pressure with the alcohol wipe. Cover the injection site with a bandage if necessary.
CONTINUE READING BELOW
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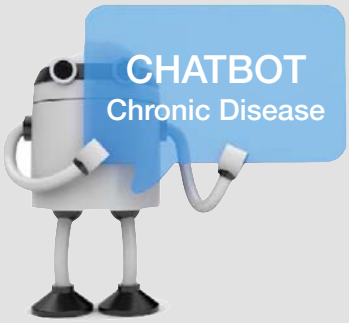

Questions

Reengineering Hospital Care to Improve Patient Outcomes

- Hospital Harm
- Circadian Rhythms in Health and Disease
- Improving the Environment of Care
- Artificial Intelligence in Hospital Care

Reengineering Hospital Care to Improve Patient Outcomes

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Hospital Harm

Primum non nocere

- Approximately 440,000 yearly deaths from U.S. hospital errors making this the 3rd leading cause of death in the U.S.
- Medicare patients have a 1 in 4 chance of experiencing harm during a hospital admission.
- About 1 in 25 people admitted to a US hospital will contract a hospital acquired infection (HAI) (1 in 10 in the UK).

Source: Leapfrog Hospital Safety Grade http://www.hospitalsafetygrade.org/what-is-patient-safety_m` Magill S.S., et al. *N Engl J Med* 2014;370:1198-208.

Value of Patient Communication

IOM recommends individuals receive access to medical and clinical information, enabling them to be the **'source of control'** in making healthcare decisions.

- Being a hospital patient has been called 'one of the most disempowering situations one can experience in modern society'.
- 90% of hospitalized patients want to review their hospital medication list, but only 28% were given the opportunity.
- Only 32% of hospital patients could correctly name even one of their hospital physicians.

Tang P, et al. Health Affairs 2005;24:1290-1295. Prey JE, et al. J Am Med Inform Assoc. 2014;21:742-750.
Cumbler E, et al. J Hosp Med 2010;5:83-86. O'Leary KJ, et al. Mayo Clin Proc 2010;85:47-52.

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OF THE NATIONAL ACADEMIES

Tang P, et al. Health Affairs 2005;24:1290-1295. Prey JE, et al. J Am Med Inform Assoc. 2014;21:742-750.
Cumbler E, et al. J Hosp Med 2010;5:83-86. O'Leary KJ, et al. Mayo Clin Proc 2010;85:47-52.

Source: Leapfrog Hospital Safety Grade http://www.hospitalsafetygrade.org/what-is-patient-safety_m Magill S.S., et al. *N Engl J Med* 2014;370:1198-208.

Hospital Discharge

Nearly 20% of patients experience adverse events within 3 weeks of hospital discharge

Source: Leapfrog Hospital Safety Grade http://www.hospitalsafetygrade.org/what-is-patient-safety_m Magill S.S., et al. *N Engl J Med* 2014;370:1198-208.

Post-Hospitalization Syndrome

- An acquired, transient period of **vulnerability** derived from the allostatic and physiologic stress that patients experience in the hospital.
- During hospitalization, patients typically experience:
  - deprivation of sleep
  - disruption of normal circadian rhythms
  - poorly nourished
  - have pain and discomfort
  - receive medications that can alter cognition and physical function
  - become deconditioned by bed rest or inactivity

Krumholz HM. *N Engl J Med* 2013; 368:100-102.

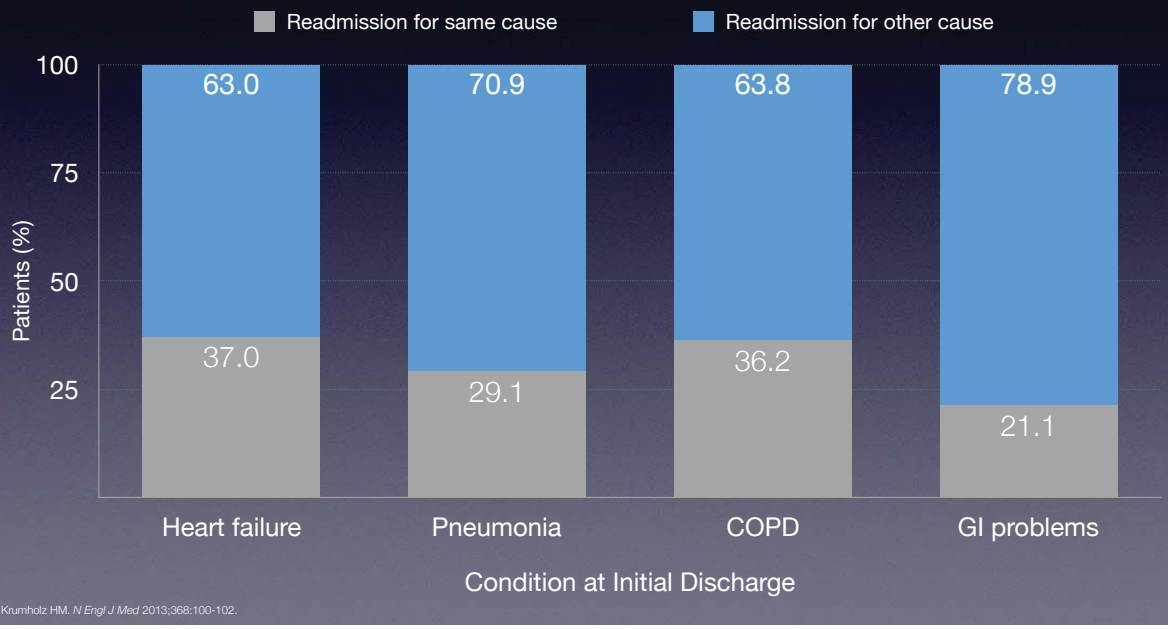
Post-Hospitalization Syndrome

- Polysomnography during hospitalization:
  - reduction in total sleep time
  - reduction in REM and N3 (slow wave) and increase in non-REM
- Results in behavioral and physiologic effects impacting:
  - metabolism
  - cognitive performance
  - physical functioning and coordination
  - immune function
  - coagulation cascade

Krumholz HM. *N Engl J Med* 2013; 368:100-102.

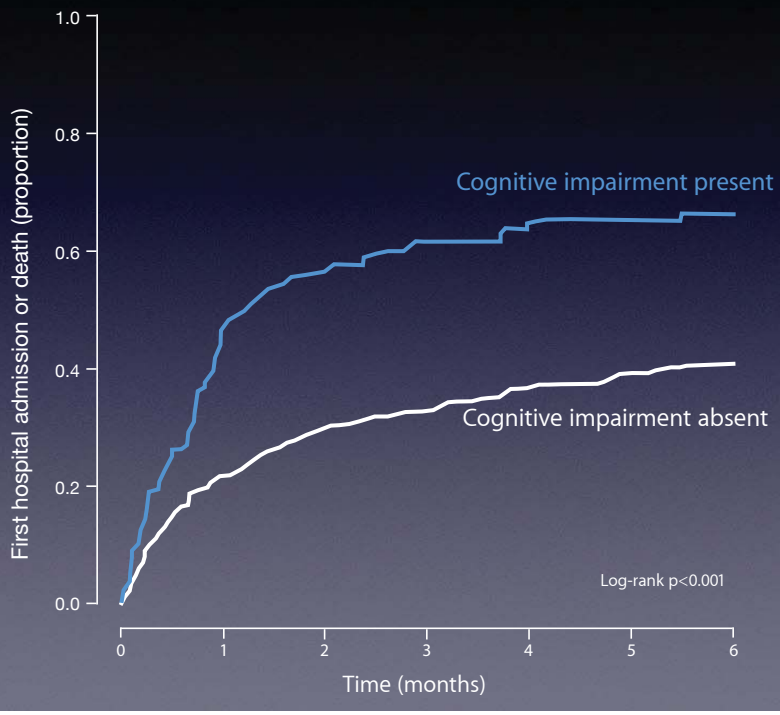
U.S. Medicare Readmission Data

Two-thirds of readmissions due to unrelated cause



Krumholz HM. *N Engl J Med* 2013;368:100-102.

Impact of Cognitive Impairment on Readmission or Death



Independent predictor of composite outcome (HR 1.9; p<0.0001) and was the most important predictor among 55 variables.

Patel A, et al. *Circ Heart Fail.* 2015;8:8-16.

Discharge Comprehension

- 200 patients admitted for > 24 hours to acute medicine, age ≥ 70 years
- Tested for cognitive function* at discharge
- 31.5% of subjects had unrecognized low cognition
- One month later, 58% of these patients no longer had low cognition ($p<0.001$).

*Mini-Mental Status Examination (MMSE), Backward Digit Span, 15 word immediate and delayed recall test.

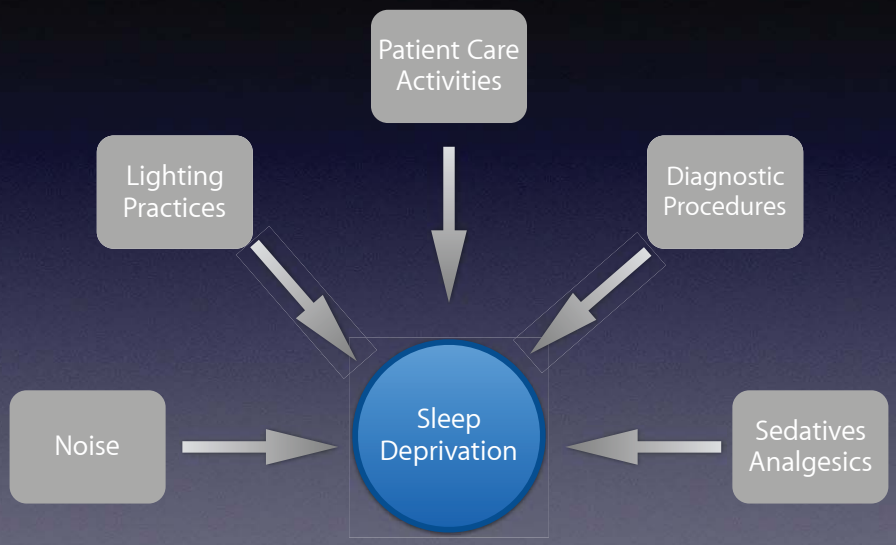
Lindquist LA et al. *J Gen Intern Med* 2011:26:765-770.

Discharge Comprehension

- 172 patients admitted for > 24 hours to acute medicine, discharged on ≥ 1 new medication
- Tested for medication literacy 4-18 days after discharge (name, dosage schedule, purpose) and whether they could name their medical contact person.
- 86% aware a new medication had been Rxed, 64% could name the med, 64% purpose, 56% dosage.
- Age and not education level was the best predictor of poor medication literacy.

Maniaci M, et al. *Mayo Clin Proc* 2008;83:554-558.

Sleep Deprivation: Hospital Environmental Factors



Friese RS. *Crit Care Med* 2008;36:697-705.

Noise

- Objectively measured hospital noise can range as high as 67 dB in ICU to 42 dB on surgical/medical wards.
- World Health Organization (WHO) international recommendations for patient rooms is **≤ 30 dB**.
- 92 patients studied at Univ of Chicago Med Ctr.: >42% reported noise disruptions during sleep. Most common sources:
  - staff conversations (65%)
  - roommates (54%)
  - alarms (42%)
  - intercoms (39%)
  - pagers (38%)

Total average noise	48.0 dB
Peak noise	80.3 dB*
Nighttime average noise	38.2 dB
Nighttime peak noise	69.7dB

*equivalent to chain saw

Yoder JC, et al. *Arch Intern Med* 2012;172:68-70.

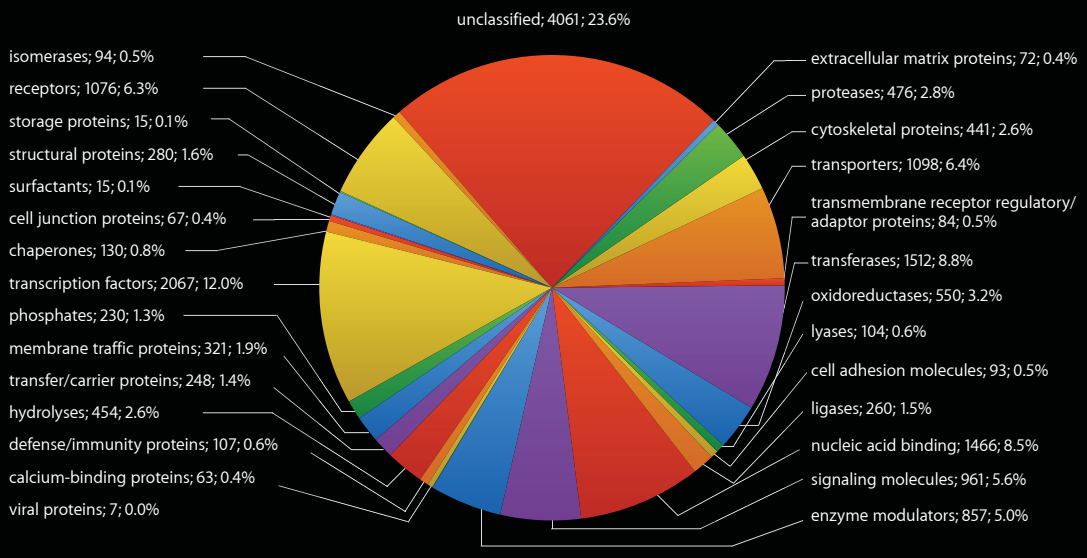

Reengineering Hospital Care to Improve Patient Outcomes


Reengineering Hospital Care to Improve Patient Outcomes
Hospital Harm
Circadian Rhythms in Health and Disease
Improving the Environment of Care
Artificial Intelligence in Hospital Care

Circadian Rhythm in Human Health

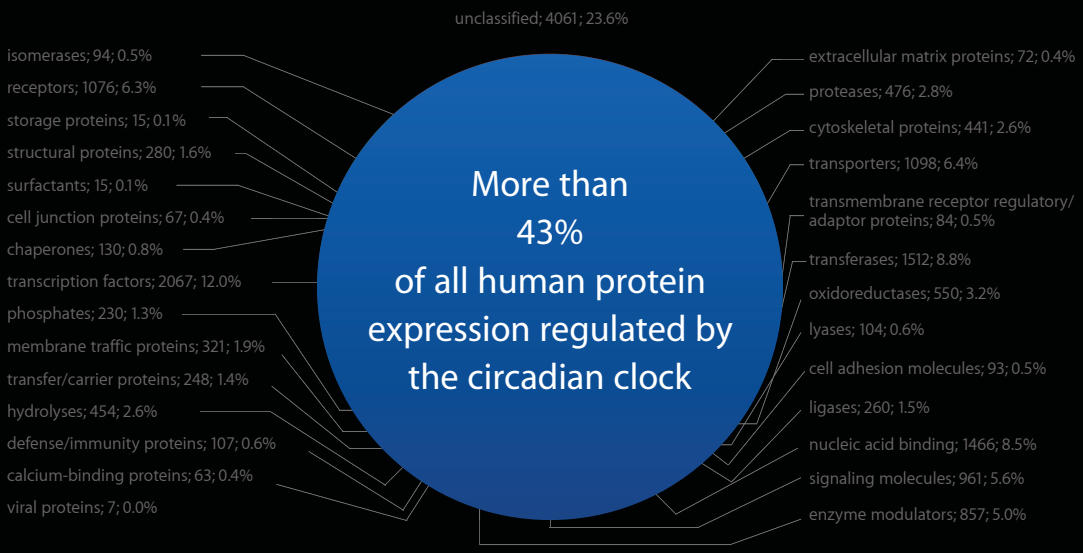
- Endogenous 24-h oscillations in behavior and biologic processes found in all kingdoms of life
- Allows an organism to adapt its physiology in anticipation of transitions between night and day
- The circadian clock drives oscillations in a diverse set of biological processes including sleep, locomotor activity, blood pressure, body temperature, and blood hormone levels.
- Regulates protein expression of the genome on a daily basis

Protein-Coding Gene Expression



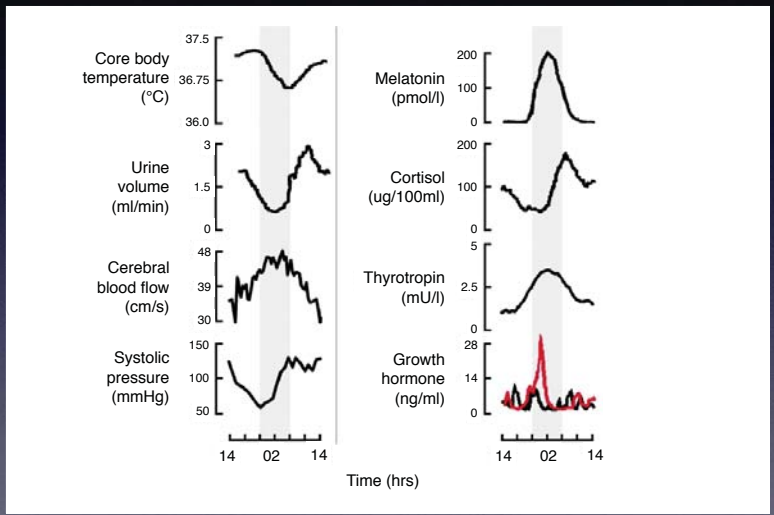
PANTHER Classification System: http://www.pantherdb.org/chart/summary/pantherChart.jsp?filterLevel=1&chartType=1&listType=1&type=5&species=Homo%20sapiens

Protein-Coding Gene Expression



PANTHER Classification System: http://www.pantherdb.org/chart/summary/pantherChart.jsp?filterLevel=1&chartType=1&listType=1&type=5&species=Homo%20sapiens

Physiologic and Circadian Cycles in Humans



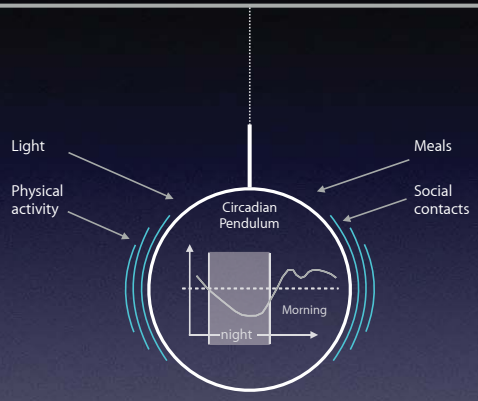
Hastings M, et al. *J of Endocrinology* 2007;195:187-198.

Zeitgeber

"Time giver" or "Synchronizer"

Common Examples

- Light
- Temperature
- Social interactions
- Pharmacological manipulation
- Exercise
- Eating / drinking patterns



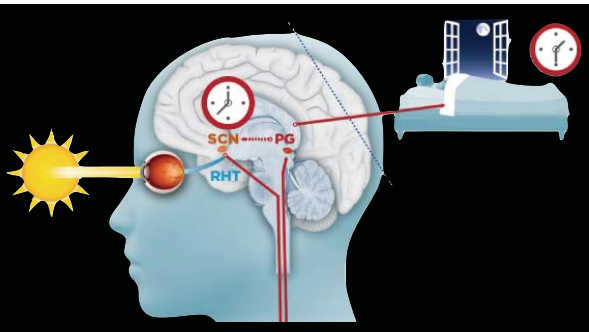
Intrinsically Photosensitive Retinal Ganglion Cells

(ipRGCs)

"Sightless visual responses"

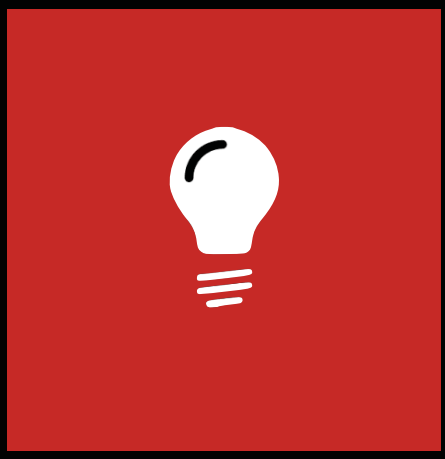
- Resets circadian clock
- Artificial light striking the retina between dusk and dawn:
  - ✦ Inhibits sleep-promoting neurons
  - ✦ Suppresses nightly release of melatonin

Czeisler C. *Nature* 2013; 497:S13.



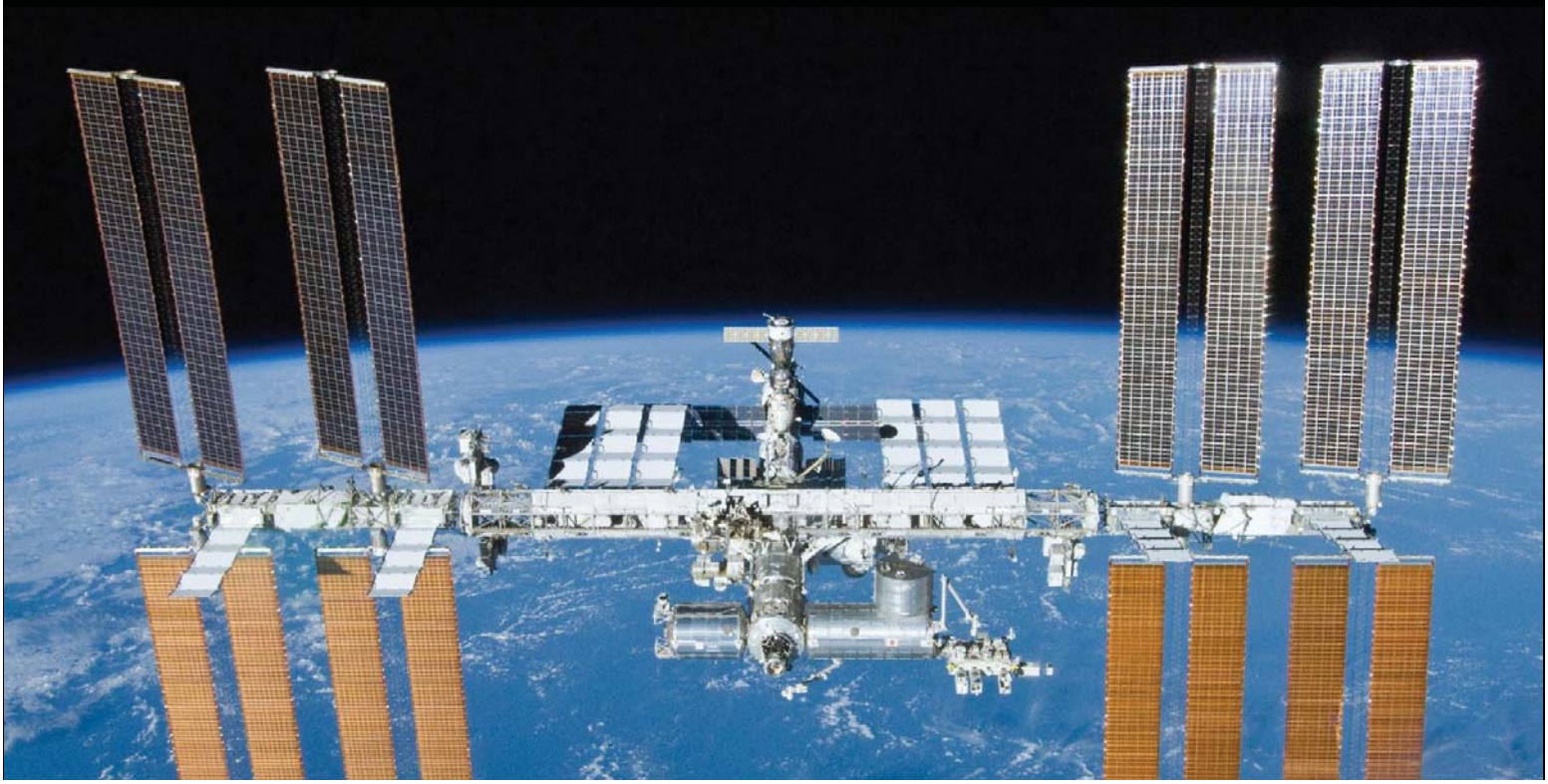
Most sensitive

Least sensitive

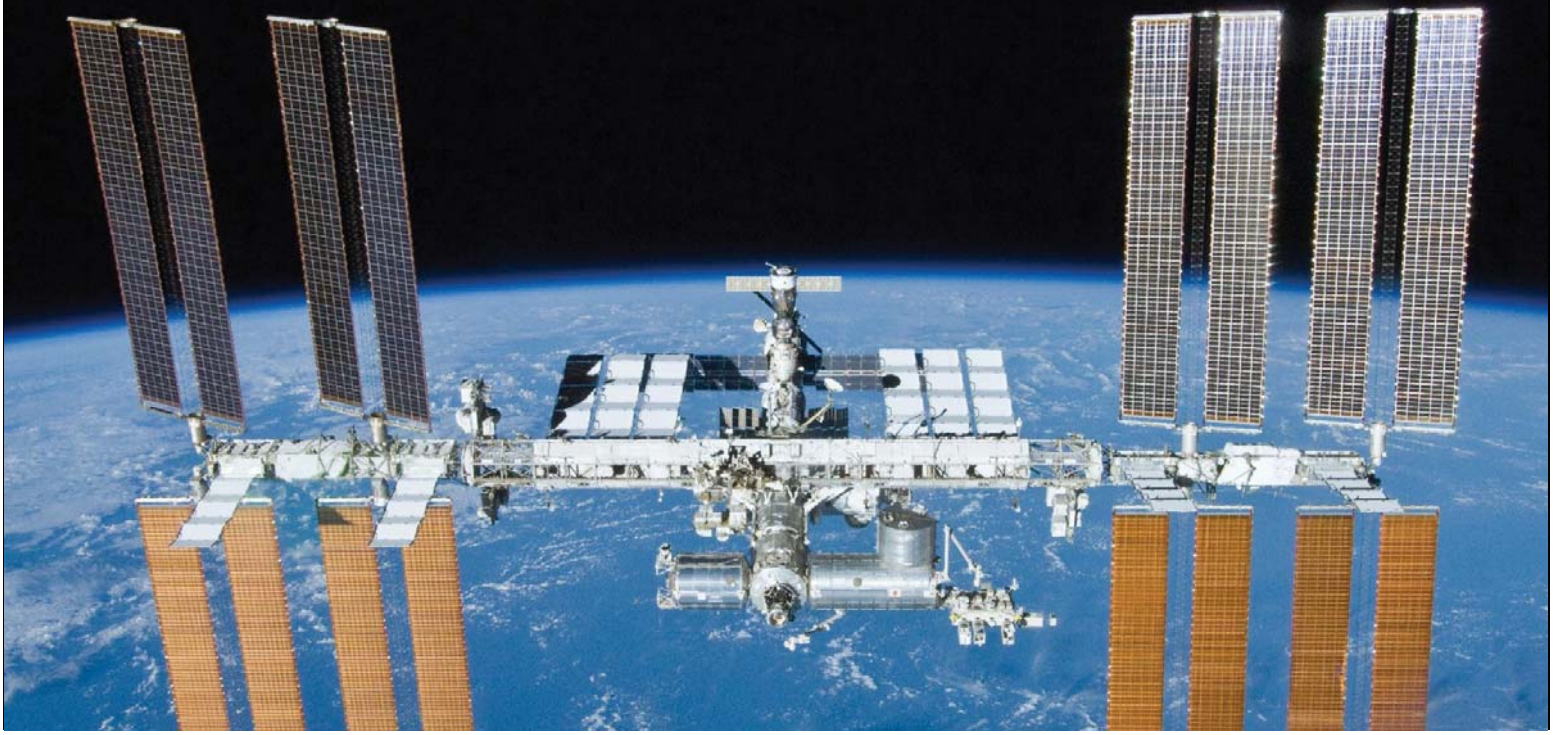


LEDs more disruptive than incandescent

How do we control circadian rhythms on the Space Shuttle?



Programmable LED Systems that shift from blue-enriched to red-enriched white light on a 24-hour cycle



Impact of Disrupting Circadian Rhythm on Population Health

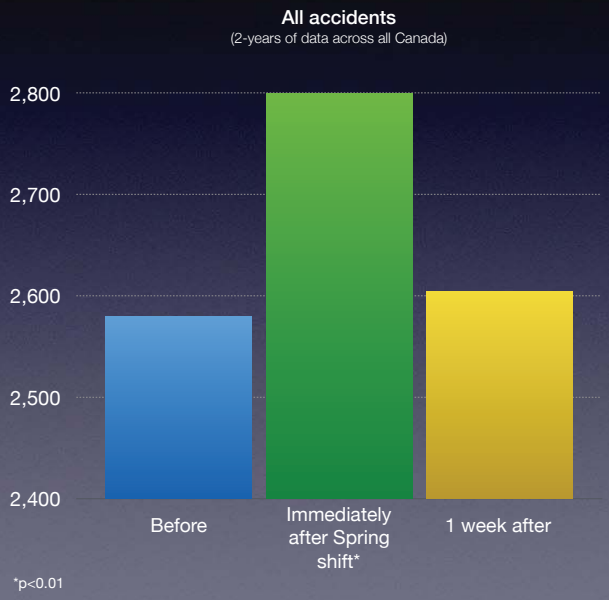
Shift Workers

- Obesity
- Diabetes
- Heart disease
- Stroke
- Cancer
- Injuries

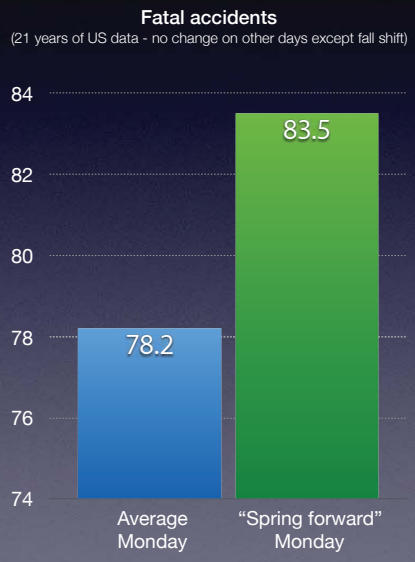
Vetter C, et al. *JAMA*. 2016;315:1726-1734. Wang XS, et al. *Occup Med (Lond)*. 2011;61:78-89.
Kawachi I, et al. *Circulation*. 1995;92:3178-3182. Vyas MV, et al. *BMJ*. 2012;345:e4800.

Circadian Effects of Changing to Daylight Savings Time

Increased risk of traffic accidents



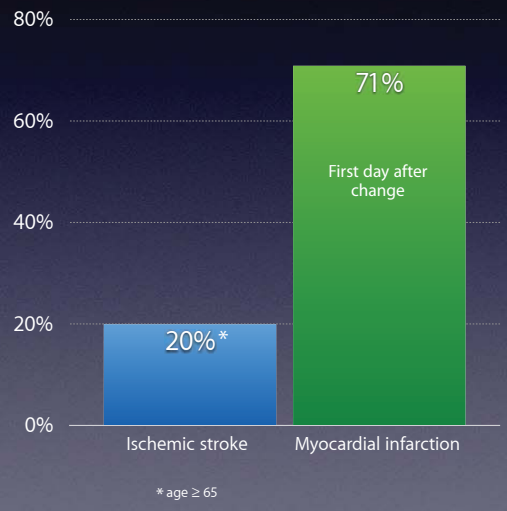
Coren S. *N Engl J Med* 1996; 334:924.



Varughese J. *Sleep Medicine* 2001;2:31-36.

Circadian Effects of Changing to Daylight Savings Time

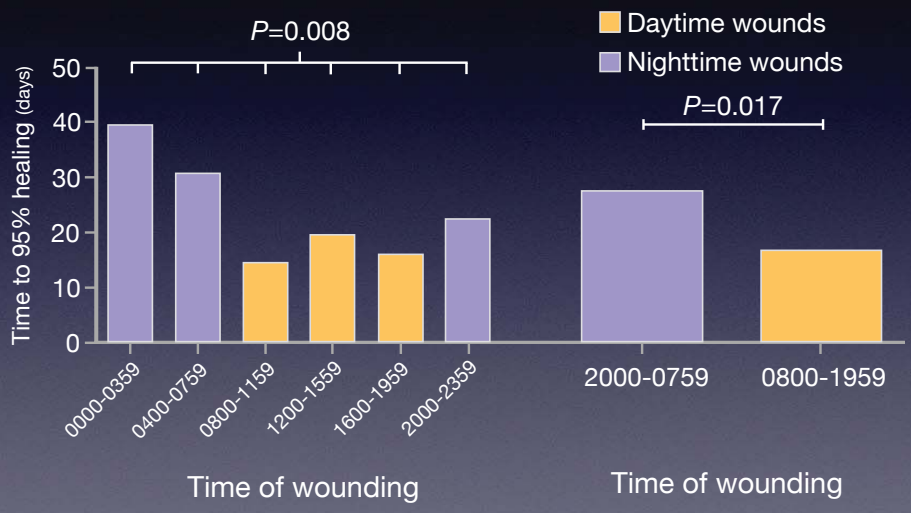
Increased risk of MI and stroke



Jidda MR, et al. *Arn J Cardiol* 2013;111:631-635.
American Academy of Neurology Annual Scientific Sessions 2016. http://www.webmd.com/stroke/news/20160229/daylight-saving-time-tied-to-brief-spike-in-stroke-risk

Circadian Effects on Wound Healing

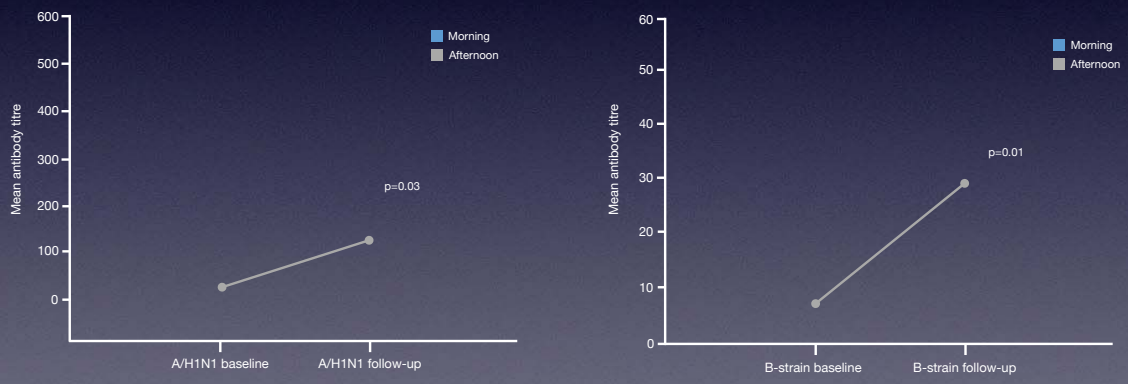
Burn injuries incurred during the daytime heal 60% faster than those incurred at night



Hoyle NP, et al. *Sci. Transl. Med.* 2017;9:1-10.

Circadian Effects of Vaccine Response

Morning vaccination enhances antibody response over afternoon vaccination



Long, JE, et al. *Vaccine* 2016;34:2679-2685.

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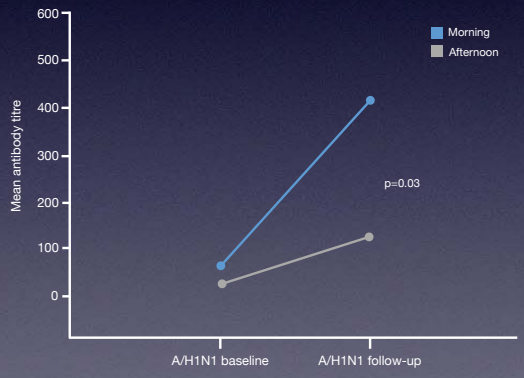
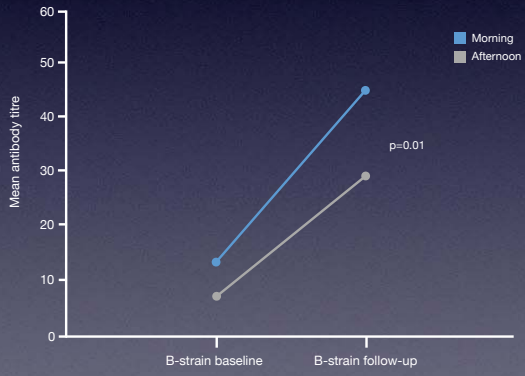


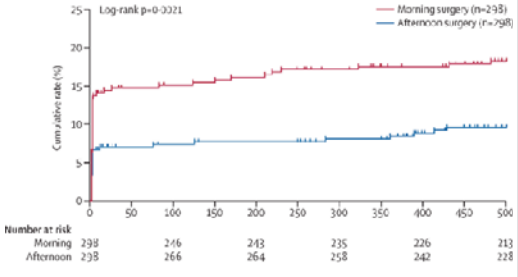


Long, JE, et al. *Vaccine* 2016;34:2679-2685.

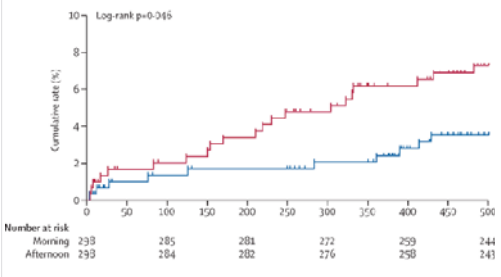
Circadian Effects upon Outcomes following Cardiac Surgery

Cardiovascular events after aortic valve replacement surgery according to time of day of surgery in matched cohort population

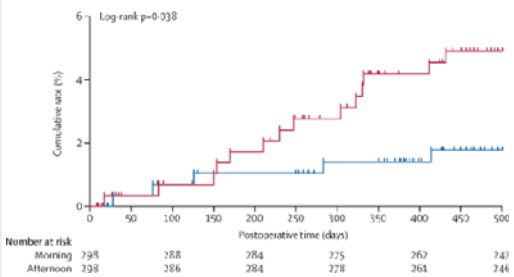
Major adverse cardiac event



Major adverse cardiac event without preoperative MI



Acute heart failure



Montaigne D, et al. *Lancet* 2018; 391:59-69.

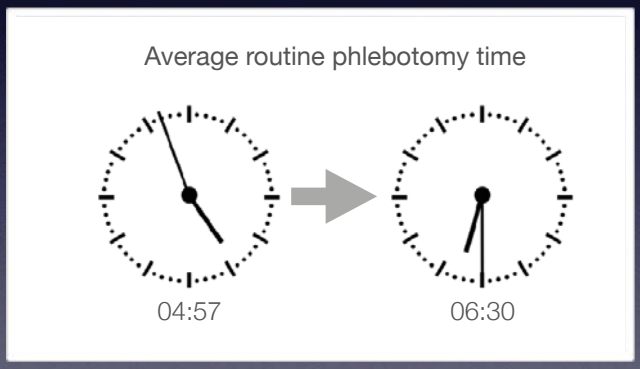
Reengineering Hospital Care to Improve Patient Outcomes

- Hospital Harm
- Circadian Rhythms in Health and Disease
- Improving the Environment of Care
- Artificial Intelligence in Hospital Care

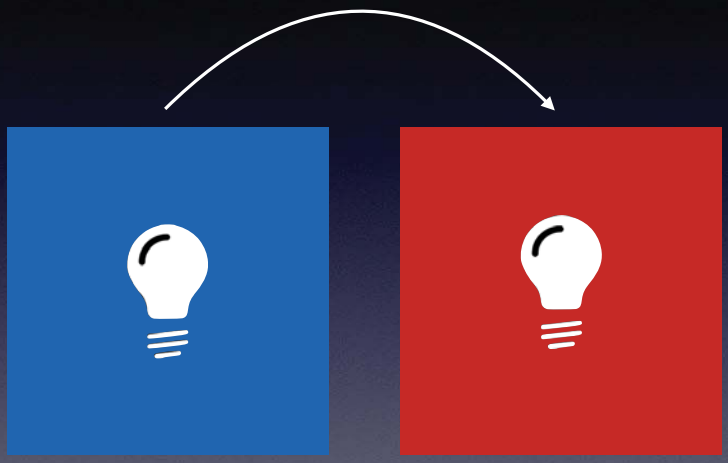
Improving the Environment of Care

- Vital sign collection
- Patient communication / access to information
- Sleep (lighting, noise, vitals, phlebotomy)
- Risk of infection
- Other technologies

Phlebotomy



Lighting at night



Noise Control

Daily reports of noises exceeding maximum threshold with time stamp of each occurrence

Routine Vitals

- Non-obtrusive
- Collects BP, pulse, respirations, O_2sat, temperature, body position every minute
- Sent directly to Epic
- Notifies nurse when out of range (sent to smartphone)

Improving Hospital Patient Safety

Sotera ViSi Mobile

Robust data capture—identifies patients at risk earlier

Manages clinical data and reduces “Alarm Fatigue”

Improves patient mobility reducing hospital-induced deconditioning

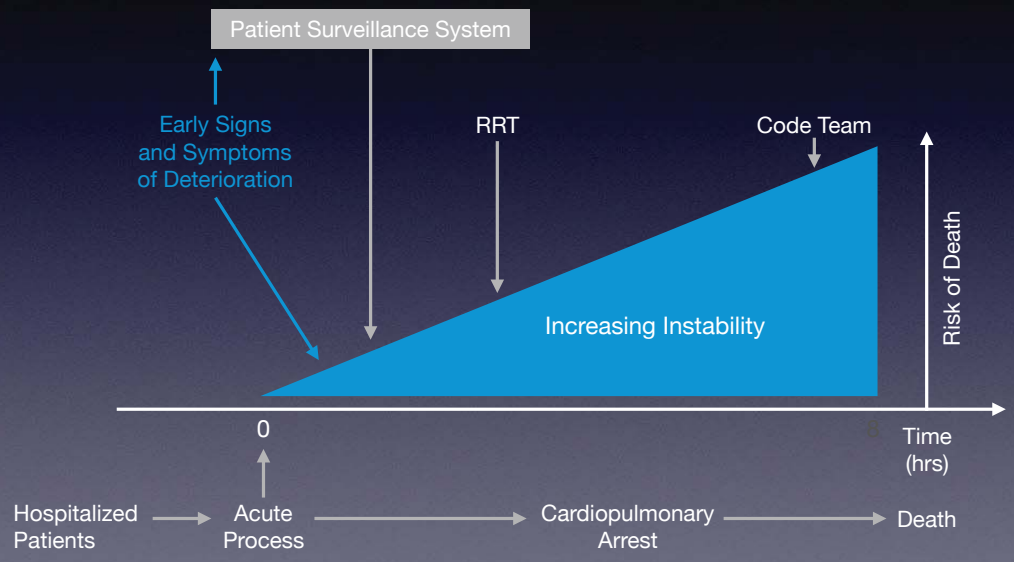
Provides more time for nurses to perform nursing functions

National Patient Safety Goal (NPSG) 6
Reduce the harm associated with clinical alarm systems.

NPSG.06.01.01
Improve the safety of clinical alarm systems.

Physiologic Deterioration

Opportunities for intervention



RRT = Rapid Response Team

Teenier AH, et al. Anesthesiology 2011;115:421-31.

Improving Hospital Patient Safety

Patient surveillance with push alerts

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At the Hospital, Better Responses to Those Beeping Alarms

When patients' monitors beep falsely, nurses and doctors can get 'alarm fatigue' and miss real warnings

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2. EU Referendum Campaigners Deliver Final Messages
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4. Donald Trump Questions Hillary Clinton's Religious Faith
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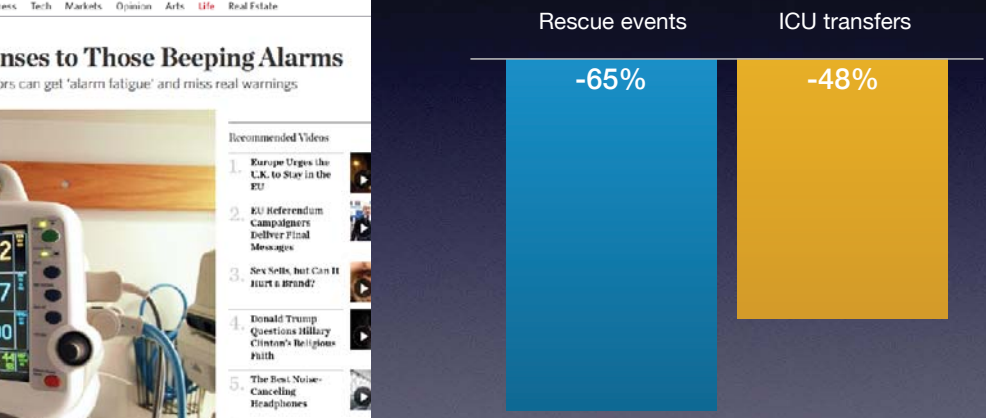
Most Popular Articles

1. Pot Apple's Next iPhone, Don't Expect Big Changes



Teenier AH, et al. Anesthesiology 2010;112:282-7.

Hospital Intervention - Summary

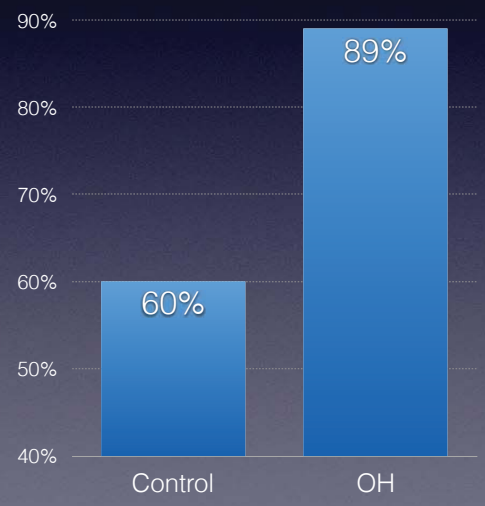
- Improved communication tools for nurses and improved care efficiency (BCMA via Rover)
- New technologies that capture vitals wirelessly without human assessment - with machine to human notifications - improvement in alarm management
- Increased patient's personal control - more information (MyChart bedside) when and where patients want it
- Improved ambulation by reducing tethering to bed
- Improved sleep quality and quantity - less disruptions of circadian rhythm - via noise control, change in lighting systems, unobtrusive vital sign monitoring, and morning phlebotomy times

Outcomes

HCAHPS Survey

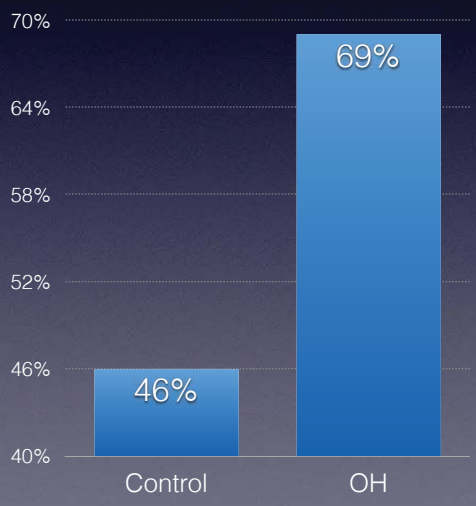
In general, how would you rate your overall mental or emotional health?

"Very Good" or "Excellent"



Before giving you any new medicine, how often did hospital staff describe possible side effects in a way you could understand?

"Always"

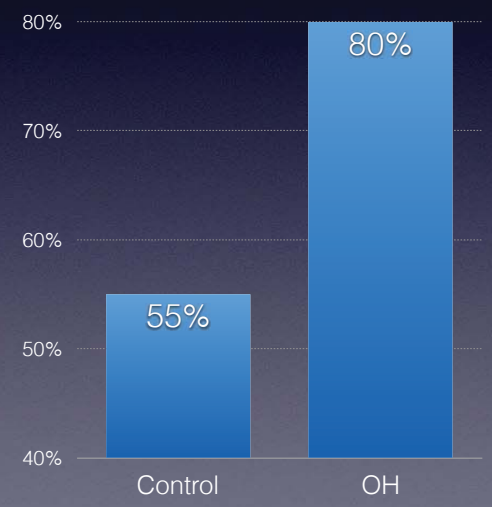


Milani RV, et al. *Am J of Medicine*. 2018: in press

HCAHPS Survey

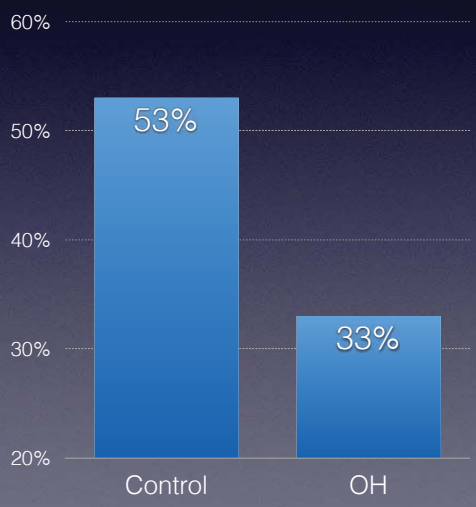
During this hospital stay, how often was the area around your room quiet at night?

"Always"



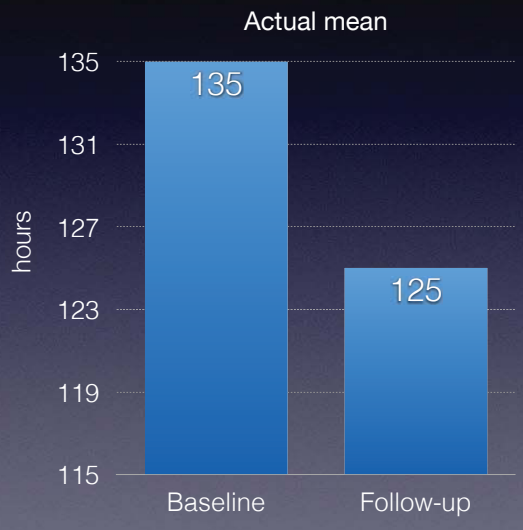
During this hospital stay, did you need medicine for pain?

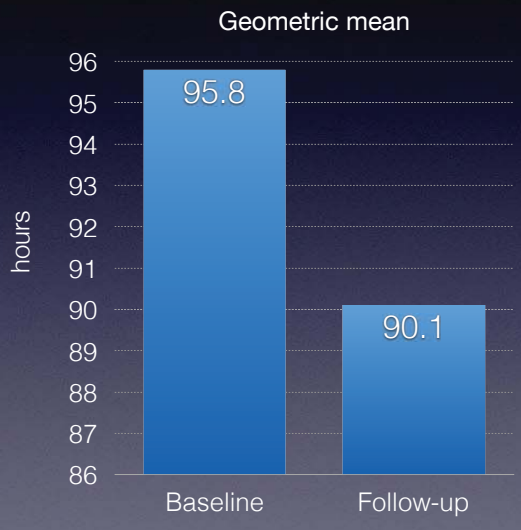
"Yes"



Milani RV, et al. *Am J of Medicine*. 2018: in press

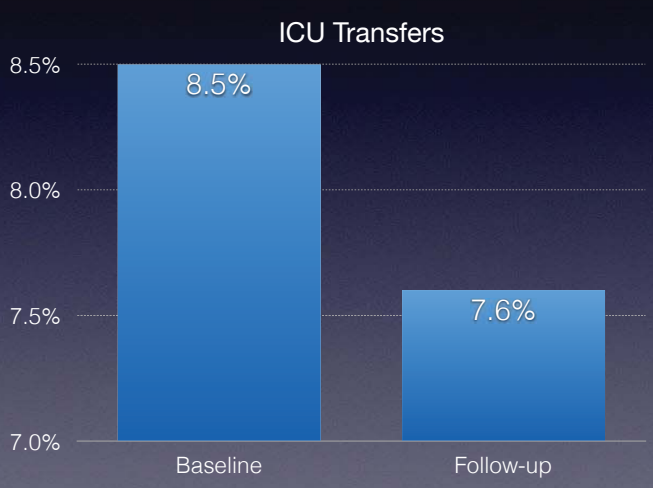
Length of Stay

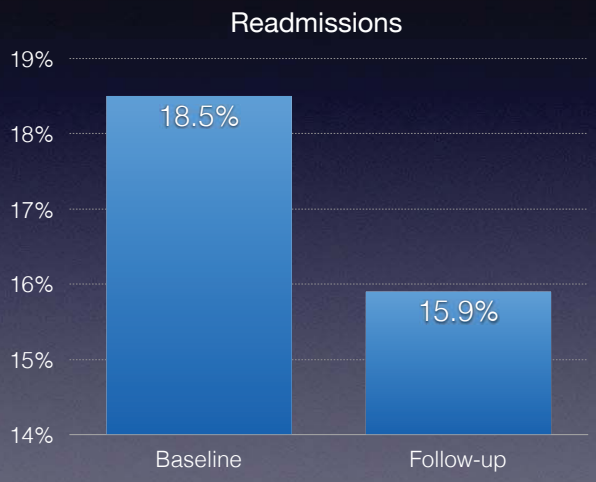




Milani RV, et al. *Am J of Medicine*. 2018: in press

Clinical Outcomes





Milani RV, et al. *Am J of Medicine*. 2018: in press

Hospital Acquired Infections (HAI)

- HAI acquisition in 1 out of every 20 patients admitted in U.S.
- ~722,000 people develop an HAI each year in U.S.
- About 75,000 die from an HAI each year
- Bacterial contamination on surfaces including MRSA, vancomycin-resistant *Enterococcus* (VRE), can survive on environmental surfaces for weeks with *Clostridium difficile* (CDI) spores surviving for months.
- More than 50% of HAIs are caused by bacteria resistant to at least one type of antibiotic.
- Regular surfaces made of plastic, stainless steel, coated metal, and wood are quickly re-contaminated after cleaning.

Source: Centers for Disease Control 2017: https://www.cdc.gov/hai/surveillance/index.html
Magill SS, et al *N Engl J Med* 2014;370:1198-208.

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Source: Freedberg, DE, et al. *JAMA Intern Med.* 2016;176:1801-1808.
Neely AN et al. *J of Clin Microbiology.* 2000;38:724-726.

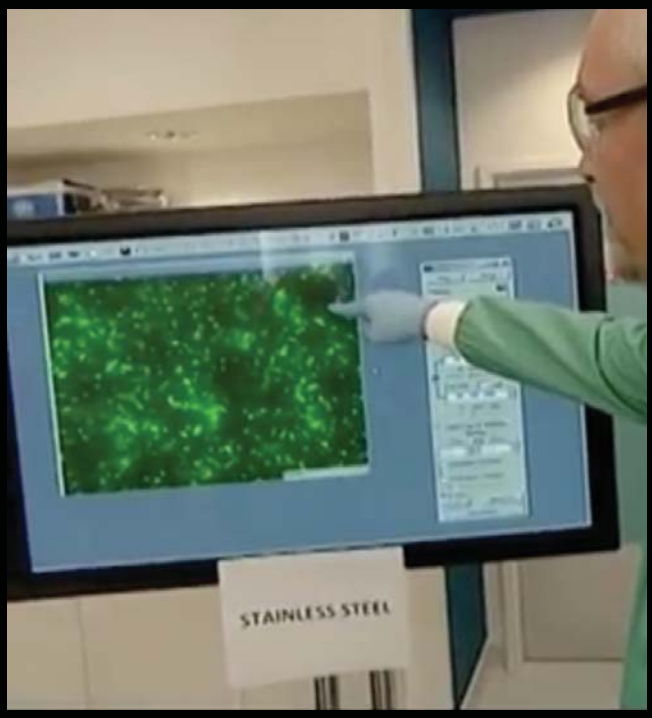
Hospital Acquired Infections (HAI)

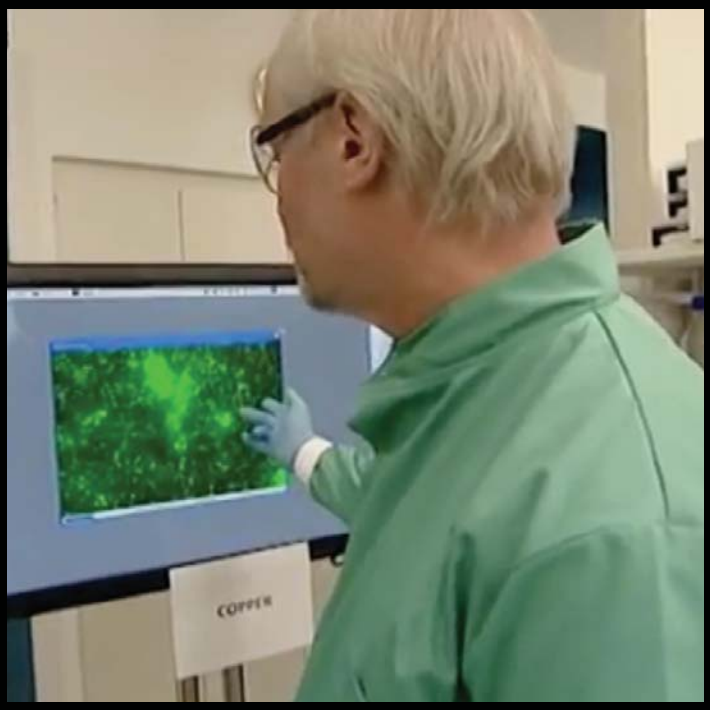
Source: *Issues in Emerging Health Technologies* 2015;133:1-11. https://www.cadth.ca/antimicrobial-copper-surfaces-reduction-health-care-associated-infections-intensive-care-settings

- Copper surfaces have intrinsic and continuous broad-spectrum antimicrobial activity that remains effective for the product's lifetime.
- Copper alloy surfaces kill 99.9% of bacteria in less than 2 hours (including MRSA, VRE, *S. aureus, Enterobacter aerogenes, Pseudomonas aeruginosa*) and continuously kill after repeated contamination.
- Mechanism of action: involves rupture of cell membrane, generation of reactive O_2 species, and breakdown of bacterial DNA, resulting in cell death - no evidence of bacterial resistant organisms.
- Copper alloys are the 1st class of solid surface materials approved by the EPA as antimicrobial and approved for public health use.

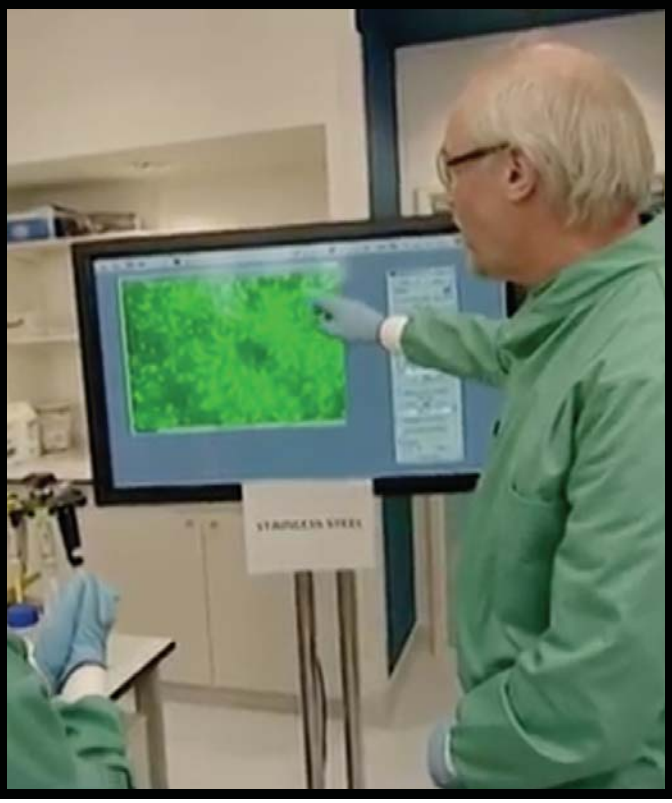
Baseline

10 million MRSA placed on each of two surfaces

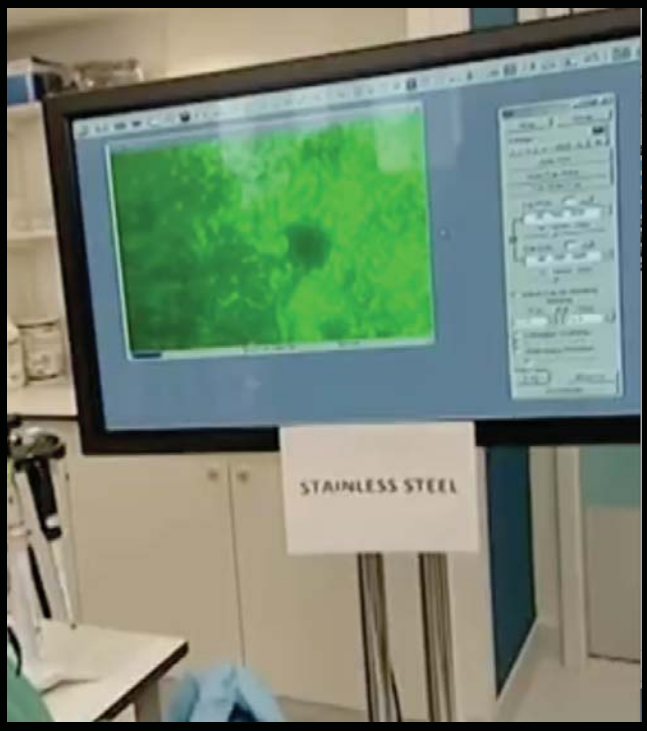




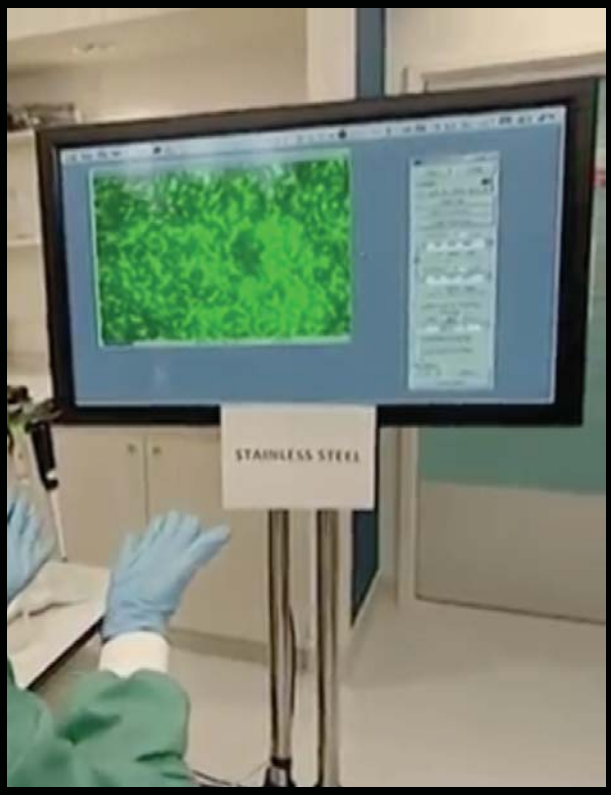
2 minutes

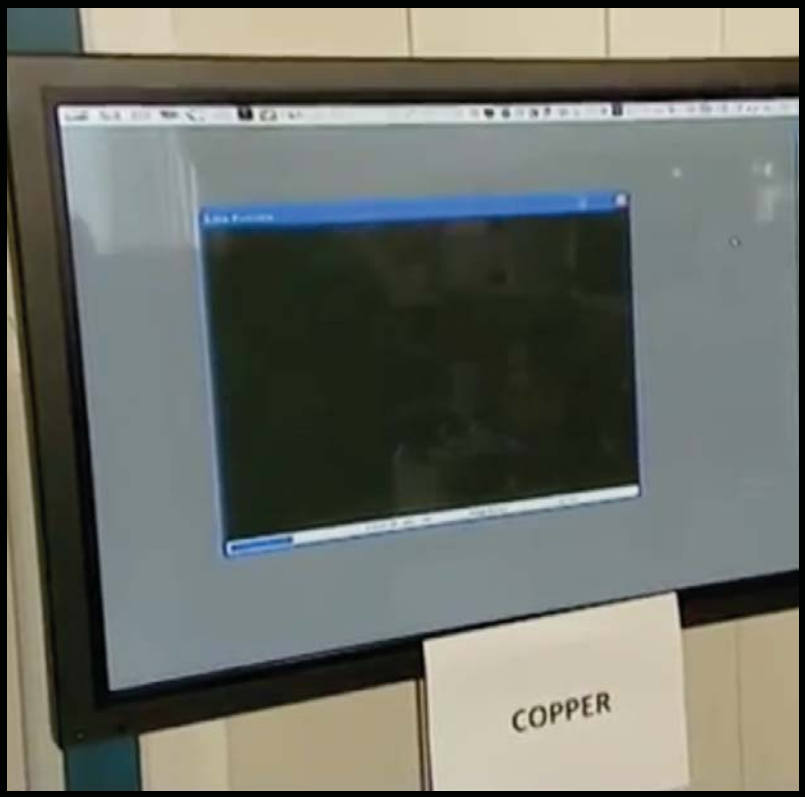


6 minutes



9 minutes





Clinical Studies

Department of Defense Trial in ICU

- Standard bedrails became re-contaminated after disinfection (at 6.5 hours: 5,198 CFU/100 cm^2 versus 424 CFU/100 cm^2 for Cu surface)
- Cu reduced antimicrobial burden on surfaces (bedrails, overbed tables, etc.) by 83%
- HAI's reduced by 58% in rooms with copper-impregnated surfaces

University of Virginia / Sentara Healthcare

- Included linens in addition to hard surfaces (overbed tables, bedrails)
- 78% reduction in HAI's due to MDROs or *C. difficile*
- Rolling out in all hospitals across Sentara system

Source: Schmidt MG, et al. *Infect Control Hosp Epidemiol*. 2013;34:530+533.
Sifri CD, et al. *American J of Infection Control*. 2016;44:1565-71.

Reengineering Hospital Care to Improve Patient Outcomes

Hospital Harm

Circadian Rhythms in Health and Disease

Improving the Environment of Care

Artificial Intelligence in Hospital Care

Early Warning Systems for Inpatient Deterioration

Modified Early Warning System (MEWS)

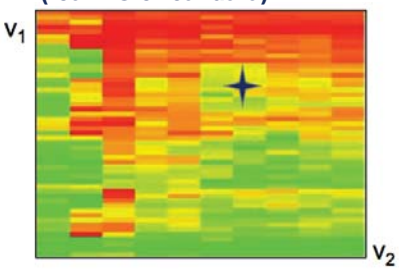
Systolic BP	≤70 mmHg	+3
	71-80 mmHg	+2
	81-100 mmHg	**+1**
	101-199 mmHg	0
	≥200 mmHg	+2
Heart rate	<40 bpm	+2
	41-50 bpm	+1
	51-100 bpm	**0**
	101-110 bpm	+1
	111-129 bpm	+2
	≥130 bpm	+3
Respiratory rate	<9 bpm	+2
	9-14 bpm	**0**
	15-20 bpm	+1
	21-29 bpm	+2
	≥30 bpm	+3
Temperature	<35° C / 95° F	+2
	35-38.4° C / 95-101.1° F	**0**
	>38.5° C / 101.3 °F	+2
AVPU Score	**Alert**	**0**
	Reacts to voice	+1
	Reacts to pain	+2
	Unresponsive	+3
Total	7.9% chance of ICU admission or death within 60 days	1

Kruisselbrink R, et al. *PLOS ONE* 2016;11:1-13.

Generalized Linear Modeling

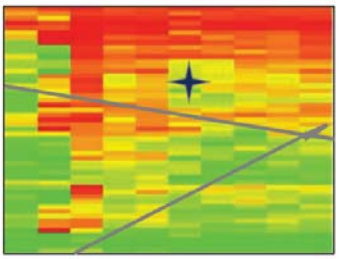
Machine Learning

The actual phenomenon (real historical data)



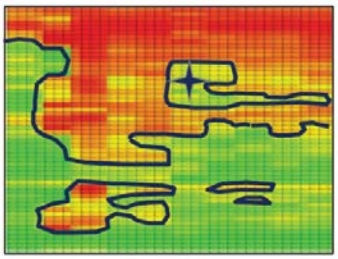
Real life phenomenon come in “all shapes and flavors” – showing patterns that are usually complex, non-linear and apparently disorganized

How Traditional stats sees it



Traditional stats will fit a predetermined “shape” into the phenomenon (ie. linear, quadratic, logarithmic models) – the square peg into the round hole

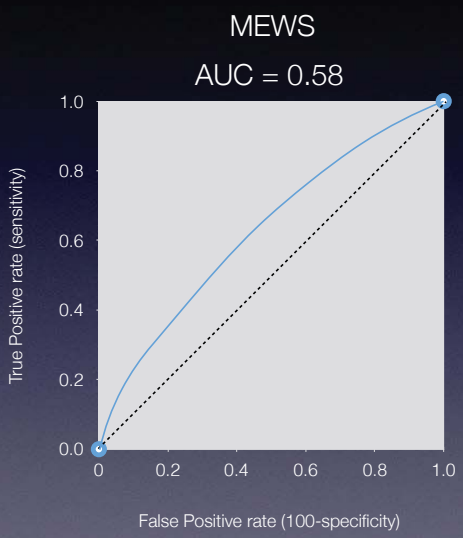
How Machine Learning sees it



While ML algorithms are adapting themselves by spotting & recording patterns without clinging to any predetermined corset

Early Warning Systems for Patient Deterioration

Area Under the curve of the Receiver Operating Characteristic (AUROC)



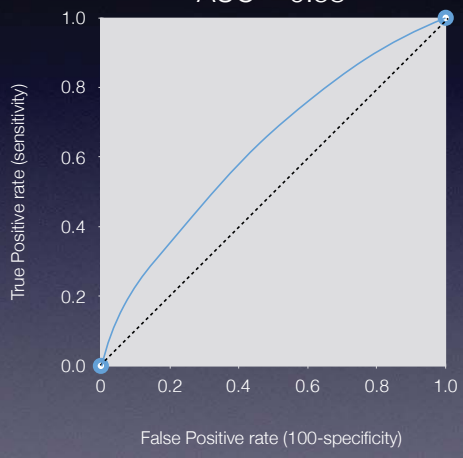
60-day outcome prediction-binary

Early Warning Systems for Patient Deterioration

Area Under the curve of the Receiver Operating Characteristic (AUROC)

MEWS

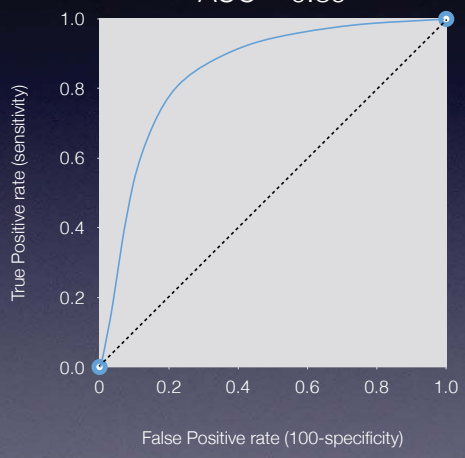
AUC = 0.58



60-day outcome prediction-binary

Ochsner-AI

AUC = 0.89



4-hour outcome prediction-realtime neural network

Ochsner Patient Deterioration Model

- We used over 1 billion clinical data points, including vitals, lab result values, nursing assessments, and echocardiograms, to create a deep recurrent neural network
- With the results of this model, a newly created Rapid Response team of providers gets real-time notifications when patients exceed a certain risk threshold
- The team can quickly assess the patient and take immediate action

Ochsner Patient Deterioration Model

90-Day Pilot Results

- Successfully reduced codes outside of ICU by 44%
- Over 40% of alerts resulted in transfer to the ICU
- Over 25% of alerts resulted in end of life conversations

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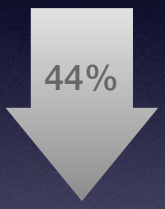

Summary

Health systems typically focus on delivery of services and operate in only 10% of the health-determinant pie.

Modest interventions impacting timely communication, social, and behavioral factors, yield impressive benefits in chronic disease outcomes along with high levels of patient satisfaction.

Hospitals function to maximize efficiency of operations, sometimes at the expense of patient safety and quality. Opportunities for improving patient outcomes and satisfaction can be realized through modest changes in the environment of care.

Thank You!